AIRplay: designing a game for children with asthma to support self-management

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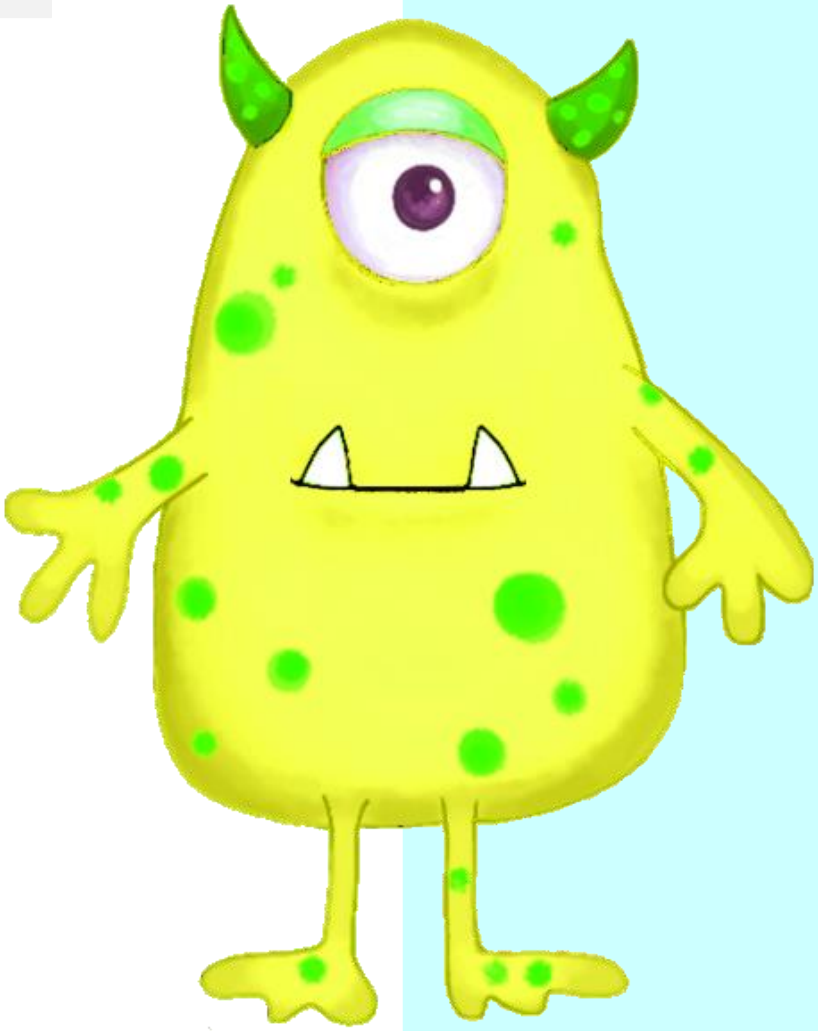

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ABSTRACT

Self-management is crucial in order to have optimal asthma control. However, asthmatic children tend to quit playing sports completely and do not follow instructions that are given during an appointment by their doctor. Therefore, it is important to promote asthma education and physical activity amongst children with asthma and their parents to improve their asthma control. This graduation project focusses on designing a serious game on the interactive playground in the waiting room of the hospital to support self-management of asthmatic children.

In the beginning, some related research has been executed. Some information about designing for children, making games, the interactive playground, the circumstances in the waiting room, and optional asthmatic topics to educate the children and their parents about, has been gathered. In the second phase a mind map was made based on the related research, including game characteristics such as repetition, teamwork, immediate feedback and motivation and more aspects that should be taken into account such as the target group and the use of colors when making a serious game for children with asthma to support self-management. 30 concepts were discussed with the supervisors of this project, 5 concepts were discussed with two medical professionals and finally one final concept has been realized on the interactive playground in the waiting room of 'Medisch Spectrum Twente'. The game that has been realized is named Eldub's Asthma Adventure. The player(s) has/have to protect Eldub, who is located in the middle of the screen and has asthma, by destroying and dodging positive and negative triggers that move towards him. The overall feedback, both by medical professionals and children with asthma, was very positive. The children personalized the game by recognizing the triggers and especially enjoyed the score and feedback that is implemented in the game. Additionally, they really like to play the game together with their parents and siblings and were really motivated to win. The medical professionals are very excited to continue working with this project and are, besides some very enthusiastic advices, in no way negative about the game. The enthusiastic advices include more personalization and even more feedback. Sadly, the game does have some bugs, so in order to continue this process these bugs should be fixed.

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1. INTRODUCTION

This graduation project is about, as the title suggests, designing a game for asthmatic children to educate them about asthma and potentially improve their self-management skills. In this section, the situation concerning asthma will be discussed briefly, to show the importance of ideal asthma control. Additionally, the importance of self-management of asthma will be introduced briefly as well. This subject will be discussed in more detail in Chapter 1 and Chapter 2.

Asthma has been around for a long time, but more people are being diagnosed with the disease more than ever before. More than 235 million people cope with asthma. This is an increment by almost 30% in the last 20 years [1]. This number will most likely grow by more than 100 million by 2025 [1]. Asthma is a life-threatening disease. Most asthma-related deaths occur in poorer countries. According to the WHO estimates released in December 2016, there were 383.000 deaths due to asthma in 2015 [2]. Asthma is the most common non-communicable disease amongst children. Every year the number of children suffering from the disease increases, which results in a decreasing of the average age every single year [2]. In the Netherlands more than 610.000 people have asthma. There are more woman than man diagnosed with this disease. Of these people, about 100.000 are children [3]. But what exactly do people with asthma cope with?

Asthma is a chronic disease that can occur at any age, but most of the time it starts as a child. Asthma is a genetic disease. If one of the parents, or both, has asthma then one out of four children will have the disease as well [2]. Symptoms of asthma include coughing, wheezing, shortness of breath, chest tightness or pressure, difficulty talking, pale, sweaty face and blue lips or fingernail [4]. A certain trigger can cause an asthma attack. An asthma attack is a sudden worsening of the previously mentioned symptoms caused by the tightening of muscles around the bronchial airways, which makes the airways narrower and breathing more difficult. During the asthma attack, the padding of the airways also becomes inflamed or swollen and thicker and extra mucus is produced. These factors together: bronchospasm, inflammation and mucus production, form an asthma attack. With an asthma attack you can inhale or exhale less air than usual [4,5].

An asthma attack does not arise out of nowhere, but what exactly triggers asthma patients to have an asthma attack? There are different types of triggers that can cause an asthma attack[5]. A lot of the time asthma is induced by an allergic reaction, 70% of asthmatics also have allergies [1]. People with asthma are allergic to for instance, house dust mite, pet dander, mold, pollen from trees, grasses and weeds. Other non-allergic triggers are dust, smoke, cold, air pollution, fine dust, and the smell of baking, paint and perfume. Exercise, stress, medicine and infections in the airways, like a flu or a cold can also cause an asthma attack.

Luckily, there is the possibility to treat your asthma and not be bothered by the symptoms most of the time. The goal of asthma treatment is to be free from severe symptoms day and night, have the best possible lung function, be able to live your life just like everyone else and engage in activities your choice and not miss school or work at all. Medication should be taken to control your asthma, and optimally these

[1] http://www.aaaai.org/about-aaaai/newsroom/asthma-statistics, last accessed: 26-04-2018
[2] http://www.who.int/mediacentre/factsheets/fs307/en/, last accessed: 23-04-2018
[3] https://www.longfonds.nl/astma/alles-over-astma/wat-is-astma, last accessed: 23-04-2018
[4] https://www.webmd.com/asthma/guide/asthma-attack#1-1, last accessed: 23-04-2018
[5] https://www.thuisarts.nl/astma/ik-heb-astma, last accessed: 23-04-2018

only have a little to no side effects, and no urgent care visits or hospital stays for asthma are needed. This is definitely a possible perspective if you have excellent asthma control [6].

This report is constructed as follows. Firstly, a compact introduction about the project will be given. The overarching project named AIRplay will introduced and problems concerning asthma will be addressed. research questions will be introduced as well. In the second chapter, the relevance of this project will be discussed in order to hopefully help solving the problems. In the second chapter related research will be collected in order to answer the research question. In the third chapter, 30 concepts will be made based on the related research, 5 concepts will be elaborated and finally 1 final concept will be chosen. The final concept will be specified in the fourth chapter. Certain goals for the game will be set, which will be realized in the fifth chapter, the realization chapter. In this chapter the realized game will be explained in detail and pictures will be shown. In the sixth chapter, the evaluations will be described. Three evaluations have been held for this graduation project, one with students, eHealth interests, an elementary teacher and a interactive playground expert, one with medical professionals and one with children with asthma. Results of these evaluations will be shared and some of the recommendations will be implemented in the game. The seventh chapter is the discussion. In this chapter recommendation will be given concerning the process of this project, the goal of this project and the game itself. Finally chapter 8 will consists a list of requirements and whether they are met or not, and answers of the research questions will be answered in this chapter as well.

1.1 AIRplay

The assignment for this bachelor project was provided by the AIRplay project. The AIRplay project is a cooperation among MIRA (University of Twente), HMI (University of Twente), Medical School Twente and two hospitals: MST and ZGT [3].

The ultimate goal of this cooperation is to improve the physical conditioning of children with asthma (7-9 years old). This goal is potentially reached by combining the interactive playground, with an app and a FitBit. The interactive game installation responds to players positions and makes it possible for the user to have a full-body game action (will be explained further in Section 2.1.2). Each child is provided with a personal daily physical activity goal, which is tracked by the FitBit. The data, which consists of the number of steps a day, is send to the application and shown here as a percentage of their daily goal. This app will also ask the children a couple of questions for them to keep an eye on their asthma. The interactive playground adds the physical game to this project, which most likely stimulates the children to move and change their daily physical behavior [4, 5]. In Figure 1 you can see children playing on the interactive playground at MST hospital.

[6] http://www.upmc.com/patients-visitors/education/breathing/pages/asthma.aspx, accessed: 03-04-2018

Figure 1: AIRplay project, the interactive playground, visualized[7]*.*

Next to the physical condition of the child, this project also targets the emotional and mental aspects of the children, by, for example, addressing both children with asthma and healthy children in a similar manner.

This bachelor thesis is about continuing and hopefully improving the AIRplay project by implementing asthma education in the physical game for the children.

1.2 Problem Statement

Exercise-induced asthma (EIA) affects 90% of the children with asthma [8]. EIA is a form of asthma where people only have symptoms of asthma when they exercise, which could lead to an asthma attack. This happens more likely if the asthma is not well managed. The symptoms of EIA are the same, but only show after exercise and normally slowly fade in time. Asthma symptoms due to exercise are caused by breathing through your mouth instead of your nose during exercise. "*Usually, you breathe in through your nose, so the air is warmed and moistened. When you exercise, you tend to breathe faster and in through your mouth, so the air you inhale is colder and drier. In some people with asthma, the airways are sensitive to these changes in temperature and humidity and they react by getting narrower. This can lead to asthma symptoms*"[8].

Exercise-induced asthma can deter especially children from participating in regular physical activity [5]. This can be because they are discouraged by the skill differences compared to healthy children, which could eventually lead to dropping out of play and sports completely [6]. Parents might also be worried and not allow their child to play sports [8], which is unhandy because physical activity and staying fit and healthy is an important part of good asthma management. "*Obesity is associated with a high incidence of asthma and poor asthma control*" [p21, 7]. After a significant weight loss, the asthma symptoms tend to have a reduction of 48%-100% as well as the use of asthma medication. Also, exercise helps to stretch the lungs and bronchial tubes [9]. Since the bronchial tubes become narrower during an asthma attack, this effect of exercise might help prevent symptoms.

[7] http://airplayproject.nl/, last accessed: 23-03-2018
[8] https://www.asthma.org.uk/advice/triggers/exercise/, last accessed: 23-03-2018

Next to physical activity, education, aimed at improving the ability of people to control their asthma themselves, and medication adherence are important subjects in self-management and are crucial for successful asthma control [4]. People should know what they are dealing with and how to anticipate triggers that enhance their asthma. When having an asthma attack both the child and parents should know what to do and which medication to take and also how to take it.

In this graduation project the main focus is on children with asthma. The children will be educated about asthma and potentially improve their self-management. Additionally, children with exercise-induced asthma will be stimulated to be physically active in their daily life even though exercise triggers their asthma.

1.3 Goal

The goal of this graduation project is to continue and hopefully improve the AIRplay project, which is explained in Section 1.1. More precisely, the game on the interactive playground, which is now a coin collecting game, will have an additional educational element to support self-management using the benefits of embodied learning. Only time will tell whether this project will include one big game or various smaller games. However, from earlier research done specifically by AIRplay and the client's wishes the following requirements can be set:

- ★ The game(s) should be designed for asthmatic children from the age of 6 to 9;
- ★ The game(s) must be designed to be played on the interactive playground in the waiting room of the hospital;
- ★ The game(s) should support self-management of the children concerning asthma and possibly also the parent;
- ★ It is important that the children are actively involved in the game(s) and potentially are stimulated to stay active also outside of the waiting room;
- ★ The game(s) should be able to be played by both people with and without asthma. The children with asthma should not feel limited by their disease while playing this game.

To conclude, the game(s) should improve the children's self-management by keeping them active, making them feel alike and educating them about asthma-management**.**

1.4 Research Questions

The problem statement and goal lead to the following research question:

"What is a good educational game on the playground in the waiting room at 'Medisch Spectrum Twente' for children with asthma to support self-management?"

Knowing the answer to this question will give a good representation on which elements should be included while making the game. Although before this question can be answered, there are various sub questions to consider.

- ★ *What are the circumstances in the waiting room?*
- ★ *Which elements of self-management are appropriate to learn in this game?*
- ★ *Which design elements should and should not be used to attract the specific age group?*
- ★ *How will a physical game improve the learning experience of children?*

2. CONTEXT ANALYSIS

In this chapter, you will be informed about projects, products and concepts concerning this project. First some background information and a literature review will be given about this topic. Then the related work will be discussed which will be followed by the state of the art of this project and the relevance of the research question (see Section 1.4).

2.1 Background Research

In this section background research will be shown about asthma and how patient's should be informed about their disease to promote self-management and reduce asthma symptoms. Secondly, instead of describing the content of the education, the designing process will be examined. Especially explaining certain aspects that should be taken into account when designing for a child. Thirdly, an interview with a doctor specialized in asthma will be summarized. Lastly, the playground will be further discussed, especially focusing on the possibilities on this specific playground and some negative aspects.

2.1.1 Asthma Self-Management and Education

In Chapter 1 the meaning of asthma has already been discussed. There the importance of self-management is already briefly mentioned. However, in this paragraph the specific reason of this importance will be explained. In fact, the Expert Panel Report 3 Guidelines for Diagnosing and Managing Asthma [10] even states that educational programs that teach self-management are a vital part of asthma care. "*Self-management is defined as the task that individuals must undertake to live with one or more chronic conditions. These tasks include having the confidence to deal with medical management, role management and emotional management of their conditions*" [p2,11]. Asthma cannot be cured, but avoiding triggers potentially can control the chronic disease [12]. Asthma self-management improves asthma control, reduces exacerbations and admissions, and improves the overall quality of life. Healthcare professionals have the responsibility to make sure that everyone with asthma or their parent(s) is/are offered self-management education, which should include a written personalized asthma plan and be supported by regular professional review [13].

An action plan (see Figure 2) provides the patients with a summary of what their daily life should look like, considering their disease, to control their asthma optimally. It gives them advice on how to recognize symptoms and gives them recommendations on how to avoid asthma attacks. An asthma plan advises them to take their recommended medication and helps them realize the importance of this. An action plan is made by both the patient and the professional, which makes it very personal. This is essential because shared decision making helps in stimulating the patient to take their medication [13]. One last addition to the action plan is two or three action points. These action points are personal goals that patients can work towards by improving their asthma control.

According to Pinnock [13] ¾ of patients actually did not have the opportunity to have a personalized asthma plan in 2015 which could guide their self-management. Additionally, despite the importance of an action plan, a large number of patients do not adhere to the self-management program even when they are given the chance, which results in poor asthma management [14].

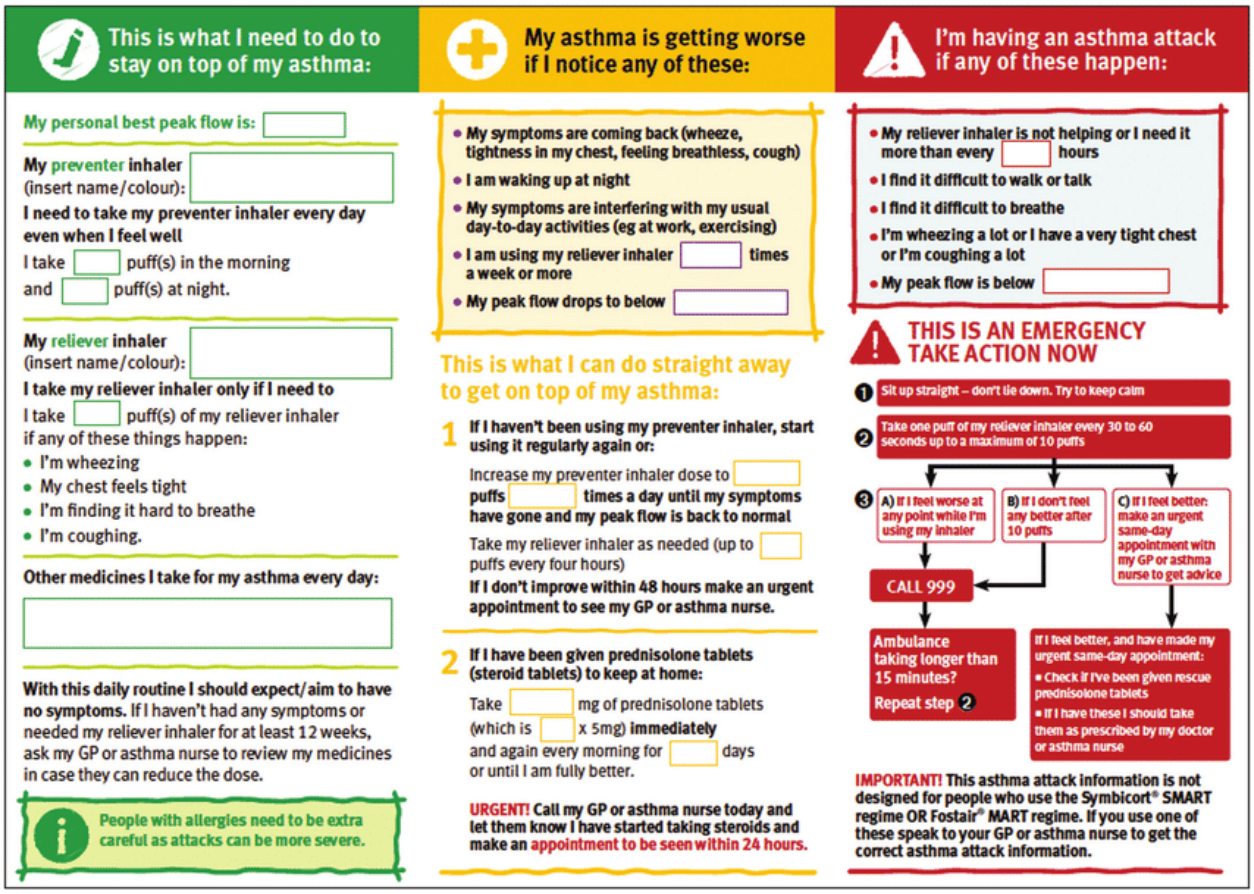

Figure 2: An example of what an asthma action plan looks like.

Three of the most important factors of asthma management include, keeping an active lifestyle, medication adherence and asthma education. "*Asthma educational programs can help reduce burden and improve the quality of life*" [p1364, 15]. "*Recent evidence indicates that asthma self-management education is effective in improving outcomes of chronic asthma*" [p912-p915, 16]. Education is important in a way that it improves the ability of the patient to control their asthma. A few of the most important topics of asthma medication are explained here shortly.

Avoiding triggers: as mentioned before, avoiding asthma triggers can be a massive aspect of asthma control. "*Asthma has a wide range of causes varying from environmental, hygienic, existing medical conditions to genetic factors. Inhalation of outdoor air pollution, tobacco smoke or smoke from burning wood may induce an asthma attack in an individual with a prevailing condition*" [p437, 17]. For instance, patients should know which triggers to remove, reduce and avoid [9]. How To Beat Your Kid's Asthma [10] explores this concept. For 9 weeks, 10 families joined an experiment and removed as many triggers as possible, that triggered their child's asthma, in their house. Cats and dogs were brought to an animal shelter, carpeting was removed and the house was cleaned every single day. Significant changes were seen in the behavior of the children. Although the families did have difficulties cleaning the house every day, removing the

[9] https://www.youtube.com/watch?time_continue=104&v=g5oW1QXfy08, last accessed: 31-03-2018
[10] https://www.youtube.com/watch?v=ukiACT4cvWE, last accessed: 31-03-2018

triggers in the house did result in the children using their inhalers way less and actually being able to have a good night of sleep.

Dealing with asthma attacks: other crucial knowledge is knowing what to do when the patient is having an asthma attack. It is important to stay calm, to take your medication and take them again in twenty minutes if this does not work [11]. Taking the right medication and knowing when and how to take it is essential for this. The doctor should even be called if the medication does reduce the symptoms. This topic also includes avoiding an asthma attack by, for example, avoiding triggers and having an active lifestyle. [11]

Playing sports: as already described in Chapter 1, people tend to quit sports or at least reduce their physical activity drastically when they have asthma. Also, asthma clients tend to have less energy than the average human being. It could be helpful for the patients to be aware of this and especially how to cope with this [12].This results in a lot of the asthma clients being overweight. Actually, young children with asthma are 51% more likely to become obese over the next ten years [13]. Exercise is one of the most common triggers that cause an asthma attack [18]. When asthma is controlled, asthma does not restrict exercise performance, actually "*exercise training can improve asthma symptoms, quality of life, exercise capacity, and pulmonary function, as well as reduce airway responsiveness*" [p641, 19]. Since having an active lifestyle is especially important for asthma patients it is important that these people are educated well about how to approach this optimally. For asthma patients it is especially important to breathe through their nose to filter warm and humidify inspired air, because this will reduce the chance of asthma symptoms [20]. Also, it is essential to consider the length and intensity of the activity to prevent severe symptoms of asthma. Additionally, it is crucial to teach the clients about the importance of physical activity, despite the fear of a possible attack due to poor asthma control.

Acceptation: a lot of patients with asthma or their parents do not want to accept the fact that they have asthma. During an interview with a health professional, who is specialized in asthma at MST this topic was also discussed. The doctor actually believed acceptance is the most important aspect that should be tackled when someone has asthma. *"The first thing I think that we need to get across is that they accept the diagnosis. It is just the first hurdle to take. That they have to really accept, and both parent and child, that they have it. Sometimes they said like, when does it go over or is it serious, so that's the first important thing I think that they should be aware of."* (The complete interview with the doctor can be read in Appendix A).

Proper nutrition: Eating healthy is important for everybody. However, following an healthy diet reduces asthma symptoms and is therefore especially important for asthma clients. The patient will feel better when eating healthy, will cough less and feel less anxious [14]. Losing weight after being overweight will reduce asthma symptoms and improve everyday life. Although there is no specific diet an asthma client should follow, studies do show that certain nutrients may help support lung function [15]. According to the Vitamin D Council, getting enough vitamin D may help reduce the number of asthma attacks in children aged 6 to 15. Moreire*, et al.* [21], which is another study, found that woman who eat higher levels of beta carotene, which is a form of vitamin A, have a better quality of life. Males on the other hand ate less iron to have the same effect. Nutrition Journal states that eating apples regularly is associated with a lower risk of asthma and a beneficial effect on lung function and European Respiratory Journal found that bananas might decrease wheezing [15]. In contrast, there are also various foods which should be avoided. In the end, it is most important to eat healthy. Eat three times a day, eat many fiber-rich products and eat fish twice a week [14].

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[11] https://www.longfonds.nl/astma/omgaan-met-astma/astma-aanval, last accessed: 31-03-2018
[12] https://www.longfonds.nl/astma/omgaan-met-astma/sporten, last accessed: 31-03-2018
[13] https://www.sciencedaily.com/releases/2017/01/170120090557.htm, last accessed: 31-03-2018
[14] https://www.longfonds.nl/astma/omgaan-met-astma/voeding, last accessed: 31-03-2018
[15] https://www.healthline.com/health/asthma/asthma-diet#2, last accessed: 31-03-2018

Educating asthma clients about every single one of these subjects or a couple of them, potentially helps them to improve their self-management skills. Especially since it is important for someone with asthma to manage their asthma themselves, and this knowledge can be implemented in their daily life to reduce asthma symptoms and increase their overall quality of life.

2.1.2 Designing Games for Children

Recently, video game industries have sold more than music and video industries. Especially popular are the violent games that are on the market, most specifically, first-person shooters [22]. Gaming is no way near an unpopular activity for children. Games are associated with fun and excitement, but not all games are a success. Children are very explorative and would most likely give a lot of games a chance. However, a lot of games tend to get boring over time. That is why in this section a couple of elements are discussed, which should be taken into account when designing for children.

As Schell [23] has written in his book, the most significant demographic variables for game designers are age and gender. Therefore, these two variables will be examined in the following paragraphs.

First of all, the age group which will be targeted is very important to be taken into account before designing a game. Schell [23] has written about this and has divided certain ages and important characteristics regarding games. During an interview with a doctor specialized in asthma, has been told that children do not get diagnosed with asthma before they are 4 years old. Therefore, children younger than 4 years old are irrelevant. At the age of 4 to 6 children generally first show interest in games anyways. The games that they play are very simple and parents most of the time make the games enjoyable for the child. When children get older they tend to be more independent. From the age of 7 to 9, children most of the time go to school and can read. Game playing start to become very important to this age group and they actually decide for themselves what they want to play and what not. Preteens, aged 10 to 13, tend to be quite passionate about their interests. For boys this interest is most of the time games. When children become teenagers, aged 13 to 18, the difference between gender becomes suddenly very clear. "*Boys continue to be interested (and often get more interested) in competition and mastery, whereas girls become more focused on real-world issues and communication*" [p101, 23]. However both boys and girls are very interested in experimenting with new kind of experiences and some might look for these experiences through gameplay. When designing for a specific age group, it is very important to remember to speak the language of their childhood and consider the games that they have played before.

Secondly, as explained above, from the age of 13 boys and girls tend to love different aspects regarding games. "*Males and females are different. They have different interests, different tastes and different skills and abilities*" [p102, 23]. When designing a game it is very important to keep these differences in mind, especially when designing specifically for girls or boys. In the first paragraph, the preferences of boys will be discussed and partly compared to the preferences of girls. In the second paragraph this will be the other way around.

First of all, as already mentioned above, boys tend to like mastery, meaning that they like to challenge themselves and be a master in a game. An experiment done by Kinzie and Joseph [24] actually suggests that boys like to be actively involved in a game, hinting that boys indeed like to put effort in a game and challenge themselves. Girls are not against challenging themselves either [24], however for them it is more important that the effort has a meaningful purpose and leads to a certain goal. Secondly, the preference of boys for competition in a game was also already mentioned in the previous paragraph. De Vette, Tabak and Vollenbroek-Hutten [25] conclude as well that boys like to compete against each other and defeat others, while girls enjoy cooperative gameplay and group problem-solving way more. Thirdly,

another game characteristic that is favored by boys is destruction. Boys really like to destroy objects, "*when young boys play with blocks, the most exciting part for them is not the building, but knocking down the tower once it is built*" [p103, 23]. Fourthly, spatial puzzles are liked by boys. They favor these puzzles in games because they are very good at navigating 3D spaces in general. Girls on the other hand sometimes feel frustrated while making these puzzles. Finally, boys like to learn by failing, especially since they are not very much into reading.

Girls however care more about the emotional experience that a game can give, which was also already briefly mentioned above. Besides the emotional experience, de Vette, *et al*. [25] add characteristics such as peaceful and cheerful to this list. More generally speaking, de Vette also concludes that variation, fantasy, discovery and creativity are preferred by both boys and girls, compared to more predictable content like football or racing. However, this data is conflicting with data collected by Kinzie and Joseph [24]. They conclude that 'explorative' is the most popular activity mode amongst both boys and girls, especially girls find this an important characteristic in a game. Additionally, girls more likely play games that reminds them of the real world. They like to play games like 'dress up' and 'the sims'. The sims is especially liked, because this game requires multi-tasking skills [23]. Girls also really like to take care of someone or something, therefore nurturing is next on this list. Girls tend to sacrifice themselves to help a weaker player and really care about the feelings of the other players. Woman read more books than man and have more verbal skills than man. That is why girls favor dialog and verbal puzzles over spatial puzzles, especially since they generally lack those skills. Lastly, in contrast to boys, girls "*have a strong appreciation for clear tutorials that lead you carefully, step-by-step, so that when it is time to attempt a task, the player knows what she is supposed to do*" [p105, 23]. Nonetheless, combining more than one game characteristic in the game, either preferred by boys, girls, or both according to previous mentioned studies, will potentially attract a bigger group of children.

On another note, besides game characteristics, colors that are used in a game are also of great importance. People tend to associate certain colors with specific emotions. When designing a game for children, the overall wanted emotion is definitely happiness. Pope, Butler and Qualter [26] conclude from an experiment that the color blue is associated with the emotion 'happy', both by boys and girls. This implies that blue should be a good color to use in the game. Black, white, red, green and brown however, were associated with the emotion 'unhappy'. As expected, differences in gender were found. Girls associated pink and purple with being happy. However, boys were more happy about the colors brown and red. Gil and Le Bigot [10] agreed with the color red rather being rated an unhappy color than a happy color. "*Children also associate red with negative valence*" [p1087, 27] as was already demonstrated in previous adult studies as well. Nonetheless, the color red could still be needed to create a different emotion in the game. "*As well as having physical and aesthetic qualities, color is charged with emotional meaning*" [p1087, 27]. All in all, the color blue should be used in the game to stimulate the children to have a happy experience, however, other colors should not be forgotten to build a game in which the user will have an optimal and emotional game experience.

2.1.3 MST Hospital (Interview)

Medisch Spectrum Twente (MST) is the hospital of the city of Enschede. In March 2018, an interview with a doctor specialized in asthma has taken place in this hospital. The complete interview can be read in Appendix A, however the most important aspects concerning this project will be summarized in the following paragraph. During this interview questions were asked about asthma in general, especially how the disease is treated at this specific hospital. This is important information because, as mentioned

before, this project is designed for this hospital. The interactive playground is already installed in this hospital and the AIRplay game, collecting coins, is already being played. However, to design a serious game it is important to know what appointments look like, what the doctor thinks is important and should be taught, and lastly the possibilities and limitations in the waiting room itself. In this section a short summary will be given about this interview with the doctor. First the general information and conclusions will be discussed concerning asthma, patients, and how this is treated at this hospital. This information is important to understand how to teach the children about asthma and self-management. Secondly, questions relating to this project in particular will be discussed.

As mentioned above, during this interview, questions were asked about the treatment of asthma. The first step is accepting the fact that you have asthma, especially for the parent to accept that the child has asthma. Most of the time, parents first visit the hospital without any prior knowledge about the disease. They still need to be educated, but this should be done carefully because you do not want to scare them. Optimally, children come here before they have had an attack. This way an attack can sometimes even be prevented completely. Once the patient and their parent have accepted the disease it is time to teach them how to manage the disease. Both the parent and the child should know about medication, but also how to monitor the disease. After the first visit the doctor already has a good picture of what the size is of the problem. However, every patient should be treated different, because they are all different on an emotional level, some might need more time to adjust and accept what they are hearing and some may be too concerned about the well-being of their child and exaggerate or the opposite and not show up until it is too late. It is very important to get to know the patient. If the child or the parent does not accept the fact that the child has asthma, they will also not treat it right. Although even after they have accepted their disease, a lot of the children still do not take their medication seriously. Therefore, medication adherence should be taught better. An another important aspect is that all the children and parents get an action plan to take home. After the treatment, if the children actually follow it, about 70% of the children will do very well, 10-20% has an acceptable quality of life and only 5-10% not so well for various reasons.

To design a game for on the interactive playground, it is important to know what the circumstances are like in the hospital, and more specifically in the waiting room. The average waiting time is about 15 to 30 minutes. There are about 4 people at the hospital doing clinics and in total there are 50 children in one morning that have an appointment. Obviously they are not all there at the same time. On average there are about 5 to 10 children in the waiting room at the same time and each child has an appointment with the doctor three times a year once they have accepted their disease. However this could also be one or ten, this depends on the child. The first time they get introduced to the disease, they will actually have three appointments in a time frame of 6 to 8 weeks. You cannot say for sure that a child has asthma until they are 4 years old, because they do not have proper lung function until then. Meaning that this is the youngest age that will visit the hospital and therefore the waiting room due to asthma. On another note, children at this hospital tend to be overweight, which is a problem to be addressed in this graduation project. However, he argues that everyone is overweight these days so it is unfair to completely blame it on asthma. At this hospital actually 50 to 60% of the children have exercise-induced asthma of the thousand children that are asthma patients at MST. This is, compared to the average percentage of 80 to 90%, quite low. He believes that this is due to great asthma control that is given and taught at the hospital. As well as the affective medication that is given at this hospital, that reduces asthma symptoms drastically in general. Lastly the doctor gave his opinion about a possible game for on the interactive playground. The most important argument he had, is that children are very explorative. They like to find out how something works by trying and do not ask questions. Older children however tend to get bored quicker, which are useful tips and will be taken into account when making the game. Also, it is great to know that the doctor finds potential in designing a serious game for these children to educate both the children and the parent in a visual and physical kind of way.

2.1.4 The Interactive Playground

Regarding the interactive playground, it is important to know what exactly will be worked with, meaning certain opportunities and limitations, to find out the possibilities of the game. Firstly, the opportunities of the interactive playground will be discussed. The playground which will be worked on is located in the MST hospital in Enschede (see Figure 3). The interactive game installation responds to players positions and makes it possible for the user to have a full-body game action. It uses top-down Kinects to track where people stand, projectors to display visualizations on the floor and PCs to process the game logic and guide player interactions during the game [28,29]. Also, speakers are used to add sound to the game. This all helps to intensify the user's game experience. This specific playground is 5 by 5 meters. Several games, like tag [30], a coin collecting game [28], cooperative football and a music game are ready to be played on the playground at the University of Twente. At the moment the variety at MST hospital is not as big. Here only a coin collecting game is installed and ready for the asthmatic children to explore. In Section 2.3.1 more related work for different playground is discussed. To conclude, the interactive playground gives the user the possibility to have a full-body game experience on a screen of 5 by 5 meters that is projected on the ground.

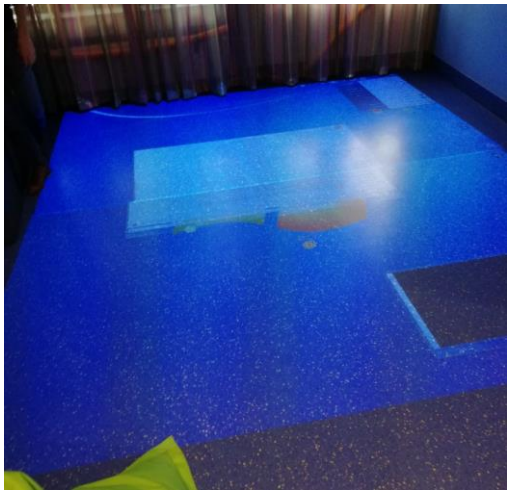


Figure 3: The playground in MST hospital in Enschede [16].

Secondly the limitations of the interactive playground will be listed, which cannot be ignored when designing the game. As said before the location of the player is detected with top-down Kinects. To prevent it from tracking unnecessary objects like the floor or a bag, a threshold is applied. The value of the threshold is chosen based on the height of the players [30]. This hinders the game possibilities a little bit. Although the amount of literature about the interactive playground is limited, in practice it shows that small movements with the upper body are not detected and lagging is not an unusual occurrence. Additionally, the device does not react perfectly to jumping. On top of that, the projections on the floor are not always very easy to be seen. The color of the ground should be taken into account and the amount of light that is in the room should also not be forgotten for the best results. To summarize, the interactive playground does have its limitations, including the tracking system, the lagging and the contrast of colors, which could obstruct the game.

[16] http://hmi.ewi.utwente.nl/IUALL/demos/interactive-tag-playground/, last accessed: 25-03-2018

2.1.5 Conclusions

In the following paragraphs, conclusions will be made concerning the background research that has been done in this chapter. These conclusions will be made regarding this graduation project and the most important aspect that should be taking into account while making the game, will be listed.

First of all, the importance of self-management was discussed, an action plan was explained quickly and educational subjects were introduced. The most important conclusion that can be made concerning this graduation project is the importance of education to improve asthma management. Aspects that could and should be educated include avoiding triggers, an asthma attack, exercise, acceptance, diet choices, smoking and medication. Educating clients and/or relatives about these aspects of the disease will help the client by implementing this knowledge in their daily life. These educational subjects are explained more clearly in Section 2.1.1 and will partially be realized in the serious game in hopes to improve the asthma management of the children.

Secondly, besides of finding an educational subject for the game, the game characteristics and color design were examined. Concerning this graduation project, it is most important to consider the age group of the children, choose game characteristics that should be embedded in the game and lastly, make design choices. The exact age of the target group has not been chosen yet, however children aged above seven years old (maybe six) are preferred at the moment, considering their independence and ability to read. Specific game characteristics will not be chosen yet either because keeping the possibilities open will make the ideation phase more diverse, nonetheless, research has shown particular favors, similarities and differences to consider. Additionally, it is important to embed more than one game characteristic, either preferred by boys, girls, or both, to attract a bigger group of children. On another note, the use of colors should be considered carefully as well. For instance, the color blue actually tends to make children happy and red is associated with negative valence.

Thirdly, the situation specifically at MST is important to discuss. This interview was especially useful for this graduation project for two reasons. Firstly, to get a view of the needs of both the client and the doctor concerning the educational subject. The doctor confirmed that acceptance in a very important aspect, which especially parent tend to have problems with. Also, medication and how to monitor their disease was recommended during this interview. Additionally, the information should be given carefully, to make sure that children and relatives do not become overwhelmed by the facts. Secondly, the more general information of the circumstances in the hospital should be considered. The diversity of children should be taken into account, since there are approximately 1000 children with asthma that attend the waiting room at MST. They all come here 3 times a year on average (except after the first appointment, then they have 3 appointments in 6 to 8 weeks), roughly 15 to 30 minutes every time.

Finally, the possibilities and restrictions of the interactive playground were discussed. The interactive playground is a 5 by 5 meter visualization on the floor. Opportunities include adding sound, visualizations on the ground and improving the learning experience of children with asthma by combining the full-body experience which is possible on the playground with educational subjects, discussed in Section 2.1.1. However, a couple of limitations which should be considered when designing a game on this device include the tracking system, the lagging and the contrast in color.

2.2 Literature Review

In the literature review, the focus will be more on concepts and experiments that have been done concerning serious games and embodied learning. This is crucial information, because the gathered

knowledge should be implemented in the game that will be designed for this graduation project, in order to increase the chance of success. First, serious games will be discussed, focusing on the popularity of games and how combining games with education improves the learning experience. Secondly, projects and theories of embodied learning will be shared. Finally, a conclusion will be made, comparing the found knowledge with this graduation project.

2.2.1 Serious Games

Games are very popular amongst children, adolescents and adults, "*with over 40% of the United States population playing computer games for 3 or more hours per week in 2015*" [p1, 31]. "*Video Games are an undeniable important form of entertainment and a large business in today's world*" [p134, 32]. In the last decade, the popularity of games is massively used in domains such as education, medicine, sociology, psychology, literature and media studies [33]. "*The launch of the serious gaming movement over a decade ago focused on games that are designed to teach academic content and skills to students playing them*" [p313, 34]. People learn the quickest when given the possibility to interact with the subject and discover its responses. When students or children have the possibility to learn with media or materials that are actually connected to real-life situations, they have a much greater chance of acquiring the given knowledge. This kind of learning experience is named an authentic learning experience. In order to combine authentic learning with education, most of the time game based learning is implemented [35]. Implementing education in games potentially improves the learning experience of students. However, for this to become reality, certain aspects should be considered. In the following paragraphs, different factors will be discussed that are of great importance when designing a serious game, according to numerous studies done regarding this subject.

Jubbar and Felicia [36] conclude that especially engagement is crucial in a serious game. This study gathered information from multiple articles, including Guthrie and McCann and Swan, and concluded that engagement affects learning and motivation. "*This effect occurs because it was observed that games can engage players to learn, can include multisensory settings, and can stimulate players' ability to think and create meaning*" [p740, 36]. Enjoyment and motivation are very important aspects in order to sustain player's engagement. To accomplish this, the link between these characteristics should be examined, especially the gaming elements that affect engagement and learning in games. Charsky [37] agrees with Jubbar and Felicia and believes that serious games can only be effective when "*instructional designers and video game designers understand how the game characteristics, competition and goals, rules, challenges, and fantasy, used in both edutainment and serious games, can influence motivation and facilitate learning*" [p177, 37]. Game characteristics overall have a similar purpose; to motivate and excite the gamer [37]. In general, these characteristics include different attributes. Jubbar and Felicia, as well as Pivec, Dziabenko and Schinnerl [38] list several game characteristics, including competition and goals, control, challenges and fantasy. These characteristics can be blurred with instructional content to create an educational game [38]. Although, the opinions on the specific list of existing game characteristics differ, the possible improvement or influence of the learning experience will be explained in the next paragraph, concerning the earlier mentioned game characteristics. The ultimate goal of these characteristics is to motivate the player to play the game and therefore improve their learning experience.

The first characteristic that will be examined is competition and goals which is especially important due to the motivational influence it has on the player. Competition can be either against another player, against the computer or against the clock. Implementing competition, as can be read in section 2.1.1, is especially favored by boys. However, girls also like to compete when it is for a purpose. In serious games, the game goals match the learning goals and competition is added to make the learning more enjoyable [37]. By adding this feature, the user potentially is motivated to complete the game activities because they

want to win. The second characteristic is control. It is crucial that the player is allowed to make choices in a game. "*Through opportunities to make choices that have direct consequences, players control the game development*" [38]. For instance, when the avatar needs to solve different tasks, the player should actually make the decisions. Players should be able to control their avatar, in the way that they can update their virtual character with received rewards. Players usually feel very attached to their avatar and feel very motivated to upgrade it, especially at a younger age [37]. Therefore, giving the player an award for giving the correct answer, potentially motivates the child to answer a second question. The third characteristic that will be examined is implementing challenges in a game. This characteristic is a combination of goals and effort and the idea behind this was already discussed in the previous characteristic. As long as the goal is meaningful for the player, and the challenge is their level, the user will put effort in the game [38]. The last characteristic that can be blurred with educational content is fantasy. Children are very explorative and curiosity drives learning. "*Curiosity is sustained by the continual introduction of new information and non-deterministic outcomes*" [38]. Since fantasy can be imaginary, the possibilities are endless. Children are curious to see what is going to happen next and "*fantasy in the context of the game leads to greater interest on the part of the student as well as increased efficiency of learning*" [38].

More specifically concerning this graduation project, Kato reviews the importance of these serious games, especially designed for the health department. "*The field of medicine has a history of embracing games as a means to engage patients behaviorally to improve their health outcomes*" [p113, 39]. The main reason behind this is to increase motivation, as mentioned earlier and distract the user from what is happening. This is especially important for the health department, because patients normally need to undergo procedures or participate in behaviors that are either very painful or boring. Additionally, games can provide repetitive information. Delden, van, *et al.* [40] agrees with the latter, and add that interactive games give the opportunity to personalize and thus make the training more efficient and enjoyable.

2.2.2 Embodied learning

Lately, education for children has been made much more enjoyable and way more relaxed, by implementing interactive learning materials [41]. In section 2.2.1 serious gaming was already examined, however it is proven that adding full-body movement creates an even better learning experience. "*The enactment of knowledge and concepts through the activity of our* bodies" [p445, 42], called embodiment, is very important regarding learning. Gaming with a mouse or a keyboard is way less direct and impressing than direct interaction. "*For ages, physical activity and manipulating physical objects have played an important role in learning and development*" [p85, 43]. Embodied learning is an educational method in which not only an intellectual way of teaching is offered, but also the whole body is involved. Although numerous experiments have proven that embodied learning does improve the experience, there is not one theory as of why. In the following paragraphs, several articles will be discussed concerning confirmation of embodied learning and different assumptions explaining the reason behind this concept.

One of the many evidences of embodied learning is an experiment executed by Ho, Zhou, Wei and Low [44]. During this test the Nintendo Wii gaming console was used to combine learning with interactions. The results were very positive, it shows an improvement in learning after using the Wii as an learning system. It is believed that embodied states can truly influence cognition. This is called embodied cognition: "*when we perceive, act, interact with things and events in the surroundings, our bodied can link minds to the world*" [p557, 41]. Another study which demonstrates embodied metaphors is the interactive Sound Maker Environment [45], "*designed to support children when learning about abstract sound concepts such*

as pitch and volume, indicated that systems with embodied metaphor based interaction models may support children in structuring their understanding of these abstract concepts" [p85, 43]. The conclusion of the study indeed was that the children did rely on the embodied metaphors in understanding the given knowledge about music. A study followed from this that suggested that children, in this case aged seven to nine, for example can understand soft and loud volume in terms of either small and big, or slow and fast movement [44]. Potentially, implementing more than one embodied metaphor could benefit learning.

However, more importantly than gathering prove is gathering information about certain theories explaining why and how embodied learning works. "*Multiple research areas now support the tenet that embodiment is a powerful underpinning of cognition*" [p446, 42]. Lindgren and Johnson-Glenberg [42] focus on "*research findings showing that cognitive processes involved in learning, such as conceptual development and comprehension, are built upon a foundation of physical embodiment*" [p446, 42]. One of the many evidences of the connection between cognition and body movement is found in a study done by Hauk, Johnsrude and Pulvermuller in 2004 [46]. In this experiment, participants listened to words, related to various body areas; lick, pick and kick, and brain activity was found in parts of the sensorimotor areas of the brain that are associated with performing those actions as you can see in Figure 4.

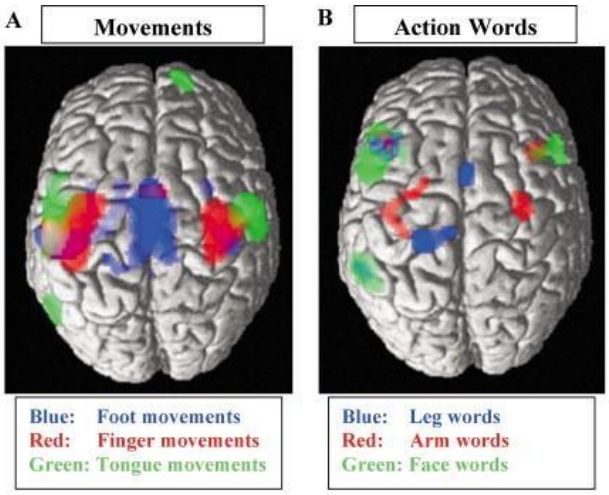


Figure 4: In this picture the similarities in brain activity are shown [44].

As expected, there are more studies concerning the connection between mind and body. Mark Johnson states that the characteristics of knowledge come from the essence of the body and Barsalou truly suggests that embodied states can influence the cognition and be influences by cognition as well [47]. Full-Body Interaction Learning Environment potentially facilitate meaning-making by providing players with multiple ways and allowing them to construct various representations [48]. Cognition, as already mentioned, is not only restricted to the mind, but also to the relation between the mind, the body and the world. Barsalou claims that this is supported by empirical research, which has shown that "*thoughts, concepts, emotions, attitudes and social competences are influences by the role of physical states, bodily structure and experimental opportunities*" [p333, 48], meaning that higher-level cognitive skills, such as implicit memory and problem solving may also arise from sensorimotor functions.

Lee, *et al.* [47] add the motivational factor of interacting with the education to the list of possible influences on the embodied learning performance. In an experiment with thirty-nine college students was concluded that the children were enjoying the full-body movement while playing the serious game a lot. Body motions that are involved in embodied learning potentially increases the amount of joy the child has. Additionally, playing in a public environment, the children were able to adjust their performance by peer

observations. However, besides the improvements the children can make due to observations, "*group work can create joyful learning atmosphere though constant human* interactions" [p557, 47].

2.2.3 Conclusions

In the following paragraphs, conclusions will be made concerning the literature review that has been done in this chapter. In this literature review, numerous articles were gathered and the reasons behind the success of serious gaming and embodied learning is examined. This information is crucial for this graduation project in order to increase the chance of success.

Firstly, some literature was examined concerning serious games. the importance of engagement in serious games was discussed. The popularity of games is not that important to take into account, however it is good to know that children most likely at least will give the game a try. However, to keep the attention of the children, engagement is especially important in a serious game. Engagement affects motivation and learning and certain characteristics of a game can be blurred with instructional content to create an educational game. These game characteristics include competition and goals, control, challenges and fantasy. In Section 2.2.1 you can read in more detail how these characteristics can influence the motivation and therefore the learning experience of the player. Other elements that are important to consider are immediate feedback and repetition to support the child.

Secondly, numerous experiments were gathered that proved the working of embodied learning. Embodied learning is a crucial part of this graduation project and understanding why and if this actually works in the real world is the first step into making a system that includes embodied learning. Although embodied learning has been proven to improve the learning experience, there is not one theory that confirms this. However, most theories are built on the connection between body and mind, and the improvement of the learning experience due to an increment of motivation.

2.3 Related Work

Related work was looked up in order to get to know existing project and thereby possibilities for this project. Since 'a serious game for children with asthma on the interactive playground', is quite specific, the topic is for now split into three sub-topics. The first topic being games on an interactive playground to create a broad view of which games can already be played on such a playground and the possibilities. The second subject being embodied learning projects and lastly, serious games designed for children (and relatives) with asthma.

2.3.1 Games on an interactive playground

Interactive playground is a fairly broad concept and does not only cover the playground which is already explained in Section 2.1. For instance, sensigom [17] makes their playground with integrated technology without a projector and trackers. Instead pressure sensors are embedded into the soft soils,

[17] http://en.sensigom.com/, last accessed: 17-03-2018

which have a high resistance and are easy to maintain. LEDs are implemented in any form to create special light games. Examples of games which are made by this company are sport games such as football (see Figure 5), basketball, rugby, sprint and long jump, multiple multiplayer-games which is played on a checkerboard floor. Also music games are created. Soils of different shapes and colors produces a sound and is designed to play alone or together. Some of these actually are developed to educate the user, like learning the alphabet, listening to animal sounds and discovering shapes and colors. Lastly, luminous games are made on these interactive playgrounds. In these games audio and visual elements are combined.

Figure 5: The football game on the playground [17].

Another company that specializes in interactive playgrounds is MotionMagix [18]. This interactive playground can either be visualized on a floor or on a wall. Over 200 games can be purchased for this game, games to be played alone, to be played together, on the floor, on the wall, but also educational games. All of these games, as expected, should be played actively. Examples of games that can be played on this specific interactive playground include: 'Digit burst', to practice counting, questions will be asked to the player in 'Board Quiz' and the player can become more familiar with colors in 'Color collect'. MotionMagix has proved to be a healthy way of blending mental and physical activity in a variety of educational and learning scenarios.

A company that is also worth mentioning is called ConnectAndPlay [19]. This company does not only make interactive floors, but also walls, tables and touch units. Since an interactive floor is more relatable to this graduation project, a short explanation will be given of this. ConnectAndPlay say the following about the floor: "*Step into a magical playfield. The floor immediately draws attention and makes visitors active.*" The floor can be ordered in different sizes, and it is especially interesting to see that at most 15 people can play on it.

Several other interactive playgrounds, either projected on the ground or on the wall are developed by audiodome [20], Lu [21], Lumo Play [22] and Vertigo [23]. It is important to keep in mind that the interactive

[18] http://www.motionmagix.com/, last accessed: 17-03-2018
[19] http://connectandplay.nl/index.php/interactieve-concepten/, last accessed: 06-07-2018
[20] http://www.khm.de/~tmok/playground.html, last accessed: 17-03-2018
[21] http://www.play-lu.com/, last accessed: 17-03-2018
[22] https://www.lumoplay.com/, last accessed: 06-07-2018
[23] http://www.vertigo-systems.de/producte/living-floor/?gclid=EAIaIQobChMI0bb1xf6P2gIVir3tCh3FjARBEAATASAAEgLMpvD_BwE, last accessed: 17-03-2018

playground that will be used in this project does have a couple of limitations, like capturing height differences and lags (read about this in more detail in Section 2.1.1).

2.3.2 Embodied games

Some of the games on the interactive playgrounds stated above already have education implemented, but there are more embodied games that promote education for children. Four of them will be discussed in the following paragraphs.

Firstly, EG [24], which stands for Embodies Games "*empowers students to learn using gesture-based methods*" [24]. Alien Health (see Figure 6) is an example of a game and claims "*to be the only nutrition instruction game to combine meaningful learning gestures with nutrition knowledge*" [24]. This particular game is designed for children of the age of seven or older. The lost alien should be fed healthy food, if done correctly his ship will be energized and the alien can save dying planets. This way players will learn about which nutrition are in which foods. Even real life food to personalize the game. More games are made by this company. 'Natural Selection', an embodied game for learning the concepts surrounding natural selection and 'Vector van Gogh', to educate children about vectors, attraction and repulsion between charges', to name a view. The educational games of EG are made with professional game designers and are supported on research showing that active learning promotes better content memory. Most of the games can be either played with the sensors, but also with mouse and keyboard.

Figure 6: Two children playing Alien Health [24].

Secondly, the award winning company named Jumpido [25] will be discussed. This is another example of a company who combined body movement with education. This company has made mathematics fun by combining the well-known Kinect with mostly seen boring math equations. The children need to "*combine intelligent thinking with physical gestures in order to solve problems*" [23]. The game is designed to be played in a classroom, and given the wide range of possibilities in the game, the teacher can decide which adventures, implemented in the game, are played.

[24] http://www.embodied-games.com/, last accessed: 17-03-2018
[25] http://www.jumpide.com/en/partners, last accessed: 17-03-2018

Thirdly, there is an embodied learning environment named SMALLab [26], which can be seen in Figure 7. "*Our mixed-reality technology is transforming learning, increasing student achievement, and improving teacher performance*" [26]. Experiments have been done with SMALLab and results show that learning gains were significantly higher after the SMALLab learning intervention compared to usual classroom education There is actually a 86% increase in student achievement. Additionally, the device improved the teacher performance as well, actually by 33%. More than 30 games are already designed to be played on SMALLab. Including a game called 'more or less' in which students work as a team to learn about greater than, less than, and equal conditions and a game to learn about 3D shapes.

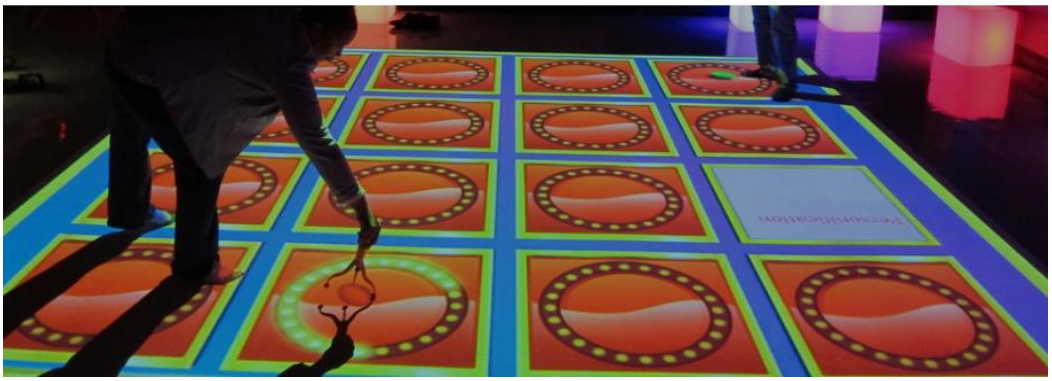


Figure 7: A picture of SMALLab [26].

2.3.3 Serious games designed for children with asthma

A game designed for on the playground or embodied games, especially for children with asthma has not been found. However, serious games, most of them in the form of a fun interactive quiz, for these children are definitely on the market. In this section two of them will be discussed.

Aspira [49] has made an astronaut-themed game, which in a way allows families to continuously monitor indoor air quality on their own. Aspira will send instant alerts of poor indoor air quality, which are intended to lead to positive behaviors to reduce the environmental triggers, thereby improving children's asthma-related health. Parents (and children) will find out which triggers are present in their house. To summarize, basically a tool is presented to help urban, minority families to both independently identify and address asthma triggers in their homes and improve their child's asthma self-management.

For example, the message "do you see any of these?" was shown if there was bad air measured for 15 to 20 minutes (see Figure 8). The kid is send to look for the source and later fill in what they found. A secret code is also asked for, this code could be found after using the spirometer. This way the child is reminded in a fun way to complete a daily task.

[26] https://www.smallablearning.com/, last accessed: 15-04-2018

Figure 8: The question "do you see any of these?" is asked after Aspira has measured poor air quality to identify the cause of O2 alerts [49] .

The downside of a game like this is that it needs to be played every day in order for it to be useful to check the air quality and for the children to fill in the questionnaire. Only half of the children, it was only tested by four families, on which this game has been tested would like to keep using the application and the other half answered with maybe. The app was rated 'somewhat fun' by children and 'somewhat helpful' by parents, which does not sound too convincing.

'The Asthma Game' [50] is another game, which is designed to teach children with asthma and their parents how to act to prevent asthma attacks by drawing attention to asthma triggers in the home, and by providing information about how to avoid them. Especially the children need help identifying the causes of asthma attacks and how to avoid them and this games helps them as follows: The game aims to teach players what basic steps should be taken at home to prevent asthma attacks. The engaging environment which is shown in Figure 9, allows players to experience everyday situations within the virtual home and copy this to their personal home situation. It helps the parents and children do the right thing when asthma triggers are present in their house.

Figure 9: The engaging environment of The Asthma Game [50].

A character in the game is associated with nine different triggers for asthma: *domestic animals, laundry abandoned on the floor, fireplaces (representing smoke), soft animal toys, moldy walls (representing dampness), curtains, blankets, cleansing products and carpets*. As you walk, the avatar of the player provides information about the asthma trigger that is nearby and the game avatar asks questions to the players about how to avoid the effect of the specific trigger. Four options are shown and at most two are correct. For each correct answer, the player gets a word. These words form a sentence about asthma in the end.

The results of this game were quite positive. Out of 18 children, 16 found the game fun to play and 12 actually were able to better understand asthma after playing the game. Despite the positive feedback,

the children tend to be distracted a lot by the game environment, characters could fly for example and you could go for a swim in the sea, and were not able to finish the game in 30 minutes, which was the predicted time slot.

OKWA [51] is an internet program that uses an interactive story like environment to teach asthma management to children aged 8 to 10. OKWA promotes self-management with the help of family, peers, community and health care providers. According to OKWA self-management includes identifying symptoms, reducing triggers, monitoring lung function and knowing when to get help from others. Next to self-management it also discusses the importance of acceptance of asthma and the physical and emotional aspects that come with this.

A storywriter wrote two different storylines in which the above stated information about asthma was given: children snowboarding and children on a school playground. The story was interactive in a way that at various points the user can decides what is going to happen. In total there are five different stories per 'story'.

During the user test became clear that the program might be a bit too difficult to understand. The problems described are not being able to restart the story before it is finished and the character in the story asking help from a stranger. Although a lot of the children do not own a smartphone, a mobile application of the interactive narrative was still asked, proving that computers are not the environment children these days are used to.

2.3.4 Conclusions

Looking at the studied related work, a few conclusion can be drawn. First of all, when looking at the variety of games and the success of these interactive playgrounds, it could be believed that these sort of devices are very wanted by children. This confirms that in general, children like to play games on any kind of interactive playground, especially since there are quite a few versions of these devices. The playgrounds displayed in section 2.3.1 and its various games are not designed for on the interactive playground which will be worked with during this project. Yet, it does give a small overview of what is already out there and what is liked by children. Sport games, music games and for now maybe the most important game genre is serious games.

In the second section, embodied serious games are discussed. The most important conclusion is that education can definitely be made fun when combining it together with games and several companies take advantage of this. It is quite useful to look at how companies attempt to combine these three elements together: education, movement and game. Although, none of these games educate the user about asthma, it does inspire this game in a way how exactly your movement influences the game. On top of that, it presents that even an alien is able to teach you about nutrition, meaning that a lot is possible and you should implement funny elements to make the game fun to play for children. The last project also shows that embodied learning improves the achievement of the student and the performance of the teacher. In this graduation project, the teacher can be seen as the parent or doctor.

Lastly, the educational games for people with asthma are discussed. This is very useful for ideas for the topic of the game. The first game, 'Aspira' also measures air quality and tries to acknowledge triggers that cause bad air quality. Measuring air quality seems to be impossible, however asthma triggers are an important topic to be discussed. This topic is addressed as well in 'The Asthma Game'. The game, or story named 'OKWA' has a broader topic. It focuses more on asthma management, but with this it includes avoiding triggers as well. To see these topics and how they are implemented in a game, even though you do not play these games with your whole body, are great inspirations for the project. Another very important conclusion which is worth repeating is that in 'The Asthma Game', children were distracted a lot by

unnecessary surroundings. In addition, ‘OKWA’ suggested that it is very important to consider the target group, especially the age, and to not make the game too difficult to understand.

2.4 State of the Art

In section 2.1, 2.2 and 2.3, the situation concerning this graduation project has been examined. In section 2.3 related work was listed. What you might have noticed, is that physical games for children with asthma were not described here. However, regular games for asthma clients were named. Aspira, The Asthma Game and OKWA. Aspira measures the air pollution is someone’s house and help them in finding the trigger, The Asthma Game also explains the user about several triggers, and OKWA focusses on asthma-management. This is only a small sample of games designed for children, adults or relatives with asthma. Therefore, the importance of educating clients about asthma and improving their self-management is not an unknown and unpopular concept, as well as serious games. Articles explain the importance of self-management as well, and suggest topics on which asthma clients could and should be educated. These topics include avoiding triggers, an asthma attack, exercise, acceptance, diet choices, smoking and medication. Nonetheless, these games that exist are not designed for a device allowing full-body movement.

A lot of research has been done concerning this graduation project. However, these different aspects, including the importance of physical activity and improving self-management for children with asthma and creating a physical game, is not very common to say the least. Embodied learning is not an unpopular concept, and various games are already designed on multiple devices such as Kinect and Wii, however such a game, including asthma education has not been found. In the previous paragraph, games were listed in which the player is educated about aspects of self-management. On the other hand, experiments concerning physical activity and asthmatic people has been done as well. However, in these experiments the participants play regular games on the Kinect, *etc.* and the game is not especially designed for clients with asthma. These tests were more focused on the influence exercise has on the client and not really about educating them and stimulating them to become more physically active.

Finally, the knowledge of designing games for children, and more specifically serious games and games that require full-body movement has been examined. Again, tons of research has been done in the last couple of years, including serious games, embodied learning and designing for children. All in all, basically all of the information can be found in articles or books to create a serious game to improve self-management for children. Experiments have shown that embodied learning improves the learning experience, and combining this with education specifically for asthmatic children, potentially makes the experience more fun and successful.

2.5 Relevance of the Research Question

The research question that is introduced in Section 1.5 was the following:

“What is a good educational game on the playground in the waiting room at ‘Medisch Spectrum Twente’ for children with asthma to improve self-management?”

As said before education is one of the most important factors in creating optimal self-management for asthma patients. When the children have excellent asthma control, the limitations caused by asthma

are limited. In an interview with a doctor, specialized in asthma at the MST hospital in Enschede was discovered that some children do not take their medication seriously and simply use their inhaler a lot five minutes before the appointment and try to fake using it regularly this way (Appendix A). Also, children and especially parents are having a hard time accepting the fact that the child has asthma (Appendix A). Additionally, children with asthma tend to be overweight, because their asthma limits them from exercising due to poor asthma control. These are only three examples which influence the ability of a child to have good asthma management. Food, knowing how to cope with an asthma attack and avoiding triggers are also very important subjects to be implemented in an educational game as well. Showing the importance of medication and learning the children in a fun way how to use them, potentially makes children take the medication more seriously. On top of this, it is very important to avoid triggers to reduce your asthma symptoms and prevent as many asthma attacks and hospital visits as possible. Additionally, showing a child and, in this case most importantly, the parents the exact asthma symptoms and presenting this in a fun way potentially helps them accept the fact that their child is sick. These are only a couple of possibilities to implement into a game on the interactive playground which will potentially help children by improving their asthma control and self-management by education them about their disease.

Optimally, such a game in the waiting room at MST will stimulate the children to also stay active in their daily life. Being active in the waiting room potentially ensures them that it is okay to have an active lifestyle. Since they only visit the hospital about three times a year, it is not completely fair to assume that the motivation to be active will be there all the time. However, the information that will be given through the game, will hopefully be remembered, especially with embodied learning as an extra element in this sort of interactive game, and will be used by both parent and child.

There are plans to build more playgrounds in elementary schools and waiting rooms, however it is not very realistic to wish that every asthma patient has the possibility to build one of these devices in their own house.

3. IDEATION

The ideation phase is an important part of this graduation project. It is the phase in which plenty of concepts will be considered, in the hope to select the most optimal one for the specific target group. First of all, a stakeholder analysis will be held. In this section, the importance of the needs of particular stakeholders, including the parents, the children, the doctors specialized in asthma at MST, and my graduation project supervisors, will be examined. Secondly, the requirements, partly drawn from this analysis, but also from Chapter 2 and the client will be described. All of this information is of great importance for the next section, which is the brainstorm section. Each educational topic (further explained in Section 3.3) will be considered and ideas for serious games for asthmatic children will be listed. In the last section conclusions will be drawn, mostly decided which sort of games are preferred and explaining why.

3.1 Stakeholder Analysis

"*Stakeholder analysis will enable you to explore the different voices that need to be considered when thinking about your strategic direction and plans"*[27]. More specifically, a stakeholder analysis identifies the key stakeholders of the project, or organization one is working for/with. It gives the opportunity to select certain stakeholders and rank them, concerning their interests, needs and expectations. These findings most likely impact the project and therefore are important to examine. Prioritizing the needs helps in setting up the importance of certain requirements, which will be discussed further in Section 3.2. This graduation project does not have many stakeholders, however it is still important to consider their needs and by doing this analysis is can be determined whose needs are most important for the success of this project.

"*A stakeholder is a person, group or organization that has an interest in your organization"* [25]. Following this definition, the stakeholders of this graduation project include the graduation project supervisors, the actual users: the asthmatic children and their parents/caregivers that visit MST regularly, and the doctors that are specialized in asthma and are associated with this children and their parents/caregivers repeatedly. In Figure 10, these stakeholders are plotted in the power/interest matrix.

[27] https://knowhownonprofit.org/organisation/strategy/directionsetting/stakeholder, last accessed: 05-05-2018

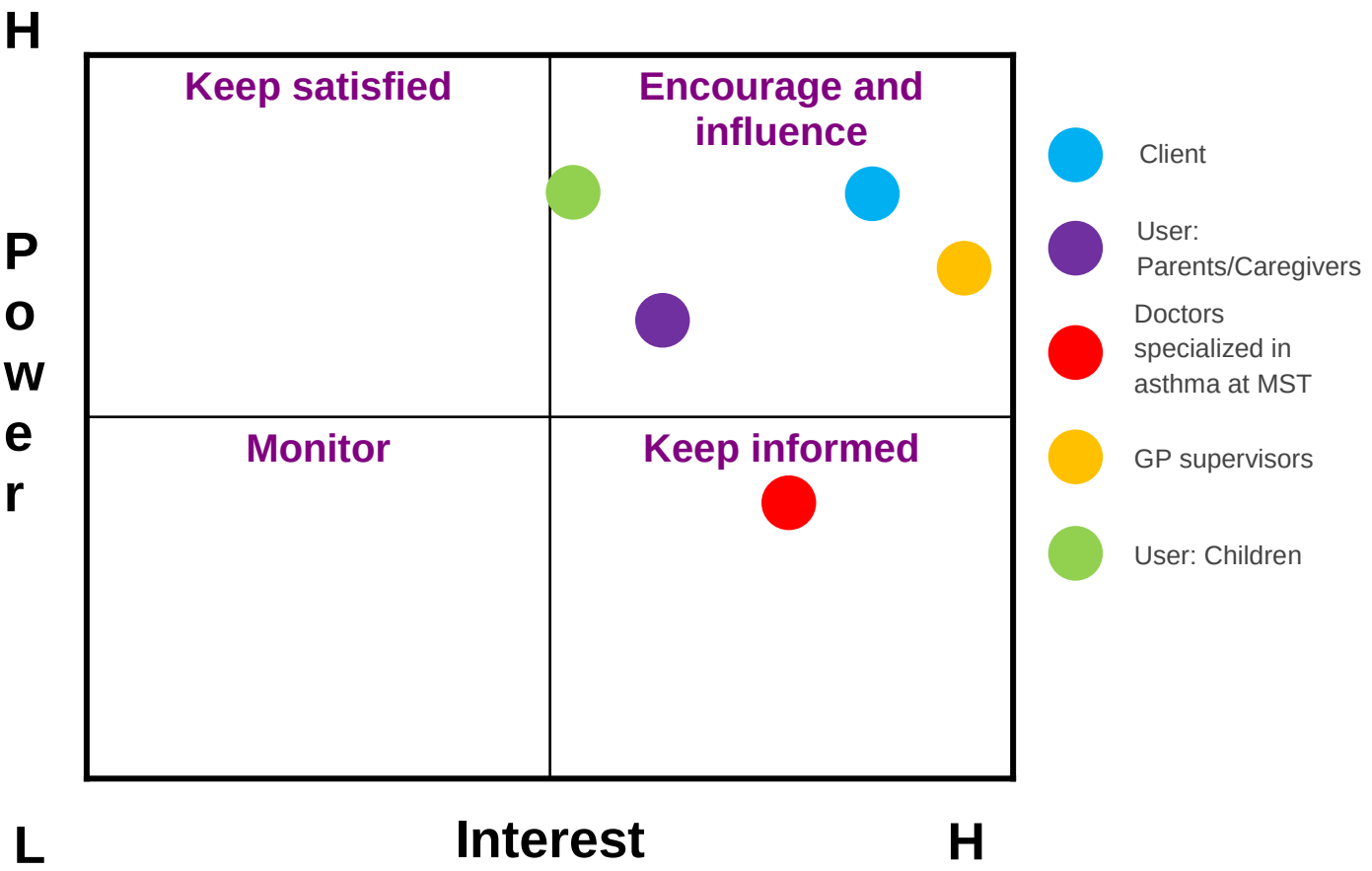


Figure 10: Stakeholder analysis: Power/Interest matrix [27], plotted concerning this graduation project..

In this section each stakeholder will be shortly discussed and the reason why they are plotted where they are is explained.

The client: As can be seen in Figure 10, the client has the most power and interest in the game. This project is specifically made for the client and therefore it is crucial that the client is content with the results. They could actually decide whether this game can actually be played in the hospital. That is probably the most power that they have. Additionally, the client works with asthmatic children at this specific hospital and knows what these children should be educated about. Also, the client has seen children playing on the interactive playground and is more aware of how active this device is used and how the game could potentially help the children (and their parents/caregivers). It is safe to say that the client is very interested in this project as well, knowing that they have actually given me this assignment. The client is plotted in the "Encourage and influence" section, which is probably not completely suitable. The client however should definitely be kept informed and satisfied.

The user: children: The children have the second most power in this graduation project. Children aged 7 and older might be very explorative, however if the game is not inviting enough these children could not play the game as often as required. When the children do not play the game, no matter how spectacular and educative it is, the complete goal of this project will not be achieved. Also, even when the game is played, the children could not take the content of the game seriously which sadly will result in a failed project as well. It is very important that the children are interested in the game, however this depends on the age

group (older children might realize a bit more that it is necessary to be educated about asthma), but also about the game itself. Children do like to learn, especially when it is fun. And the fun factor is very important when deciding whether the children are interested in such a game. On the other hand, the parents, doctors and client are more likely to be interested in the educational factors of the game. The user: children, is plotted in the “Encourage and influence” section of the matrix, which is definitely suitable. The fact that it is very close to the section “keep satisfied” makes a lot of sense as well at the moment. Optimally, the children will be very interested in the game and be in the upper corner next to the client.

The user: parents/caregivers: Although the parents hopefully learn something about asthma as well and stimulate the children to play the game and to be engaged in the game, they do not have as much power as their children. In the end, the most important target group are the children and not the parents. However, educating the parent most likely will improve the asthma control of their child as well. Nonetheless, there is a bigger chance that parents already get these sort of information from the internet, articles that they have read and appointments with the doctor. They have a higher interest in the game, because they want their children to know more about their disease and they also are more aware of the importance of this. Especially when they notice that they have severe asthma symptoms. The user: parents/caregivers, is plotted in the section “Encourage and influence” which is a very suitable place for the user.

Graduation project supervisors: The supervisors of this project do have a lot of interest in this game. They actually have already been working on a previous version (the AIRplay project, see Section 1.1) and are determined to improve this project by implementing the serious gaming element, which is done in this graduation project. They are very much aware of the importance of education and should definitely be informed about this project. Every step of it, to be exact. They do have a lot of power as well, more or less the same way the client has power over this project. A meeting is scheduled with the supervisors every single week and their opinion is taken very seriously. Although they will not be playing the game and their game-experience does not determine the success of the game, they do have a say in whether the game has potential and whether it is suitable to be running on the interactive playground in the waiting room at all. The supervisors of this graduation project are plotted in the section “Encourage and Influence” which is a suitable place for them. In the end they do not need to play the game, however they need to be kept informed and that way they are able to have an influence on the outcome of this graduation project and prevent certain mistakes from happening. Additionally, they need to be persuaded into liking the outcome and have a fair amount of influences on the game itself.

Doctors specialized in asthma at MST: The doctors will not be playing the game as well, therefore they do not have as much power as the user does. However, the fact that they work at the hospital and actual treat the patients, they do have some power in whether or not this game succeeds. At least, they could help by possibly reflecting the information given in the game during an appointment (if this is suitable).Optimally, children could actually go to such an appointment with questions about the content of the game and look at it at a more personal level. Already being informed about some aspects of asthma could motivate children to listen more carefully and ask questions. This is also one of the reasons that doctors are very interested in the game(s). Another reason is again that they are aware of the importance of asthma education. Therefore, they should be informed, which is also the section they are plotted in. They know exactly which sort of information is necessary and in a later state can argue whether this game has positive influence on the child’s behavior.

3.2 Requirements

When designing any game, or any project in general, it is very important to know and understand what the customer wants because in the end, this project is designed for them. "*Once there is a clear set of requirements, it is important to rank them*" [28]. This rank will be very helpful when designing the game. It makes it easier to decide in what order to develop the games and which requirement could be neglected when there is too little time for instance. The MoSCoW method divides requirements in aspects that Must, Should, Could and Would be done. As expected, Must is/are the most important requirement(s) in this list and must be succeeded to complete the game. Should is very important as well, however the game does not rely on it. Requirement(s) that are ranked as Could is/are not as important, but could be an addition as long as it does not affect the game in a negative way. Lastly, the requirements ranked as Would potentially will be a great supplement, but there was not enough time to implement it yet. To conclude, the aim is to deliver all of the must and should requirements. The could and would requirements are nice to have, however they do not influence the overall success of the game. [24]

In the next paragraph, the requirements of the serious game for children with asthma will be ranked concerning the MoSCoW method. These requirements are made concerning the target group, which include asthmatic children at MST aged from 7 to 13. Additionally, the location and technology are definitely taken into account and the client's wishes are included in the list as well. In Section 1.4 a list of requirements was already given in general and were specifically relying on the wishes of the client. However, these requirements include the information that has been found in Chapter 2, consider the Power/Interest matrix described in Section 3.1.1, and are ranked according to the MoSCoW method.

Must:

- ★ The education subject must either be exercise, asthma attack including medication, avoiding triggers or acceptation;
- ★ Strategies from the PSD model must be included in the game(s);
- ★ The game(s) must be able to be played by a child aged 6 to 9 by themselves;
- ★ The game(s) must still be fun even though it is educative, especially since there are children without asthma in the waiting room as well;
- ★ The educational aspects of the game must be implemented according to Section 2.2.1;
- ★ The location of the interactive playground must be taken into account when designing the game, especially since it is located in a hospital;
- ★ The doctors must approve the content of the game;
- ★ The game(s) must be able to be played by a child aged 6 to 9 by themselves, but also playing with their parent(s) s be a possibility;

Should:

- ★ The game(s) and the complete AIRplay project should motivate the children to be more physically active;
- ★ The game(s) should include numerous game characteristics liked by boys, girls or both, including genres such as mastery, competition, destruction, puzzles, emotion, fantasy, discovery, creativity, real-world experience and nurturing;

[28] https://www.projectsmart.co.uk/moscow-method.php, last accessed: 28-04-2018

- ★ When playing with peers, asthmatic children should not feel left out or different when playing the game(s);
- ★ This game should stimulate behavior change for both the children as the parent and thereby improving their asthma control;

Could:

- ★ This project could consist of several games, all educating the children about different asthmatic topics;
- ★ This game(s) could include cooperative gameplay;
- ★ This game(s) could include competitive gameplay;
- ★ The game(s) could include the color blue to trigger happiness;
- ★ The game(s) potentially could motivate the children to be active outside of the waiting room as well by ensuring them that physical activity does not necessarily result in an asthma attack or other (severe) asthma symptoms;

Would:

- ★ The game(s) would save personal data of the children to make the game experience more personal;
- ★ Each of the educational topics will be included when given the time;
- ★ The game(s) would be designed all for specific ages and gender, especially since the interests of boys and girls differ a lot and different ages would like to be addressed differently;
- ★ The game(s) would be connected to the app (made by another Creative Technology student);
- ★ The game(s) would track the activity of the children with the help of a FitBit (as in the AIRplay project);
- ★ Optimally, children will be curious about their disease and actually ask questions during their appointment with the doctor.

3.3 Brainstorming

To start of the brainstorming session a mind map is made, including topics which should be thought about. Most importantly, topics should be eliminated since doing all of them is not possible due to lack of time. The mind map is presented in Figure 11. Next to these keywords, it is also important to remember the opportunities and limitations of the interactive playground. Since these are facts, this is not included in the mind map, but should be remembered at all times while making the concepts.

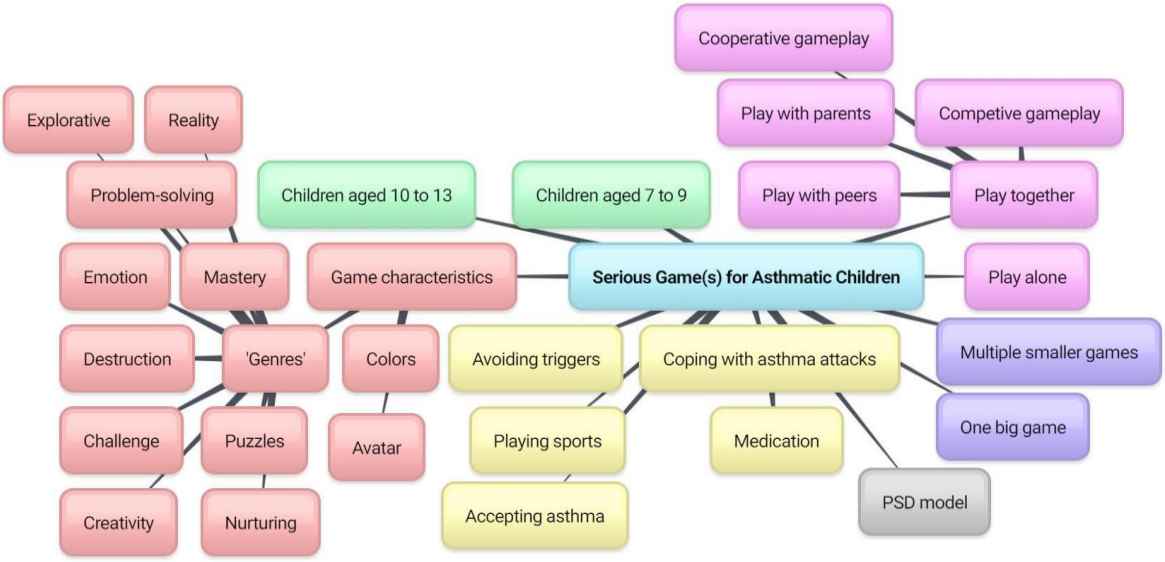


Figure 11: Mind map made about this graduation project (created with bubbl [29]).

3.3.1 Concepts

In the mind map the different topics of which decisions should be made, are given an individual color. In the next section, concepts for this graduation project will be shared. In all of these concepts, a good amount of colors of the mind map will be addressed. Both in the mind map and the following concepts, the PSD model will be considered as well. Oinas-Kukkonen and Harjumaa [52] created four tables in which specific elements are explained which should be implemented in a persuasive system such a this project. These tables can be found in Appendix B [52]. Most of these concepts are not completed yet. Later, certain elements of these games will be combined to create the final concept that will be elaborated, specified and realized.

★ Concept 1

Educational topic(s): avoiding triggers, asthma medication, asthma attack
Amount of players: single player; can possibly be played together (cooperative gameplay)
Age group: 7 to 9
Game 'genres': destruction, nurturing
PSD model: liking
Avatar: yes

Idea: A very cute looking avatar has asthma and tells the player about their allergies. The avatar is in the middle of the screen and the player should try to make sure that the avatar does not have an asthma attack. Multiple allergies will be flying across the screen, some of which should be caught and some of which should be avoided. When too many triggers have triggered the avatar (there will be a health bar somewhere), then it has an asthma attack and the player should help it by giving him medication.

★ Concept 2

Educational topic(s): avoiding triggers, asthma medication, asthma attack

29 https://bubbl.us/, last accessed: 06-05-2018

Amount of players: single player; can possibly be played together (cooperative gameplay)
Age group: 7 to 9
Game 'genres': destruction, nurturing
PSD model: liking
Avatar: unknown

Idea: The idea is the same as the concept 1, however, instead of dodging and catching triggers or different elements. The triggers should be destroyed by jumping on them. The triggers either move a lot or are hiding behind something to make the game a bit more challenging.

★ Concept 3

Educational topic(s): exercise, medication, acceptance, (nurturing)
Amount of players: multiplayer; parent and child (cooperative gameplay)
Age group: 7 to 9
Game 'genres': nurturing, explorative
PSD model: include famous athletes, target
Avatar: famous footballer with asthma (David Beckham?)

Idea: The avatar has asthma again, this time the player will exercise together with the avatar. However, before this is possible, first the avatar should take some medication. The player helps. This probably will be done in the form of a quiz. Together with your parent/caregiver you will be catching a ball. The parent/caregiver will throw the ball and the child (who moves the avatar) has to try and catch it. Finally, the avatar will become tired, however it will not show many symptoms. Some medication might be necessary, nonetheless, this game will show that exercise is still possible without any severe symptoms. The avatar could actually be a famous football player that has asthma, and the catching and throwing game can be made on a football field.

★ Concept 4

Educational topic(s): avoiding triggers
Amount of players: single player
Age group: 7 to 9
Game 'genres':
PSD model: rewards
Avatar: snake

Idea: The game snake with a twist. The player is the snake and should catch some sort of candy to become bigger and dodge the triggers. Each time the player catches the candy, a question or tip about triggers pops up and as in the usual snake, they grow. When they fail in dodging the trigger, they 'die'. A message will pop up, telling them that they need medication, so they will need a break.

Rewards: when the player has reached a specific amount of points by catching the candies, a bonus level will pop up.

★ Concept 5

Educational topic(s): avoiding triggers
Amount of players: multiplayer (both competitive and cooperative)
Age group: 7 to 9
Game 'genres':
PSD model: rewards
Avatar: snake

Idea: Same as concept 4, but then multiplayer. When more than one player is playing, there is only 1 candy at the time on the screen and both of them want to catch it. The largest player wins, so it is competitive gameplay. On the other hand, they should prevent running into each other, because that will end the game, which makes is cooperative as well.

★ Concept 6

Educational topic(s): avoiding triggers, exercise
Amount of players: single player, multiplayer
Age group: 10 to 13
Game 'genres': reality, emotion
PSD model:
Avatar: human

Idea: This game takes place in a house. It is basically sims, but the sim has asthma, because it visualizes the player. Players can easily be added. The player can select certain sports that fit best that will give the player points, but most importantly, you can create their home. Should cats and dogs be added? What kind of curtains,

etc. For each action, points can be earned and with this points games can be opened and played to motivate the player(s) to pick the best options for someone with asthma.

Sources should be included when information is given. For this specific concept, the experiment described in Section 2.1.1.

★ Concept 7

Educational topic(s): exercise, medication, avoiding triggers
Amount of players: multiplayer (possibly single player)
Age group: 7 to 9
Game 'genres': explorative
PSD model: include famous athletes
Avatar: famous athlete

Idea: Olympics game as has also been done one time by Mario. The player can play archery or jump on a trampoline in should try to beat previous players or just scored that were already programmed in the game beforehand. Playing on the trampoline would mean that the avatar will jump and the player has to follow lines that are on the screen to make them jump perfectly. They will receive a medal if they end up first, second or third place. To implement the educational aspects, maybe a cat could walk by suddenly, making the contestant fall. A warning sign comes up once this starts, and tells you to get rid of it. Then maybe a quick story as well about more triggers and these will come by as well. However, the jumping continues as well so you must be quick. They should use medication. Education about exercise can definitely be implemented as well in the form of a quiz. Again, warming up before hand, etc.

★ Concept 8

Educational topic(s): exercise
Amount of players: multiplayer
Age group: 7 to 9
Game 'genres': explorative,
PSD model: include famous athletes
Avatar: famous athlete

Idea: Just make a game that really focusses on famous athletes with asthma. Play football with David Beckham, go swimming with Tom Dolan, etc. Especially acknowledge their successes so children will be amazed by the opportunities even though they have asthma.

★ Concept 9

Educational topic(s): unknown
Amount of players: single or multiplayer (competitive gameplay)
Age group: 7 to 9 / 9 to 11
Game 'genres': active
PSD model: unknown
Avatar: unknown

Idea: Not a complete idea, however this concept is about giving the player the possibility to compete against another player or the computer. The maximum amount of players is six. If three players are playing, they will be playing against three computer players. If two players are playing, they can decide whether they want to compete against each other or against the computer. The player should also have the opportunity to decide the difficulty level of the computer players and the amount of computer players they want to compete against.

★ Concept 10

Educational topic(s): unknown
Amount of players: single player, multiplayer (cooperative)
Age group: 7 to 9
Game 'genres': puzzle
PSD model: unknown
Avatar: unknown

Idea: Again, this is not a complete idea. There is a timer. Within these amount of minutes or maybe even seconds, the player should solve a puzzle. When a puzzle is solved a message is given. Some sort of asthma tips and a physical game is unlocked.

★ Concept 11

Educational topic(s): unknown, could include all of the topics

Amount of players: single player or together with your parent/caregiver
Age group: 7 to 9
Game 'genres': explorative, reality
PSD model: personalization, tailoring
Avatar: looks like themselves

Idea: This game actually takes place in the waiting room of the hospital. The goal is to make it look alike and certain elements of the waiting room can be clicked and then a game, quiz or story pops up. Icons already show whether it is a single player game or multiplayer.

★ Concept 12

Educational topic(s): medication
Amount of players: single player
Age group: 7 to 9
Game 'genres': explorative
PSD model: unknown
Avatar: unknown

Idea: A small game in which the avatar has an asthma attack and the player need to quickly find the medication. However, this is not as simple as it might sound. The medication of the avatar is at the end of a maze and multiple obstacles will make it more difficult for the player to get to it.

★ Concept 13

Educational topic(s): medication, triggers
Amount of players: single player
Age group: 7 to 9
Game 'genres': explorative, active
PSD model: unknown
Avatar: unknown

Idea: Again a small game, and it takes place in a maze again, just like concept 12. However, now there is not necessarily an end point. Instead the player has 3 lives and it should avoid triggers and catch medication.

★ Concept 14

Educational topic(s): medication
Amount of players: multiplayer
Age group: 7 to 9
Game 'genres': explorative, active
PSD model: unknown
Avatar: unknown

Idea: Continuation of concept 12: instead of avoiding triggers, a second player could also make the game more difficult for the first player by trying to catch them. There should be some live meter that will go down every millisecond the two players touch. And after a total of 3 seconds the first player has lost. However, the first player can win by catching all the medication.

★ Concept 15

Educational topic(s): unknown
Amount of players: single player
Age group: 7 to 9
Game 'genres': explorative, active
PSD model: unknown
Avatar: unknown

Idea: Flappy Bird; do not touch the obstacles, but catch the coins. The further you get, the faster it moves.

★ Concept 16

Educational topic(s): unknown
Amount of players: single player, two players (competition)
Age group: 7 to 9
Game 'genres': active
PSD model: rewards
Avatar: unknown

Idea: Instead of running across the whole screen to catch coins the player simple stands on one side of the field and the coins come their way. Some should be avoided and some should be caught. If there are 2 players then there will be coming coins from two sides of the screen, one for each player. The players will play against each other, but also against previous players by trying to beat them and get the high score.

★ Concept 17

Educational topic(s): unknown
Amount of players: single player
Age group: 7 to 9
Game 'genres': active

PSD model: praise
Avatar: unknown

Idea: This could also be included in concept 7. The player has to run a 1000 meters as fast as possible. They should run several circles or rectangles. Where they have to run should be very clear, but changes multiple times to keep the player's attention. After about 500 meter a message pops up telling the player that they are halfway and are going really fast or encourage them to go a bit faster. Again, some elements should be dodged and some should be caught.

★ Concept 18
Educational topic(s): should include all topics
Amount of players: maximum of 4
Age group: 7 to 9
Game 'genres': nurturing, reality
PSD model: rewards, reminders
Avatar:

Idea: More broader idea, that could include concept 1 and 2 as well. The avatar can be picked themselves, it can even wear cute clothing, however, coins are needed to be able to get this. Additionally, medication and (healthy) food is not free either. You basically need to play mini games (concept 1 and 2 for example) to earn coins and take care of your animal.

Reminders will be given, basically helping the player remember that their avatar needs medication.

★ Concept 19
Educational topic(s): medication
Amount of players: 1 to 4 players
Age group: 7 to 9
Game 'genres': active
PSD model: unknown
Avatar: unknown

Idea: Takes place in the hospital or at least where a lot of asthma patients are. They are just quietly sitting, but each time an inhaler pops up next to them it means that they need their medication (inhaler specifically this time). The player that has helped the most people wins.

★ Concept 20
Educational topic(s): medication
Amount of players: 1 to 4 players (competitive)
Age group: 7 to 9
Game 'genres': active
PSD model: unknown
Avatar: unknown

Idea: Continuation concept 19. Instead of just walking across the inhaler that pops up, you first need to get the inhaler from somewhere else on the screen.

★ Concept 21
Educational topic(s):
Amount of players: two players (optimally, child and caregiver)
Age group: 7 to 9
Game 'genres': active
PSD model: rehearsal, tailoring, tunneling
Avatar:

Idea: Continuation of concept 19. Instead of simply needing to run to the inhaler to give the medication, the children will also be taught how to take their medication. A little window will appear and instruction will be given about holding your breath for a couple of seconds and how many puffs you should take. Maybe a peak flow meter can make an appearance as well.

★ Concept 22
Educational topic(s): medication, includes more topics
Amount of players: two players (optimally, child and caregiver)
Age group: 10 to 13
Game 'genres': active, reality, explorative
PSD model: rewards, tailoring, tunneling, rehearsal
Avatar: includes a famous athlete, but not all the time

Idea: Continuation of concept 19 and 20. Maybe this game could include more than just medication. Question marks could pop up as well and the person has a question about asthma that

should be answered. Someone is bored and the player has to entertain them by playing a physical game (exercise). The game will give information why exercise is healthy and maybe this will be told by a famous athlete. Maybe they are wondering what they are allergic for and the player should do a test to find out. Answers to the questions should include sources.

It is a single player game, however, multiple people can think of an answer to these questions and they could go in turns since helping each person does not take a lot of time. For this concept in particular it would be nice to include the parent/caregiver. Sometimes a second player might be needed: by doing the allergy test or taking medication. Therefore, the best second player would be the parent or caregiver of the child.

★ Concept 23

Educational topic(s): unknown, as many as possible
Amount of players: 2 or 3 players
Age group: 7 to 9
Game 'genres': active, emotion, tailoring
PSD model: liking
Avatar: unknown

Idea: The avatar is in the middle and the player has to give the avatar what they are asking for as quick as possible. The avatar might say something like "This makes me cough" or "This helps me breath" and the player needs to look for these things, step on them, and walk to the avatar to give it to them. 2 or 3 players should play the game, because this makes competition possible to motivate the player to play faster and try to win by giving the most subject to the avatar. If the wrong object is brought to the avatar by one of the players, the avatar will become sad. The right object will make the avatar happy.

★ Concept 24

Educational topic(s): as many as possible
Amount of players: up to 6
Age group: 7 to 9
Game 'genres': problem-solving, active, challenge
PSD model: rewards, suggestions, praise
Avatar: someone with asthma

Idea: inspired by tower defense. The triggers walk across the screen, following the path and the user needs to build the towers to destroy the triggers. It is most important that the triggers do not get to the end of the path, because there is the avatar who has asthma. The player does not necessarily destroy the triggers. They should get a bone for example to distract the dog and a mouse to distract the cat. Once the trigger is distracted or captured they will disappear from the screen. A big difference between this game and tower defense is that the 'tower' can only be used once. It could be played with multiple players, than more triggers will appear at once.

★ Concept 25

Educational topic(s): as many as possible
Amount of players: one child and their parent/caregiver
Age group: 7 to 9
Game 'genres': puzzle
PSD model: rewards
Avatar: unknown

Idea: Inspired by memo: when the player has found two the same pictures, they will get a question about it that they should answer. If they got the question wrong, all the cards will be shuffled. If they answer the question correctly, the found pair will disappear. In the end the player wants to get rid of all the cards. The amount of minutes the player needs to finish the game will be kept up. Finally, they will be able to compare their own score with the score of their peers.

★ Concept 26

Educational topic(s): avoiding triggers
Amount of players: 1
Age group: 7 to 9
Game 'genres': active
PSD model: rewards, praise
Avatar: unknown

Idea: A very short mini game in which the player has to run across the playground and dodge the

triggers. Each trigger that is touched will add 0.3 seconds. The quicker the better, because the amount of seconds he or she needs to run across the screen will be kept up and will be send to a high score when wanted. The player should be education about triggers beforehand.

★ Concept 27

Educational topic(s): avoiding triggers, medication
Amount of players: single player
Age group: 7 to 9
Game 'genres': active
PSD model: rewards, praise
Avatar: unknown

Idea: Continuation of concept 26: to reduce their time by 0.2 second for each object, they could try to catch some medication or healthy food. In this game the player will be educated beforehand about triggers and medication.

★ Concept 28

Educational topic(s): unknown
Amount of players: single player
Age group: 7 to 9
Game 'genres': challenge
PSD model: praise
Avatar: unknown

Idea: Play the big piano, make popular songs that they know. In the end they have caught good and bad objects concerning their asthma and they should divide it. There is no good or wrong, because it should be done on a personal level.

★ Concept 29

Educational topic(s): as many topics as possible
Amount of players: 1 to 3 players (including at least one child and one caregiver)
Age group: 10 to 13
Game 'genres': emotion, reality
PSD model: praise
Avatar: child, customized

Idea: Inspired by a game named: secretly kissing. The player is attending an asthma class. The entire time, the game will educate the player about asthma, however at the same time they should try to kiss secretly as well either with a second player or a computer player. Possible, another player (the parent/caregiver) will decide what the educational subject is. Each time the player gets caught kissing, they need to answer a question about asthma. If the player fails to answer the question, the game is over.

Little hearts will form in the upper right corner. Once one heart is filled the player has earned it and a message will pop up that they have done a good job, but if it is only filled halfway, not kissing can make the heart 'empty' and the player(s) will need to start over. Maybe these hearts can be used to change your avatar.

★ Concept 30

Educational topic(s):
Amount of players: 2 players
Age group: 7 to 9, 10 to 13
Game 'genres': mastery
PSD model: unknown
Avatar: child, unknown

Idea: Beforehand each player gets 5 questions they should answer. If they answer all of them correct they will get 5 chances to destroy the castle of their opponent, if they have 4 correct answers then 4 chances, etc. The players basically want to destroy each other's castle. They can aim the canon by standing somewhere on the playground. After about 5 seconds the cannon will fire and hopefully destroy the castle of the opponent.

3.4 Further Elaborated Concepts

30 concepts have been presented in the previous section. As explained before, certain elements of this games will be combined to create a game that suits this graduation project the best. With the input of the supervisors of this project, these 30 concepts have been transformed into 4 potential games. These 4 games will be listed here and some additional information, as well as some sketches, and these ideas will be shared with the client of this project.

Concepts that did not make the list at all were either impossible or too difficult to make for on the interactive playground, were too complex for children to understand quickly or some of the elements are used but in another game as well. Anyways, hereby the 4 potential concepts will be presented:

★ Memo with famous athletes (combination of concept 8 and 25)
Age group: 7 to 10

Figure 12: A digital sketch of memo with famous athletes [30,31].

Memo is a game played by a lot of children, however the asthma version will help children accept their disease. Each card has a famous athlete on its back, in Figure 12 you can already see David Beckham on two of these cards. Each time the player finds a pair, they will get 5 points. To explain to the children that being a famous athlete is possible even if you have asthma, there will be some sort of pop up with awards and information about each player when a pair has been found.

An addition to this game could be that they have to ask a question every once in a while, as explained in concept 25. Nonetheless, this game feels complete without this addition as well. Potentially,

[30] https://www.nieuwsblad.be/cnt/dmf20130516_00585117, last accessed: 09/05/2018
[31] https://blog.animaker.com/introducing-animated-sports-characters/, last accessed: 09/05/2018

children will not feel sad about their disease anymore and feel like they cannot exercise after they have played this game and have seen that playing sports at high level is very much possible.

This game can be played alone and beat other players by finishing the game as fast as possible. Or together, competing against each other and against the clock.

★ Decorate the house (concept 6)
Age group: 7 to 9

Figure 13: A digital sketch of decorate the house [32,33,34].

In this game (see Figure 13), the player needs to decorate the house for someone with asthma / for themselves. In this case the person with asthma is basically allergic for everything which could trigger asthma. Making the game as much as a challenge as possible. The player should stand on top of the cues for about three seconds and then multiple options for the player will pop up. Do they want an oak tree or a pine tree? These options are associated with a certain amount of points. Does the chosen tree consist of pollen then the player will get minus points for example. The sad avatar in the corner will show how the chosen options influence the asthma client. When, for example buying a dog, he could be fine. However, when this dog is placed in his room he will start crying, coughing and he will look very tired because he does not get any sleep. Where should the dog live, how many times should they be washed? These are important aspects to consider in real life for asthmatic people, but also in this game.

The player decides what the aim of the game is. It could be to make the avatar as happy as possible and decorate the house asthma friendly. On the other hand, the player could also decide to make his life miserable by adding carpeting and terrible sheets.

[32] https://teruchan716.deviantart.com/art/sad-spongebob-393659134, last accessed: 11/05/2018
[33] https://nl.pinterest.com/pin/372532200403388455/, last accessed: 11/05/2018
[34] http://modthesims.info/d/527281, last accessed: 11/05/2018

On another note, it could be smart to not display the complete house at once. Start by displaying the living room and then insert arrows in certain directions to go to another room. Otherwise, the rooms will be displayed to small on the playground.

★ Serving game (combination of concept 19, 20, 21 and 22)
Age group: 7 to 11

Figure 14: A digital sketch of the serving game [35,36,37,38,39,40,41,42,43,44].

The serving game (see Figure 14) comes with tons of possibilites. As you can read in concept 19, 20, 21 and 22, it can be made as easy, but also as complex as someone wants. The most important aim of all of these possibilities is that all of these popups should be solved as quickly as possible. The more players there are, the more questions and complaints there are.

The easiest version of this game is to play it with multiple people and each time a question, comment of need pops up, the player needs to run towards it as quick as possible. The player who has helped the most people wins the game (concept 19). However, this is not really a serious game and neither is concept 20. To make the game educational, this game should be played by one player instead. This one player needs to help all of these patients as quickly as possible. Not to win, but to make sure that the patients do not become angry and leave the waiting room. At the end, the goal is to help as many patients as possible, before the player has no lives left (the penguins in the right corner). Instead of only standing on top of the pop up, the player actually needs to answer their questions, needs and comments. This way

[35] https://www.pinterest.ca/pin/649785052457871736/, last accessed: 10/05/2018
[36] https://seeklogo.com/vector-logo/299130/facebook-angry-emoji-emoticon, last accessed: 10/05/2018
[37] https://www.shareicon.net/face-happy-smiley-smile-positive-excited-welcoming-887026, last accessed: 10/05/2018
[38] http://www.emoji.co.uk/view/8047/, last accessed: 10/05/2018
[39] https://www.iconfinder.com/icons/45395/asthma_inhaler_icon#size=256, last accessed: 10/05/2018
[40] https://nl.pinterest.com/pin/800937114952214525/, last accessed: 10/05/2018
[41] http://www.imagefully.com/cartoon-family-parents-wallpapers/, last accessed: 10/05/2018
[42] http://www.stickpng.com/img/at-the-movies/cartoons/caillou/caillou-sitting, last accessed: 10/05/2018
[43] http://nickjrcharacters.blogspot.nl/2014/01/wordgirl-png.html, last accessed: 10/05/2018
[44] https://nl.pinterest.com/pin/367536019574522591/, last accessed: 10/05/2018

patients are instructed for instance on how to take their medication and play physical games with the characters. For this concept specifically, it is important to remember not to make the game too complex.

★ Dodge and catch game (combination of concept 1, 16 and 17)
Age group: 6 to 9

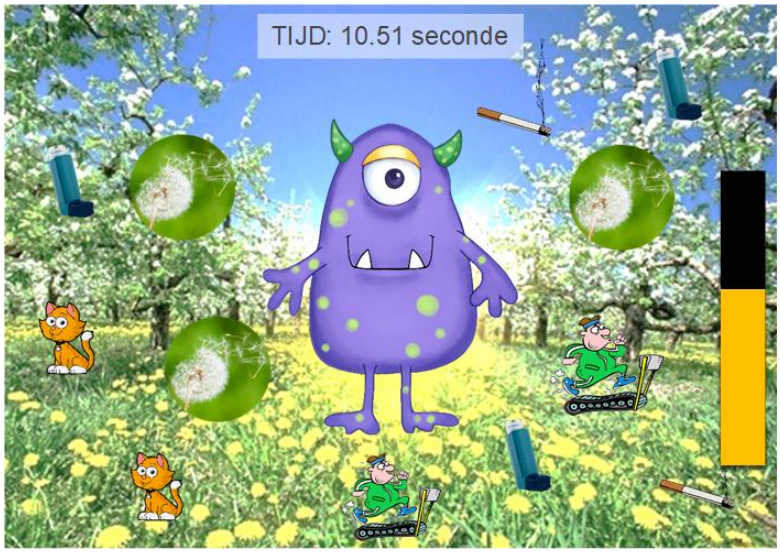


Figure 15: The first digital sketch of the dodge and catch game [45,46,47,48,49,50].

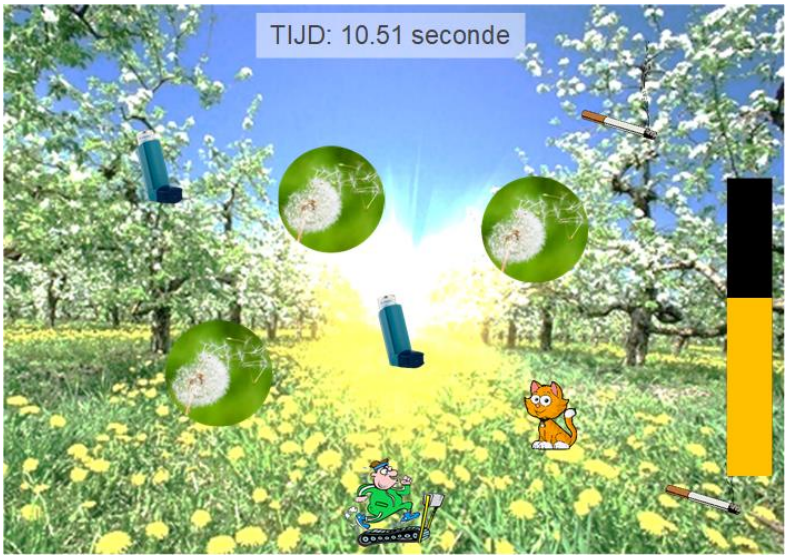


Figure 16: The second digital sketch of the dodge and catch game [42,43,44,45,46].

[45] https://nl.pinterest.com/pin/244883298462805639/, last accessed: 11/05/2018
[46] http://www.acupunctuurbrigittearts.nl/workshops-tai-chi-qi-gong/lente-hout/, last accessed: 11/05/2018
[47] https://openclipart.org/detail/213120/colour-cigarette, last accessed: 11/05/2018
[48] https://mycanadianpharmacyteam.com/ventolin.html, last accessed: 11/05/2018
[49] https://www.jamiesale-cartoonist.com/free-cartoon-cat-vector-clip-art/, last accessed: 11/05/2018
[50] http://www.al-ko.com/pl/technika-powietrzna/al-ko-pure-sterylizator-powietrza, last accessed: 11/05/2018

There are two versions of this game (see Figure 15 and 16), however the player will learn the same educational aspects. In the first game the player needs to make sure that triggers do not touch the avatar by destroying them (standing on top of them). Each time a trigger does touch the avatar, the right medication should be taken. The health bar will slowly lower until it is completely empty and the game is over.

The second game looks like temple run. The elements actually come the player's way. And instead of destroying the triggers, the player should avoid them. Just like in real life. In the end, for both games, the goal is to play the game as long as possible.

There are numerous additional features that could be included in such a game. For example, especially in the second version competitive gameplay this is possible. Elements could come from multiple directions. Each player should pay attention to one direction. Another example would be that taking medication could actually prevent certain triggers from showing asthma symptoms. For this concept, it is important to dig a little bit deeper in how exactly asthma medication works.

3.5 Final Decision

As written before, the final four concepts were discussed with a doctor (the client of this project), who mostly focused on the content of the game, and an interactive playground 'specialist', who could critize on the playground abilities to actually create the game. The decision was made quite easily during this conversation. The final concept that will be worked with is the dodging and catching game (concept 4 and 5). Children tend to like these active games way more. Additionally, one of the requirements of this project (Section 1.4) actually stated that this game should motivate children to be physically active outside of the waiting room as well. Although this is not a must have, it is a great addition to the game.

Also, it has been decided that, if there is enough time, the memory game with famous athletes will be realized as well. Even though this game is not as active as the dodging and catching game, it is believed that this game has potential in helping the children accept their disease drastically.

4. SPECIFICATION

In the previous chapter, the final decision has been made concerning which games or game will be realized during this graduation project. Out of 30 concepts two concepts have been chosen to further elaborate. As mentioned in the previous chapter, the main focus will be on the catching and dodging game. The main reason behind this is because this sort of active game has been found way more successful on a playground than a card game such as memory. Additionally, physical activity is a very crucial part of self-management. The catching and dodging game invites the children to run more than the memory game. However, the idea behind the memory game has a lot of potential to help the children accept their disease by showing successful athletes and even visualizing their highlight by implementing video, and should therefore not be forgotten.

Nonetheless, this chapter will be based only on only one concept, which is the catching and dodging game, knowing that due to lack of time, the memory game sadly cannot be realized. As a reminder, a short summary of the game will be given. Secondly, every main element which should be implemented in the game will be explained and examined individually. Additional aspects will be discussed to make the game more challenging, entertaining and artistic. This chapter is mostly based on Schell's [23] four aspects of a game: story, mechanics, aesthetics and technology. The goal of this chapter is to present a clearly specified idea of the game.

4.1 Summary of the Game

The catching and dodging concept has already been explained shortly in Section 3.3 and Section 3.4. This section will tackle this subject one more time, but this time in more detail. The overall goal of the game is to protect the monster, who is the main character of the game and is named Eldub (see Figure 17). Therefore, the name of this game is "Eldub's Asthma Adventure". Numerous negative triggers will appear and move towards this little creature. The player should destroy the triggers before it reaches Eldub or else his health will go down. The triggers will be destroyed when the player runs towards it and bumps into it. However, there is a twist.

Figure 17: The main character of the game. A cute little monster named Eldub [45].

Since right now, the health of Eldub can only go down, there should be a way to increase his health as well. For that matter, the inhaler and physical activity will be introduced. The exact meaning of these triggers will be explained in Chapter 5, however, an inhaler and exercise icon will fly across the screen, exactly like the mentioned negative triggers. For Eldub's health to go up, sometimes these triggers should not be destroyed. The player should actually dodge these icons to make sure that the medication or exercise icon reaches Eldub. This will result in him taking his medication and doing some exercise, which could actually increase his health when it is done at the right time.

Potentially, the influence of these positive and negative triggers on Eldub will influence the player and will make them realize the importance of them. By avoiding asthma triggers, asthma symptoms can be reduced drastically, therefore it is of great importance that the children and their parents are aware of this fact. Additionally, the importance of medication and physical activity is underestimated and the goal is to promote both of these aspect in the game. In Section 3.4, two version of this game were mentioned. However, the actual game will be focusing on the first version.

The game will consist of two different levels, but it is possible to expand the game in the future. It would be great to implement as many triggers as possible spread over these levels. Additionally, more differences should be existing in the game. For example, the second level should be a bit more difficult than the first level. In Figure 18 an overview is presented in which possible adjustments are discussed. This mind map was made to get a clear view of these possibilities. Afterwards, the fitted ones should be implemented in this specific game.

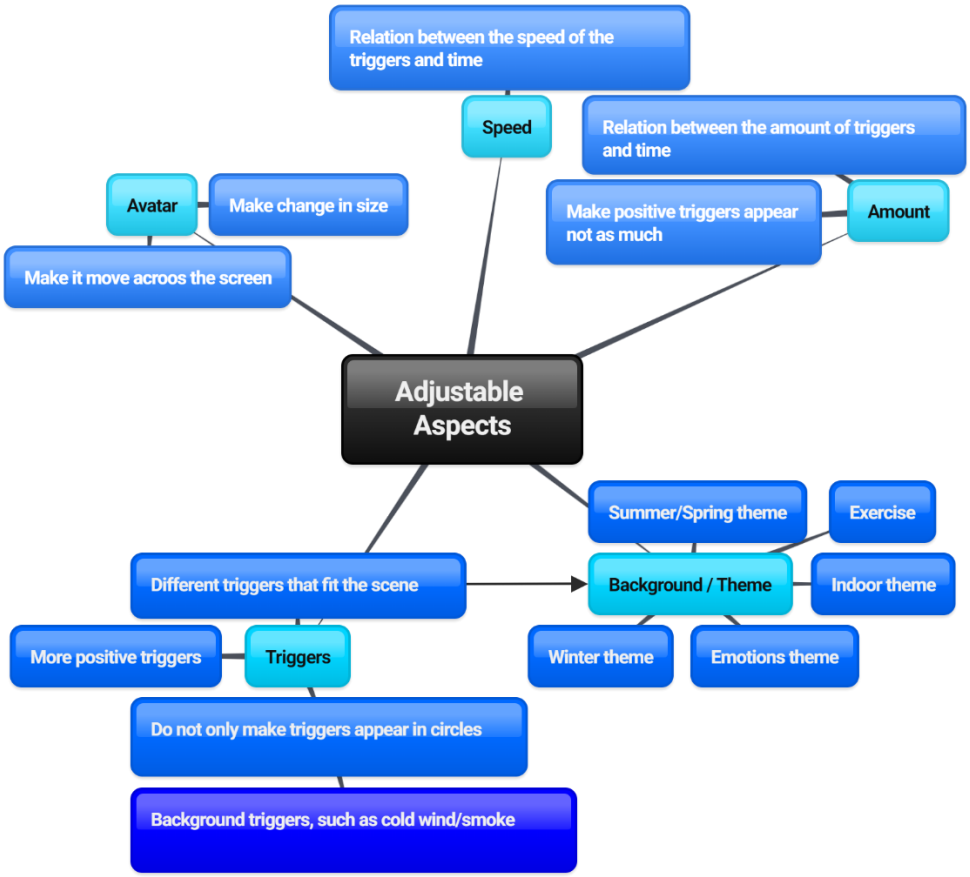


Figure 18: An overview of possible adjustments that can be made to the overall idea (created with bubbl [29]).

4.2 Mechanics

Before the actual game can be made, it is important to acknowledge and consider every single element that is wished for in the game individually. In the following paragraphs, each different aspect of the game will be described and requirements of these aspects will be listed. Additionally, the design of these elements is given in this chapter. As a side note, adjustments have been made to the different elements with Paint.NET [51], which is a graphics editor that given more than enough opportunities to smoothly make the necessary changes, such as changing the colors, adding circles with different outlines as will be noticed later in this chapter and Chapter 5.

Game character

‘

The game character (see Figure 19), Eldub, is very important in this game. It should be the goal of the player to take care of him. Negative triggers should be caught before it reaches Eldub and certain elements should be avoided so it can actually reach him. The design of the game character as shown in Figure 19, is chosen based on two reasons. Firstly, the game character should be cute and attractive to both boys and girls. Secondly, the user should not possibly be allergic to the game character. This was the reason that a cute dog or a horse were considered, but not chosen to be used in this game. The children that will play this game could be triggered by seeing these animals, because they are not able to have them due to their disease.

Figure 19: the original monster, previously shown in Figure 17 [45].

Score

A score should be implemented to provide feedback for the user. Adding this feature is also important because children like to compete as mentioned in Section 2.1.1. Being able to remember their score and try to do better next time potentially motivates the user to keep playing the game.

[51] https://en.wikipedia.org/wiki/Paint.net, last accessed: 20-06-2018

Health/Happy bar

A health/happy bar should be added to the game to provide feedback, but also to end the game. Meaning that when the health bar is at 0% the player has lost and could try again. The design of the health bar is shown in Figure 20.

Figure 20: The design of the Health/Happy bar [52].

Besides the health bar and the score, more feedback should be given to motivate the children. "*The best way to help humans improve their performance is to provide feedback"* [53].

Timer

To make sure that the game will not last forever, a timer is implemented in the game.

Positive and negative triggers

As already explained in section 4.1, it is necessary to both have positive and negative triggers. An overview of the triggers that can be found in the game is shown in Figure 21-30. Elements that will pass by and move towards Eldub include: an inhaler, exercise, cats and dogs, cigarettes, pollen, dust mite, strong odor, a cold, cold air and smoke. It is very sad that the game character is allergic to all of these triggers, however it is the best way to show the player examples of which triggers they could be allergic to and which could influence their asthma. These triggers were chosen based on the research that has been done in Section 2.1.1.

[52] http://pluspng.com/free-png-emotions-3621.html, last accessed: 16-05-2018

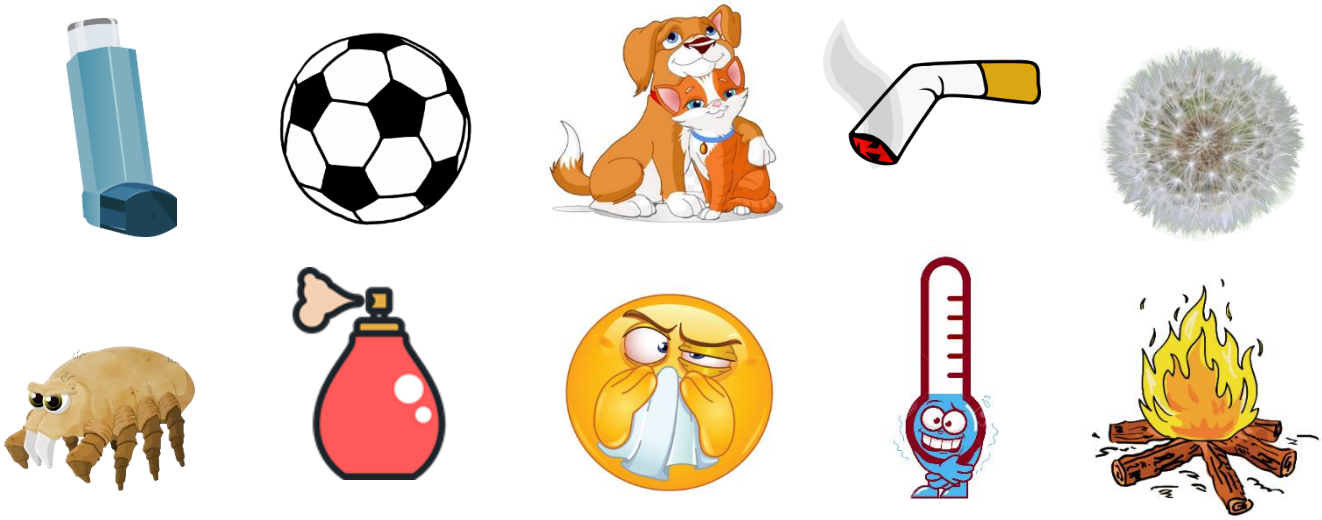


Figure 21-30: Negative and positive triggers [53,54,55,56,57,58,59,60,61,62].

These triggers should be self-explanatory. Additionally, the design should help children in understanding which trigger is bad or good for you. Also, it should be designed in such a way that it is visible on the interactive playground and easily programmable in Unity.

4.3 Aesthetics

In this section the aesthetic of the game will be discussed briefly. The overall look of the game is very cartoonlike. This decision was made based on two reasons. The first one being that children are very familiar by this sort of design from watching cartoons and reading comic books [54]. Additionally, sometimes children are just in desperate need for something fantastical and unrealistic to escape the real world [63]. As mentioned before in Section 4.1, when a system is visually attractive for users it is more likely to be persuasive. And although this is not the only reason that attraction to the game has been found important, it does play its part. There is one exception to this cartoonlike design. The picture that represents the pollen

[53] https://www.nrshealthcare.co.uk/articles/condition/asthma, last accessed: 16-05-2018
[54] https://www.martin-missfeldt.de/kunst-bilder/ausmalbilder-malvorlagen/fussball.php, last accessed: 1705-2018
[55] http://www.clker.com/clipart-2958.html, last accessed: 17-05-2018
[56] https://www.kisspng.com/png-scottish-fold-dog-puppy-kitten-clip-art-cartoon-pi-185462/, last accessed: 17-05-2018
[57] http://d-ramirez.com/graphic-design/, last accessed: 17-05-2018
[58] http://www.stickpng.com/img/nature/flowers/dandelion/dandelion-seed, last accessed: 17-05-2018
[59] https://www.shareicon.net/tag/perfume?&s=flat&p=2, last accessed: 18-05-2018
[60] https://nl.pinterest.com/pin/320177854743076856/, last accessed: 18-05-2018
[61] https://www.123rf.com/photo_51511580_stock-vector-hot-and-cold-cartoon-thermometers.html, last accessed: 18-05-2018
[62] https://www.dreamstime.com/royalty-free-stock-photo-campfire-image24369415, last accessed: 18-05-2018
[63] https://rizzitrinidad.wordpress.com/2011/08/06/three-reasons-why-children-like-watching-cartoons/, last accessed: 20-06-2018

is actually not cartoonlike. Nevertheless, this seemed to be the best option in this specific case. In Figure 31-33 an overview of pollen will be shown, all cartoonlike. These picture did not look very self-explanatory, which is crucial. Every picture should give a clear meaning of what they represent, this is at least the goal. The second reason for the design is that the bright colors will make the contrast between elements more visible, which is especially important when projecting it on the ground. As mentioned before in section 2.1.2, the color of the floor and the amount of light that is in the room should not be forgotten for the best results. Since the color of the floor in the waiting room is dark blue, brighter colors will be easier to be seen. Another reason as of why the cartoonlike look was chosen is because it is more appealing to the target group.

In Chapter 2, the color blue was named as a happy color. And therefore, it was decided that this color should be implemented in the game. The first level was made with a very obvious blue background. The second level however had to present a much darker scene. Therefore the color is not as well presented in this scene, nonetheless it has still not been forgotten. The specific pictures were chosen based on their looks and similarities amongst each other. The snowman and flowers have been added to make the scene a bit more entertaining. However, it was taking into account that meaningless elements should not be too distracting from the actual game by making them small and static.

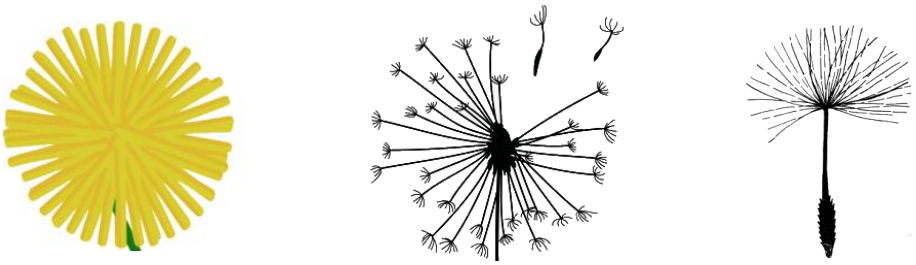


Figure 31-33: Cartoonlike pictures of the dandelion (pollen) that are either too small, too black or do not look like what it should represent [64,65,66].

4.4 Technology

The game will be projected on the interactive playground that is located at the waiting room of MST, which has already been mentioned various times. A briefly detailed description was given in Section 2.1.4. However, what has not been mentioned before is the program which will be used to design the game. This program is named Unity. Unity calls itself "*the ultimate game development platform*"[67] that has been around for almost 13 years [68]. It is not very useful to describe the program in detail, however, it gives the opportunity to design both 2D and 3D games and these games should be programmed in C# and JavaScript.

[64] http://www.clker.com/clipart-310200.html, last accessed: 17-05-2018
[65] https://pngtree.com/freepng/cartoon-dandelion_3137034.html, last accessed: 17-05-2018
[66] http://www.realcurriculum.com/scopecurriculum/support/seeds.htm, last accessed: 17-05-2018
[67] https://unity3d.com/, last accessed: 05-06-2018
[68] https://en.wikipedia.org/wiki/Unity_(game_engine), last accessed: 05-06-2018

5. REALIZATION

In Chapter 4 the game has been specified and elements that are wished to be implemented are explained clearly in detail. In this chapter the focus will be on the next phase of this graduation project, which is the realization phase. In the realization phase the actual game will be made that is designed for children with asthma. This chapter will include a very precise explanation on how this game came to be, how the specifications have been realized, and will contain pictures that have been taken of the game. Firstly, six different stages will be addressed. Within these stages, screenshots of the games will be implemented and pictures of the interactive playground will be shared. Also, the wishes that were presented in the specification chapter will be addressed. Secondly, a summary of these phases will be given and as well as an explanation on how these phases led to the first version of the game. Lastly, an overview will be given of the game itself and which information was used from Chapter 2.

Another important remark is that a great part of the code was already written by Robby van Delden, namely the code to connect Unity with the interactive playground and to track the players. This game has been made in a project including the previous mentioned code.

5.1 Process: 7 Stages

Stage 1: Implementation of the design

The very first step of the realization, after unity was installed, was to implement the design that has been copied from the internet and edited with Paint.NET (see Figure 34) onto Unity. Every design element was already introduced in Chapter 4. However some features were added to these pictures. As mentioned in Section 4.2, it is important that the triggers are easy to program with, visible on the interactive playground and self-explanatory. Every trigger has been transformed into a circle to make it easier to work with in Unity. Additionally, a trigger is either surrounded by a red, green or 'blue' circle. This circle indicates whether the trigger is negative or positive. The original circle surrounding the exercise element is blue, because, as will be explained later, this can be both a positive and a negative trigger. In Figure 36-46 the new trigger elements are displayed. These images were simply converted to a material folder in Unity as can be seen in Figure 35. Every material was converted to a sprite. The alien was positioned in the middle of the screen and the triggers were simple located on random, but visible positions, knowing that these will be forgotten later in the process anyways. The background was simple dragged into the correct position and Figure 47 was slowly appearing. This has later been done for the second level as well (see Figure 48).

Figure 34: An screenshot of Paint.NET

Figure 35: An overview of the implemented images in Unity in the Materials folder and the inspector.

Figure 36-46: The final version of the design of the triggers[51,52,53,54,55,56,57,58,59,60].

As mentioned in section 4.1, there are two levels in this game at the moment. Multiple wishes have been drawn up, including that as many triggers as possible should be implemented in the game. This is why the decision has been made to create a level that takes place at different times in the year. In this way, seasonal triggers can make an entrance in the game.

★ Environment level 1

The first level should present a sunny spring day. This was mainly chosen to make it possible to include various triggers. This scene includes pollen (the seasonal, and also very common trigger), dust mite, cigarettes and dogs and cats (see Figure 47). Some of the triggers, such as cigarettes, might not fit only this specific scene. However, hopefully it does make sense. Especially when comparing it to the triggers that are implemented in the second level.

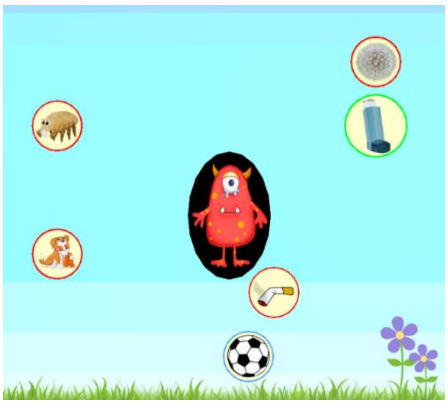


Figure 47: The design of the environment of scene 1 [69,70].

★ Environment level 2

This scene should represent a colder environment. The cold air is a very common trigger for people with asthma [71] and this can be easily implemented in an environment such as this one. The cold air is actually implemented as an extra trigger that effects Eldub for the entire level. More of this will be explained later in this section. This scene includes smoke, cold air, cold and strong odors (see Figure 48).

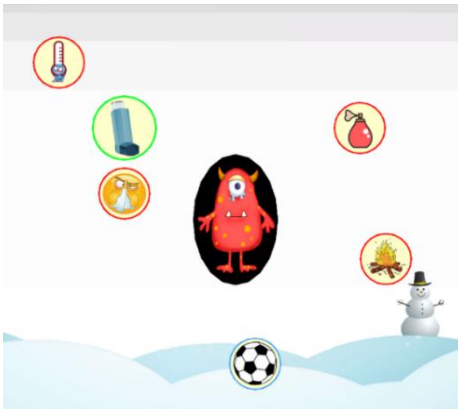


Figure 48: The design of the environment of scene 2 [72,73,74].

[69] http://kays.makehauk.co/grass-background-cartoon/, last accessed: 17-05-2018
[70] https://learnfree.me/images-of-cartoon-flowers/flower-cartoon-images-artcommission-me-for-alluring-of-flowers/, last accessed: 17-05-2018
[71] https://www.accuweather.com/en/weather-news/how-to-prevent-flare-ups-of-asthma-triggered-by-cold-weather/70003182, last accessed: 28-06-2018
[72] https://www.youtube.com/watch?v=dW2GJ4I2sso , last accessed: 17-05-2018
[73] https://www.videoblocks.com/video/blue-snow-background-merry-christmas-snowy-background-with-animated-text-merry-christmas-red-winter-background-with-falling-snowflakes-rxe9_3wgxivth1kjd, last accessed: 17-05-2018
[74] https://pixabay.com/en/photos/mud/, last accessed: 17-05-2018

Stage 2: Make it move

This stage is a big one, because once this stage was finished, a big part of the game already came to life. The overall idea is that both the positive and the negative triggers come from a random point outside of the screen and move towards Eldub. The speed of these triggers are constant in the first level. In the second level, the speed is actually related to the time. If the trigger reaches Eldub, the trigger will disappear. Each trigger rotates as they move towards the center, where Eldub is located. The game is coded in such a way that spawn points were created and every 1 to 4 seconds a trigger would spawn at one of the spawn points randomly. The spawn rate depends on the amount of time that has passed in a level and which level is being played. Lastly, when these triggers collide with the player, they will disappear, making it look like the player has destroyed a trigger. In Figure 49 a screenshot is made of the scene. In this figure, the spawn points are highlighted.

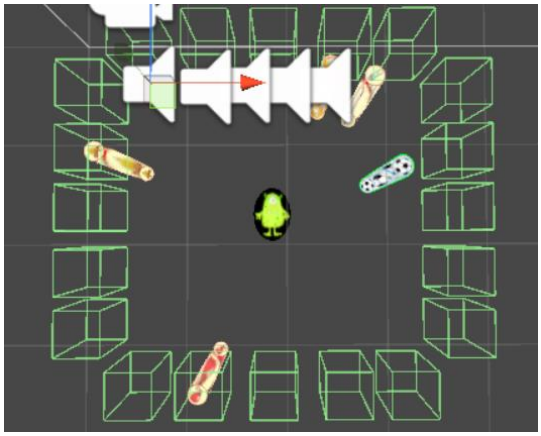


Figure 49: A screenshot made in Unity of the spawn points.

These decisions were made upon the following reasons. Firstly, Eldub is located in the middle of the screen. This has been done to create the possibility to let Eldub give useful feedback. As already mentioned in Chapter 4, feedback is very important. In short, Eldub changes color and facial expressions in connection with his happiness and health. This concept will be elaborated later in this section. However, it is important to mention it right now, because for this reason he is located in the middle of the screen where everyone can see him clearly. Secondly, the positive and negative triggers are rotating for one simple reason. It makes the triggers stand out more against the background. Thirdly, the differences of the speed of the triggers has been discussed. This has been done to make the second level a bit more difficult. Finally, the spawning rate has been mentioned. To make the level more difficult after a specific amount of seconds, a piece of code has been written to make the spawning rate of the positive and negative triggers smaller over time. Aside from making it more difficult, the last two decisions were also made to create some differences between the levels.

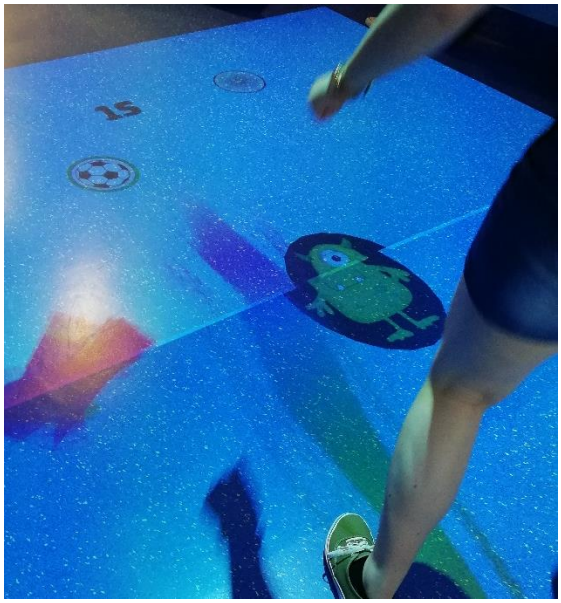


Figure 50: A real-life picture of the positive and negative triggers approaching Eldub on the playground in Design Lab.

Stage 3: Special features

When the previous stage was finished, the game was already playable. Triggers were already introduced and they could be caught or dodged by the player. However, to turn this game into a serious game, special features must be added. These special features include the inhaler and exercise. The inhaler was programmed in such a way that this always has a positive effect on Eldub. Additionally, a shield instantiates on top of Eldub when the inhaler in dodged by the user (see Figure 51). This will protect Eldub from negative triggers that come his way for a total of 7 seconds. Eldub's health will also go back to 100% each time he uses his inhaler. A second special feature that is implemented into the game is exercise. This could either be a bad or good trigger (see Figure 52). Therefore it has been decided that when Eldub's health is below 50%, exercise will no longer be a positive trigger. The implementation of Eldub's health will be explained later on in this chapter.

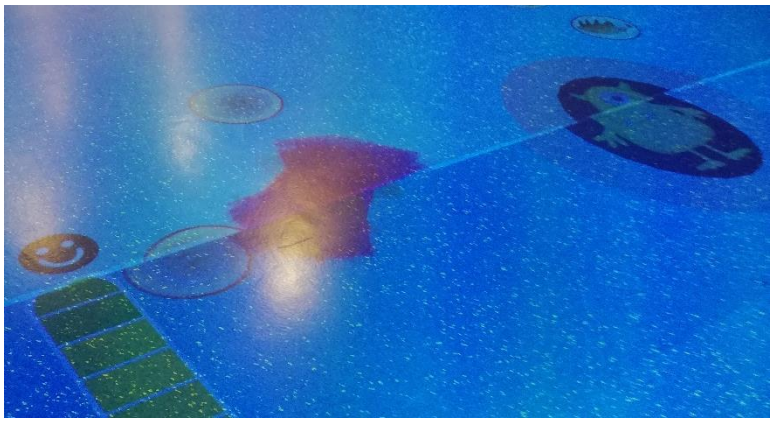


Figure 51: A picture of the shield that is activated because the inhaler was dodged.

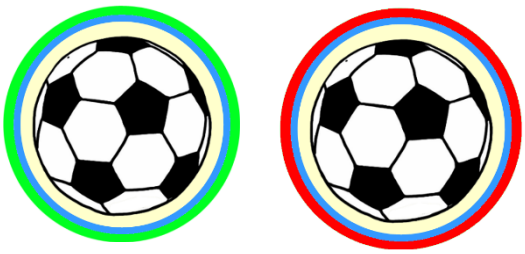


Figure 52: On the left, exercise as a positive trigger is visualized and on the right the negative version is shown [49].

The main reasons that these elements were included was to make the game more representable and educative. These functions are truthful and for a serious game it is very important that the information that is given, is correct. Else, the children will be learning the wrong information. Additionally, these two elements have been elaborated, because they are very important. Exercise and medication are two out of three factors (together with education, which is included as well) that define self-management (read more about this in section 1.2). For example, showing the children the effect the inhaler has on Eldub will hopefully stimulate them to actually use their own inhalers and also use them correctly.

Stage 4: Timer, instructions and feedback

Numerous implementations have been made to make the game competitive, more understandable and in general more entertaining for the user. First of all, a timer has been programmed to be at the top of the screen. In the first level the timer starts at 150, and in the second level the timer starts at 200. The user should try to protect Eldub for this amount of seconds to win this level. Secondly, feedback is given in three different forms. First of all, points will be added or subtracted to a score every time the correct or wrong trigger is caught or dodged. The score will go up by 10 points if the right trigger is destroyed and it will go down with the same amount of points if the wrong trigger is destroyed. Additionally, the score will either go up or down by 10 points when it reaches the game character, depending on whether the element is positive or negative at that specific time. This makes it possible to have an end score of below 0, but also of above 1000. Second of all, a health bar is displayed on the left side of the game. This bar will show how happy/healthy the Eldub is. When the game begins, the happy bar is completely filled. However, elements that appear on the screen can increase and decrease this value. The exact numbers include:

- Negative triggers: dandelion, cigarettes / smoke, animals and dust mite make the bar go down by 10%;
- Exercise can either decrease this value by 20% or increase the value by 20%;
- The inhaler can either have no influence on the monster's health at all or make it go back to 100%;
- In the second level an special trigger is implemented: cold air. The health bar will decrease by 1% every second in this level to make the game more difficult and educative.

When the health becomes zero, the game is finished and the player should be able to play the game again. Third of all, more feedback was wished concerning visualizations. Therefore, it has been decided that the colors, as well as the facial expression of Eldub change dependent on his health as can

be seen in Figure 53. These colors are chosen in such a way that they are equal to the colors in the health bar.

Figure 53: Every color and facial expression of Eldub in a row [43].

Fourth of all, numerous explanations are given to make the game more understandable for young and old. In Table 1 all of these instructions will be listed. In the first column, the literal text will be given in Dutch and the English translation of this. In the second column will be explained why this text appeared in the game. In the last column will be mentioned when and in which level the text is displayed. Finally two pictures will be shared to show examples of what these texts look like on the interactive playground (see Figure 54 and 55).

Text	**Why**	**When**
Dutch: “Bescherm mij tegen: honden en katten, sigaretten, pollen, huisstofmijt.” English: “Protect me against: dogs and cats, cigarettes, pollen, and dust mites.”	To introduce every negative trigger that will come across in the first level.	At the beginning of level 1.
Dutch: Bescherm mij tegen: verkoudheid, rook, sterke geuren, koude lucht.” English: “Protect me against: a cold, smoke, strong odors, cold air.”	To introduce every negative trigger that will come across in the second level.	At the beginning of level 2.
Dutch: “Oh nee! Pas op! Het is hier heel erg koud en mistig. Mijn gezondheid zal langzaam naar beneden gaan.” English: “Oh no! Be careful! It is very cold and foggy. My health will slowly go down.”	To introduce an extra trigger that is triggering Eldub’s asthma all the time in the second level: cold air. An extra introduction was needed because this trigger does not have a picture and is simply running in the background.	After the introductions of the negative triggers in level 2.
Dutch: “Sporten vind ik erg leuk, maar alleen als ik me goed voel!” English: “I really like to exercise, but only if I feel okay.”	To warn the user that they should be aware of this new trigger and to give them a clear hint that this trigger can be both positive and negative.	When the exercise elements enters the game for the first time in the first level.
Dutch: “Als ik mijn puffer gebruik dan voel ik me veeeeel beter! Zelfs als ik het niet nodig lijk te hebben.” English: “When I use my inhaler I feel a lot better! Even when it does not look like I need it.”	To warn the user that they should be aware of this new trigger and to give them a clear hint that this trigger will always be a positive trigger.	When the inhaler element enters the game for the first time in the first level.

Dutch: “*SCORE* Jammer! Probeer het nog een keer.” English: *SCORE* That is unfortunate! Try again.”	To let the player know that they have lost the level and could play again if wanted.	At the end of the first and second level if the player has lost the level.
Dutch: “”SCORE* Gefeliciteerd! Level 2 begint snel.” English: “Congratulations! Level 2 starts soon.”	To let the player know that they have won the first level and can play the second level next.	At the end of the first level if the player has won the level.
Dutch: “*SCORE* Gefeliciteerd! Speel nog een keer :)!” English: *SCORE* Congratulations! Play again :)!”	To let the player know that they have won the second level and can play the game again if they want.	At the end of the second level if the player has won the level.

Table 1: A table with an overview of every text that is implemented in the game.

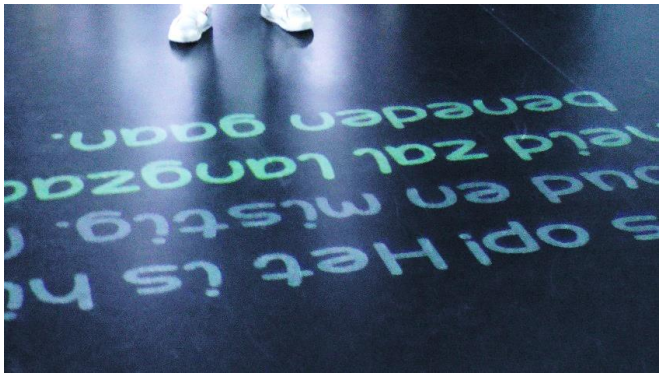


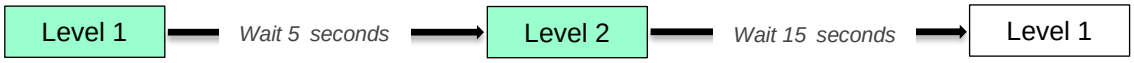
Figure 54: A picture on which the “oh no! Be careful!” text is visible.

Figure 55: Another picture on which the “Congratulations! Level 2 starts soon” text is visible.

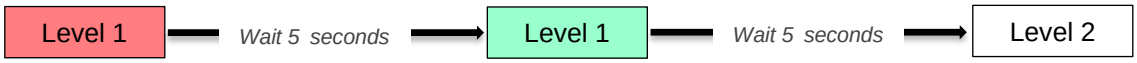
Stage 5: Transitions

The individual parts are complete at this point and the game can be played already. However, level 1 and 2, at this point, are still two individual scenes that are not connected to each other. The transitions between the first and second level has been programmed as follows. The green and red boxes indicate whether the user has won or lost the level. The white boxes mean that this level has just been loaded and whether the user will win or lose the game is at this point undecided.

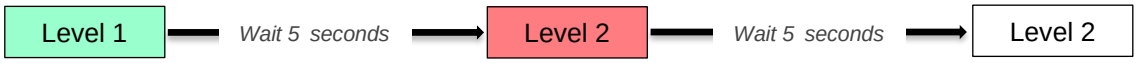
If the user wins every level:



If the user loses the first level:



If the user loses level 2:



Stage 6: Sound

To make the game more interesting, entertaining and to provide more feedback it has been decided to add numerous sound effects. There are 4 different kinds of sounds effects. First of all, a sound is added every time the user destroys a negative trigger. The same sound is played when a positive trigger reached Eldub. Second of all, another sound clip is played when a positive trigger is accidentally destroyed. Third of all, a short audio clip of 7 seconds is played when the inhaler intertwines with Eldub. This has been done to let the user know by sound for how long they are protected against negative triggers so they can focus on the game and do not need to keep an eye on the shield. Finally, a coughing sound is played every time a negative triggers collides with Eldub.

Additionally, next to sound effect, the instructions that are given (explained in stage 4) are read out loud. This has been done because it is possible that the user cannot read yet, does not want to read, or reads very slow and these users should not be limited while they play the game due to these reasons.

Stage 7: Final game

All of these stages combined formed the first prototype of this graduation project. Eldub can be protected by the player(s), the negative and positive triggers are created and every single form of feedback wanted in the scope of this project is implemented. A picture of the game projected on the ground in the waiting room of MST is shown in Figure 56. At the moment it is possible for the children to play as long as the interactive playground is turned on.

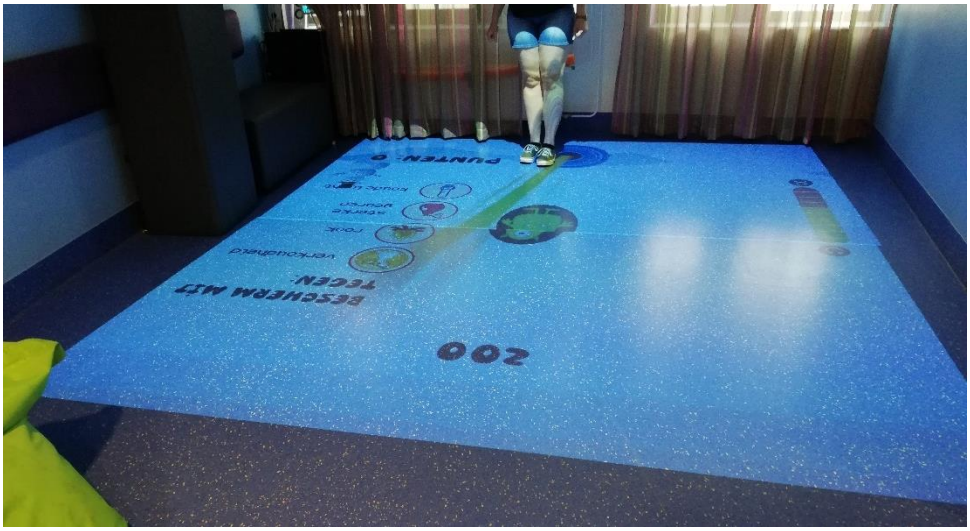


Figure 56: The game being played in the hospital.

5.2 Learning Goals and Related Research

In the following table, the goals of the game will be discussed and how they potentially will be achieved. The goals and additional information describes the complete game, meaning that this is the same for level 1 and 2. Next to the goals of the game, research that has been done in Chapter 2 will be mentioned and conclusions concerning Eldub's Asthma Adventure will be made. In Figure 11, which was shown in Chapter 3, a mind map is already presented. In this mind map multiple elements were listed which were concluded from Chapter 2 and could be implemented in the game. An overview of the topics that cover this subject were presented in this mind map. These topics include the age-group, the different genres and possibilities for gameplay from Section 2.1.2, the different asthmatic educational topics from Section 2.1.1 and the PSD model which is explained further in Section 3.3.1. Additionally, a choice between making one bigger game or multiple smaller games had to made, which was already discussed previously.

First goal of the game	Teach the players about certain objects, creatures and elements that could trigger their asthma and lead to asthma symptoms.
Explanation	Potentially, the game will motivate the children to be more aware of the triggers that are visualized in the game and are more curious about what triggers their asthma.
Second goal of the game	Teach the players about the importance of medication.
Explanation	Potentially, the game will stimulate the children to take their medication when necessary, but also not too little. Although the game does not go into much detail, hopefully the children will see the importance of medication and will be more curious and motivated to find out which medication routine fits them best.
Third goal of the game	Teach the players about the importance of exercise.
Explanation	Potentially, the game will motivate the children to be more physically active. This is done in two ways.

1) it being a physical game itself and still inviting the children to play might comfort both the children and the parent and make them enjoy physical activity instead of avoiding it due to their asthma.
2) The implementation of exercise as both a negative as a positive trigger. Hopefully, the visualizations and explanation in the game will show that exercise is definitely a positive trigger for people with asthma, as long as their asthma is controlled well.

Asthmatic educational topics	In Section 2.1.1 a list of educational topics concerning asthma had been given. In this game three of these topics will be included: avoiding triggers, playing sports and (partly) dealing with asthma attacks (medication). Potentially the game itself will help the children accept their disease, but that is not the main goal of this specific game.
Gameplay	This game can be played with 1 to 4 players. The players should work together to win this game.
Number of players	Maximum of 4 players.
Target group	Children aged 7 to 10. As researched in Section 2.1.2, this particular age-group tends to be very interested in games. Additionally, it is very important that children can most likely read at this age and the differences in gender is not very big yet. When brainstorming and taking notes it felt way easier to make a game for a younger target group, therefore this group was chosen.
Game 'genres'	In Section 2.1.2, numerous genres and game characteristics were discussed that are preferred by either boys, girls or both. Since the target group is both boys and girls, as many characteristics as possible were implemented in this game to please a larger amount of people. For this game, game genres and characteristics include: it being an active game, cooperative gameplay, destruction and nurturing. Lastly, an avatar has been made to make the game more personal.
PSD model	First of all, the goal is to make the game as child-friendly looking as possible. When a system is visually attractive for users it is more likely to be persuasive [52]. Additionally, the information that will be given can be used to improve their asthma control and potentially will actually push them into the right direction. The educational aspects of the game will reduce the effort that the users will have to make, because they will already have some general knowledge about the topic. The positive and negative triggers themselves will hopefully serve as reminders and due to the similarity of what the user experiences themselves and what Eldub experiences, they will me more readily persuaded. Additionally, the direct feedback given when a trigger collides with Eldub, showing the direct link between cause and effect, can support persuasion. This is called simulation.

6. EVALUATION

In this chapter the evaluation process will be discussed. It has been decided that this will be done in 4 different parts. Firstly, observations will be made both during multiple events, but also experiences from other students and myself will be evaluated. Secondly, an interview will be held with a doctor who is specialized in asthma and someone who is specialized in the TG, both of them working at MST for which this project is made. The reason behind the interview and the tests will be given, questions and protocols will be shared, and lastly, the results will be analyzed or an explanation of how this information was supposed to be used will be shared. Thirdly, a user te+st will be executed and fourthly, an evaluation test will be discussed as well. For these tests, the same aspects will be examined as the interview. The evaluation tests and interviews are ordered in chronological order.

It is important to note that only evaluations with impartial people were included in this chapter. Meaning that evaluations with myself and the supervisors of this graduation project were not included in this chapter, but in the realization chapter.

6.1 Observations

At numerous moments during this graduation project, a simple observation was done to see whether the game functions well on the interactive playground. This specific part of the evaluation was held in the Design Lab at University of Twente. The goals of these observations are quite diverse. This could either be to see whether any adjustments need to be made regarding the speed of the triggers. On another note, experiences and behaviors were observed and during the last observations and simple and fitted questions were asked as well.

There will be four sessions that mainly exist of observing the user and asking a question or two if necessary and useful. The first one will most likely mainly be with students. The game will be turned on and running on the interactive playground for about 5 hours and people who pass by and interact with the game will be observed. Secondly, there is an arranged meeting with an elementary teacher who will be playing the game and giving his opinion. Thirdly, a meeting with an expert in interactive playgrounds will be scheduled. And again, his opinion will be asked and his remarks will be noted. Lastly, on the 19th of June, an eHealth event will be held at the design lab of University of Twente and the serious game for children with asthma will be running on the playground as people specialized in health and different departments pass by. Hopefully the game will attract some of these people as well as they either enter or leave the design lab and some more opinions and experiences will be gathered.

6.1.1 Functionalities to be Questioned and Observed

The aim of these observations and asked questions is to evaluate the usability of the game itself. Both students as adults who appeared to be either specialized in health, education, interactive playgrounds or other business should be observed. The understanding of the functionalities and the necessary actions is analyzed. The user is asked to play the game, or is observed as they play the game, in this way the unclarities and possible improvements will be studied. Although they do not fit the target group, their opinion on the overall look of the game will be asked shortly. Suggestions from the test subject are therefore more than welcome, especially if they are actually specialized in this particular subject. This could concern, for

instance, the overall look of the game, the easiness or believes whether the potential goal of the game will be reached in such a way.

6.1.2 Test Protocol

These sessions are difficult to predict since most of them are not arranged. People passing by and stopping to play the game will be observed and asked a question or two if found necessary. During this particular usability test, there is sadly no possibility to interview and observe children with asthma due to the fact that these observations could be seen as a preparation for the actual user test which will be discussed in Section 6.3 and those children should not be bothered more than one time. It is known that students and adults might act differently in a game such as this one, however it is still interesting to see how these people interactive with the system and what their thoughts are about this game. Additionally, they all have been a child and do have the ability to depict whether their 7 to 10 year old self would like to play this game.

What is needed for the test:

- ★ Questions;
- ★ The interactive playground;

A couple of things need to be ready before the test:

- ★ Set up the game:
  - ○ Turn on the interactive playground if it is turned off;
  - ○ Start the Asthma Game;

As explained before, the test is either arranged and one person is observed and listened to specifically, or the asthma game is simply running on the interactive playground and people passing by and interacting with the game are watched. In the beginning the participant will not be told exactly how they should play the game. Some information about the AIRplay project might be given, however, it is up to the participant to figure out which elements to catch and which ones to avoid and what the message is behind the game. However, if the participant seems clueless, a hint will be given or the complete game will be explained shortly.

It is not necessary to make some time schedule. Especially because the interactive playground is located in a very public space and it is impossible to make these sessions private.

While the user is playing the game, the observer should take notes about the following things:

- ★ Does the user know what they are doing?
  - ○ Do they need an explanation or does the game speak for itself?
- ★ What is hard for the user to understand?
- ★ What is easy to understand?
- ★ What emotions do they show throughout the test? Joy/frustration/indifference?
- ★ At which point during the task do usability issues arise if at all?
- ★ Do they play actively?
- ★ Do they feel motivated to win the game?
- ★ Do they give up?

The test is completed when the user had either managed to survive both level 1 and 2, or when they have given up. The test will not take too long. It is important that every element has appeared, but if the participant wants to stop playing, there is no need in forcing them to continue until they have won the game. Especially since this can take some time. After completion, a few last questions could be asked if felt useful to the participant:

- ★ What is your opinion on the game?
- ★ Do you have any positive feedback?
- ★ Do you have any negative feedback?
- ★ Do you like the overall design?

It is important to note that these questions will not be asked in the form of an interview. Some questions might be ignored due to it not fitting the participant, but the complete evaluation session hopefully will give numerous answers to these questions.

6.1.3 Data Analysis Plan

Data will be retrieved from these sessions. As mentioned before, it is important to get data from the user by watching them interact with the playground as well as by listening to their opinion on certain parts of the game afterwards. Observations are especially important to get the feedback they will not actually say out loud. The possible questions that have been mentioned before will be asked in the form of a live interview. This allows space for follow-up questions and it brings the opportunity to only ask questions that fit the participant. This potentially will make the information that will be drawn during the usability tests more reliable and it will retrieve more data that has not been observed as well. During these sessions, the observations and remarks will not be written down. Instead, when a session is finished, notes will be made. At a later moment, the data will be analyzed. At a later moment, once the four sessions have been executed, the notes, that include both the observations and the opinions of the test objects, will be compared and combined.

The analysis will result in a number of varying recommendations and problems that were discovered throughout the test. These problems will not all be equally as important. Therefore, a ranking will be made. Problems that occur will be ranked as either a critical problem, a serious problem or a minor problem depending on how much the problem will affect the ultimate goal of the game. As a reminder, the ultimate goal of the game is to improve the self-management of asthmatic children at MST, both by motivating them to be physically active and by teaching them about asthma. This ranking will potentially make it obvious which problems should be tackled immediately and which problems are either personal or minor, and should not be taken too seriously.

6.1.4 Results and Redesign Recommendations

Numerous interesting observations have been made and opinions have been shared. The remarks of the observations and the answers to the questions will be discussed in this section. Problems and recommendations will be listed and ranked as explained earlier. As also mentioned before, there were two arranged meetings and two sessions in which passersby were watched and talked to when they interfered

with the installation. First the results will be divided in these two groups since they were approached differently. Later, some overall conclusions will be drawn and redesign recommendations will be shared.

First of all, observations were made of students and possible eHealth professionals who passed by. It was sad to notice that a lot of these people were already very familiar with the interactive playground and therefore not interested at all in what was happening on the ground. Only four people who attended the eHealth event stepped by. Luckily, a lot more students, 21 to be exact, were interested during these two sessions. However, when someone or a group of people did interfere with the game that was projected on the ground, the overall reactions were quite positive. The game was playable correctly with either a small explanation or without an explanation at all. This did definitely partly depended on whether they spoke Dutch, since the explanation in the game is in Dutch. Although, it must be mentioned, that a lot of people had difficulties with hearing and reading the instructions. This was both due to the sound being edited and therefore a bit more difficult to hear and because of the amount of lighting in the Design Lab making the projections on the floor a bit harder to see. The sound is seen as a serious problem, however the lightning in the Design lab is for now seen as a minor problem. This is because this game is not designed to be played on this particular interactive playground anyways. User tests on the actual playground in the waiting room at MST will tell whether this should be seen as a bigger problem.

Although the participant could play the game correctly quite soon, the fact that the game was especially designed for children with asthma did not seem to be obvious. This is not seen as a surprise, but since the final version of the game will be running on the interactive playground at MST, this is seen as only a minor problem or maybe not even a problem at all. One more important aspect concerning the students or adults understanding the game is that they seem to have difficulty with the exercise element being both a positive and a negative trigger. This observation is taken into account and considerations will be made whether this should be seen as a good or bad thing. Additionally, exercise is programmed in such a way that a red or green circle is instantiated behind the exercise element depending on Eldub's health. However, Eldub's health does change over the time that the element moves from the instantiated location to Eldub. Unfortunately, this did not go unnoticed. This should be seen as a crucial problem, because this can be very misleading, especially for the children.

One more important observation is that the students tend to have a very diverse opinion on the sound that appears when Eldub takes his medicine. Some say that it is way too happy for what it is presenting and are annoyed by the sound. Others cannot stop dancing every time the sound starts to play. This is not necessarily seen as a problem, especially since it is not even sure whether the sound will be turned on when running on the playground at MST. However, it is an interesting aspect to think about. Additionally, as mentioned, the opinions are very diverse, so this is another reason to mark this as a remark and not per se as a problem.

Sadly, most of the students and even the adults that passed by, did not have shocking recommendations that could be included in a second version of the game. As mentioned before, the overall opinion was positive. In the fourth session, two adults even mentioned that this game should be the start of an own company. Although not everyone was as exited to run, they did seem to believe that the game has potential. The design has been found cute by most people. Only one student seemed to think that Eldub was a dangerous monster that should be killed instead of saved, which will be remembered but not taken too seriously until the opinion of the children are collected. A small hand of students found that some of the triggers were too difficult to catch, however they did also manage to win the game.

Second of all, the arranged meetings with an elementary teacher and an expert in interactive playgrounds will be discussed. The elementary teacher was actually given an explanation of AIRplay and of how the game works beforehand. The man specialized in interactive playgrounds on the other hand wanted to be surprised. It was nice to notice that he realized how to play the game right away and only asked about the idea behind this game, which is AIRplay. The observations that were made, were more or

less the same as expected after the session that had already been done. However, since they were playing the game with the supervisors of this project who helped during the design process and have played the game before this evaluation numerous times, these observations are seen as less valuable than the ones that were discussed previously. However, their opinions and remarks were very much appreciated.

Since the evaluation was part of a meeting, a lot of information has been shared. However, not all of it is applicable for this graduation project. Therefore, part of this will be discussed in Chapter 8. However, two important notes were made. Firstly, the elementary teacher noted that the game should include even more feedback. Even though some feedback is already included, such as the health bar and the look of Eldub, he advised to implement speech bubbles, especially since the health bar is not very visible when projected on the ground. In these speech bubbles Eldub should share how he feels at that moment. The fact that the feedback was not good enough will definitely be taken into account and be seen as a critical problem. Secondly, the expert in interactive playgrounds suggested to put something with where the playground will be to make the projections clearer and he discussed the importance of a good mix between education and fun when making a serious game. No specific remarks directed to this particular serious game were made sadly. However, both of them seemed to have positive feeling about this game.

To conclude, a couple of serious problems and useful recommendations were notified and should be considered. First of all, the sound was not clear enough. This could easily be fixed by making the sound a bit lower and make it sound more like my natural voice. Secondly a minor problem was addressed. The user did not really know that the game was about asthma until this was explained. A short explanation in which Eldub introduces himself and says that he has asthma will most likely fix this problem. Whether this adjustment will actually be made is unsure at this point. Thirdly, the exercise element was difficult to understand and the color of the circle surrounding the element can be misleading at times. The difficultness of the trigger can be seen as a positive observation. This makes the user think about this specific element and this will potentially help them remember it better. Therefore, this is not necessarily seen as a problem, at least not right now, but more as an observation. However, the problem concerning the red or green circle should be solved. Lastly, a great advise had been given to include more feedback in the game. As instructed, speech bubbles will definitely be implemented to give the user more feedback and give them a better overview to what is happening and whether they are doing a good job or not.

6.2 Interview

After the observations, an interview will be held with a doctor and a man specialized in interactive playgrounds. The interview takes place at MST, on June 25th, 2018, to be exact. During this interview there are two main aspects that will be investigated. Firstly, it is very important to assure that the information that is given in the game is representable of the correct. Secondly, questions will be asked on whether the game is designed optimally for on an interactive playground and for the target group. These are two completely different questions and although it is important to mention that the focus will be on the first question, this section will be examining both of them. This information is important, because the user should not be taught false information. Additionally although an expert in interactive playground might not know it all, they have had more experience with the playground and the behavior of children as they play on in, therefore certain tips and tricks could be helpful to improve the game itself and entertain the children as well as teach them about positive and negative triggers concerning asthma. Hopefully, positive conclusions will be made and the interviewees will be very enthusiastic about it.

6.2.1 Functionalities to be Questioned

The aim of the interview is to evaluate the usability of the game, as well as the informative features and the design choices concerning the interactive playground. The interviewees might want to play the game and based on their experiences and knowledge they will answer questions that will be asked. Even though they do not fit the exact target group, the doctor works with these children and therefore has a great view of their interests. This is enough reason to collect his opinion on whether they found this game has potential or not. Suggestions from the interviewees will be collected. This could concern the overall look of the game, the information that is given in the game, the game experience on the interactive playground and more.

6.2.2 Interview Protocol

Firstly, the two interviewees and the interviewer will gather somewhere and discuss shortly what has been going on concerning this project. After this very short meeting, the game will be showed on the interactive playground. They can decide by themselves whether they only want to watch or actually play the game. During this, they might make some remarks that should be remembered and written down as soon as the interview has been finished.

Secondly, for the actual interview, a list of questions has been prepared. This interview is about the game that has been designed. Therefore, it was important to show the game beforehand. The questions can be found below. However, there is room for follow-up questions. Before the interview, the interviewees are asked to sign the informed consent. Also, the interviewees will be asked whether they are okay with the interview being recorded.

1. What are your first impressions of the game?
2. Is the information that is given in the game representable and correct?
3. At this moment I have tried to include as many triggers as possible. Do you think it will be a problem that Eldub is allergic to so many triggers? Will it make it look fake?
4. Should something be added?
5. Is the game designed optimally for on an interactive playground?
6. What elements of my game have potential but could be improved easily to attract the target group more?

6.2.3 Data Analysis Plan

Data will be retrieved from this interview. It is very important to get data from the user by listening to their opinion on certain parts of the game. The questioned that have been listed will be asked in the form of an live interview. This interview will be recorded to make sure that all the information can be collected since this is an important part of the evaluation. Once the interview is over, the audio will be used to make notes and draw conclusions from the new data that has been collected.

The analysis will probably return a number of varying recommendations and problems that were discovered throughout the interview. It is expected that these problems are crucial, especially if they concern the information that is given about asthma. Also, the interviewees work at MST and their opinions

are very reliable and therefore quite important. However, if useful, the problems that occur will be ranked as either a critical problem, a serious problem or a minor problem depending on how much the problem will affect the ultimate goal of the game. This ranking will potentially make it obvious which problems should be tackled immediately and which problems are either personal or minor, and should not be taken too seriously.

6.2.4 Results

The complete answered can be found in the Appendix C, however here are the conclusions that were drawn during and after the interview was held.

It was very pleasant to hear that both of the interviewees were very enthusiastic about the game. They both showed much interest and enjoyment as they saw the game running on the interactive playground. They really believe that the game has potential, that it is the best game that can be played on the playground in the waiting room, and that it will motivate the children to be physically active. The medical content that is given is correct, which is obviously very important when presented in a serious game. The fact that so many triggers were implemented in the game was also positively received, "*Else there could be children who cannot relate to the game, because they are missing triggers that influence their asthma."*

They were particularly very happy with the fact that the game has the possibility to attract numerous age groups already. However, one specific idea was mentioned to broaden this even more. The doctor explained the following when asked if there are elements in the game that can be improved easily to attract the target group more. *"To personalize the game, to let the choose their avatar. This gives the possibility to attract different age groups. An older child would choose another avatar than a younger child."* As of right now, Eldub is the main face of the game. However, given the children the opportunity to pick their own avatar and the overall theme of the game with it, really created a broader age group that will be interested in this game. *"I can even imagine that if you pick for Ronaldo for example, that the game can be played in a football theme."* Additionally, Oinas-Kukkonen and Harjumaa [52] claim that personalization offers a greater capability of persuasion.

Next to personalization, more comments have been given regarding this graduation project. Both of the interviewees were very enthusiastic with the implementation of exercise. However, they were concerned whether the information that is given regarding this element, but also other elements were clear enough for the target group. Suggestions were made including a tutorial of 10 to 15 seconds in which every trigger is explained shortly. This was implemented after the observations discussed in the previous chapter (Section 6.1). In addition, they suggest that these one-liners should generalize these triggers. Meaning that instead of introducing the 'cat and dog' image as being allergic to 'cats and dogs', introducing it as being allergic to 'animals'. Or, 'I have to be more careful in the hay fever season' instead of 'pollen'. They did have one more slight remark regarding the text that is implemented in the game. Every 50 seconds, Eldub tells the user how he is doing. However, if the user is playing very well Eldub's messages are basically identical. Therefore, it was desired to make the feedback more diverse. Especially since children tend to love feedback like this.

Lastly, a slight possible problem has been noted. It is possible that the children are very aware of the fact that there is an opportunity for the user to cheat in the game. Especially in the first level. The user could simply stand on top of Eldub and catch every trigger. Eventually they will win without being active, which is not the wanted result. This problem was already noted during the realization phase, however, a very useful solution was shared. To get to the high score, the children have to catch the negative triggers as soon as possible. Children tend to be very competitive, so this could definitely make the children run faster.

These remarks and suggestions will not be implemented in the game before the next user test (Section 6.3). All of the advices of the interviewees will be taken seriously and considered. However, due to lack of time, not all of them will be realized in this graduation project.

6.3 User Test

After the interview, a user test will be executed. This user test takes place at the MST. Children aged 3 to 9 will be observed as they play the game on the interactive playground together with their parent(s). In previous chapters has been mentioned that the target group is 7 to 10 years old. However, since a lot of the patients are younger and the enjoyment is as important as the education, the age group has been broadened for this particular usability test. Afterwards, they will be asked a couple of questions. During this user test the most important data that will be collected is whether the game is liked by the target group and whether the game has potential. The children (and their parent) that will participate during this user test were assigned by a doctor specialized in asthma, who works at MST.

These user tests will be executed on Wednesday afternoon, June 27th, 2018 and Thursday morning, June 28th, 2018. Both sessions will take around three hours. Each session will take about 10 to 15 minutes. In total 6 children participated during the user tests.

As mentioned before, 'the children (and their parent)' will participate and be observed during the user tests. To create a realistic view, the parent will not directly be asked to play the game, however if they want to join their child because they are too young or are asked to tag along, this is in no way discouraged. Especially, parents tend to have a hard time with accepting the disease. Therefore, having children play together with their parents should be promoted in general. Although both the parent and the child might be observed in some cases, the questions that are asked after the game is played, will be directed only to the children. They opinion matters more in this particular project, because they should hopefully be reminded about certain aspects concerning asthma. Optimally they will use the information that is given during the game at home.

6.3.1 Functionalities to be Tested

The aim of the user tests is to evaluate the usability of the game, the design choices and the potential it has or does not have. This also includes the experiences of the users. The overall goal of this project is to support self-management. Since these user tests are actually executed with the target group, it is possible to draw some conclusions regarding this. Although it is not possible to see if the game works for the long run at this moment, it should be possible to predict whether the goal can potentially be reached. Therefore, the following aspects will be evaluated.

Firstly, it is important to observe whether the children are physically active while they play the game. As discussed during the interview in Section 6.2, the player can still win the game without being as active as intended. Therefore, one of the factors that will tested during this usability test is whether children will actually decide to stand still on top of Eldub. If this is the case, then this problem should be tackled in the near future. Secondly, it could be important to question whether the children actually learn something during the game. However, if the answer ends up to be no, this game could still be helpful to work as a reminder. During the interview (see Appendix A) was mentioned that children tend to ignore given instructions and eventually forget what they are supposed to do to control their asthma optimally. That is also why it is important that the children like the game enough that they would play again in order to be reminded again

before or after their next appointment. Thirdly, positive and negative feedback will be gathered. This could include, for example, the design of the game. Fourthly, another crucial factor is whether the children not only understand the game, but also the aim of the game. As suggested in Section 6.1, there is a thin line between education and fun when designing a serious game. Although the game should be fun, the information that is given should be captured by the children. Lastly, the interaction between parent and child will be evaluated briefly for the reasons that have been discussed previously in Section 6.3.

6.3.2 Test Protocol

As mentioned before, these user tests will be held at MST. Both the child and the parent will be observed and questioned during this particular user test.

The usability test will be around 10 to 15 minutes. Test subjects will be send by the doctor towards the interactive playground at the end of their appointment if they want to participate in the user test.

What is needed for the test:

- ★ The interactive playground;
- ★ The game;
- ★ 1x informed consent for the child;
- ★ 1x informed consent for the parent;
- ★ 1x Brochure (Appendix D);
- ★ Timer;
- ★ Questions on the laptop to be filled in by the observer digitally (Appendix D).

A couple of things need to be ready before the test:

- ★ Set up the game:
    - ○ Turn on the interactive playground if it is turned off;
    - ○ Start the Asthma Game and make sure that it is working correctly;

The very first step is to give a very short explanation about the user test. This explanation will only address the user test itself. The aim is to explain the participants why they are asked to play the game. More will not be addressed at this moment, only if the participants themselves have questions about it. This has been decided due to the children probably getting bored after two or three sentenced. Secondly, the participants will be asked to play the game. They will be observed precisely and if they seem confused, more information will be given about the actual content and instructions of the game.

While the user is playing the game, the observer should take notes about the following things:

- ★ Does the user know what they are doing?
    - ○ Do they need an explanation or does the game speak for itself?
- ★ What is hard for the user to understand?
- ★ What is easy to understand?
- ★ What emotions do they show throughout the test? Joy/frustration/indifference?
- ★ At which point during the task do usability issues arise if at all?
- ★ Do they play actively?
    - ○ Do they stand on Eldub most of the time?
- ★ Do they look motivated to win the game?

★ Do they give up?

The test is completed when the user had either managed to survive both level 1 and 2, when they have given up, or when they have been playing the game for more than 5 minutes to make sure that the complete test will not take too long. It is important that every element has appeared, but if the participant wants to stop playing, there is no need in forcing them to continue until they have won the game. After completion, a few last questions could be asked if felt useful to the participant:

★ How old are you?
★ What did you enjoy most about the game?
★ What did you like less?
★ Was the game understandable?
★ Did you learn anything or expect that the game could be educative for someone?
★ Would you play this game, or a game like it, again here?
★ Did you enjoy playing together with your parent/child?

These questions will be asked in a short live-interview. The answers will be remembered during the interview and written down on the questionnaire that can be found in Appendix D. It is possible that a question of two will be added due to an unexpected observation. However, it is important that the overall session does not take longer than 15 minutes.

6.3.3 Data Analysis Plan

Data will be retrieved from these user tests. Next to observations, is very important to get data from the user by listening to their opinion on certain parts of the game. The questions that have been listed will be asked in the form of an live interview. This interview will not be recorded. This is not seen as necessary, because only a couple of questions will be asked and short answers are expected. Additionally, there will be a short break after each user test, giving the time to write down the answers and the most important remarks before the next user test starts. Once the user tests are over, the notes will be combined and conclusions will be drawn from the new data that has been collected.

The analysis will probably return a number of varying recommendations and problems that were discovered throughout the several user tests. It is expected that these problems are serious, because the data is given by the target group of this graduation project. However, if useful, the problems that occur will be ranked as either a critical problem, a serious problem or a minor problem depending on how much the problem will affect the ultimate goal of the game. This ranking will potentially make it obvious which problems should be tackled immediately and which problems are either personal or minor, and should not be taken too seriously.

6.3.4 Results

The overall results were more positive than expected. This could be due to shyness, but the children did not have any negative remarks concerning the game. The game itself was liked and seen as the best

game that can possibly be played on this particular interactive playground. When asked what they liked about the game, the most common answer was “everything”, which was very flattering. 2 out of 6 children were unaware of all the triggers and actually personalized the game by saying that they are allergic to … as well. 3 out of 6 children exclaimed that they love to exercise while they played the game, which was good to hear too. 2 out of 6 children played alone, meaning that 4 out of 6 children played together with their parent. 3 out of 6 times this was because the children were too shy to play alone. 1 out of 6 times the child did not manage to beat the level by themselves and needed his parent, because he wanted to win. It was surprising to see that so many children wanted to play with their parent, but this information was received positively due to reasons mentioned in Section 6.3.

Although the children were too shy to answer every question truly during the interview, the observations that were made while the children (and their parent) were playing the game were very useful. First of all, positive feedback that was observed during the user tests will be discussed. Second of all, the negative feedback will be listed. And finally, redesign recommendation will be given concerning the collected negative feedback or observed problems.

The most important positive observation that was made was that even the shy children started to play the game enthusiastically after a minute. The difficulty level of the game seemed to be alright. The first level is significantly more difficult than the second level. However, knowing that there are only two levels, this has been done on purpose. The first level was a challenge, but not an unreachable one. One of the children even managed to survive the level on his own. It was fun to see how much the children cared about the score they had. Even if they had lost, once they had seen that they had 600 or more points they were still very excited because of the high number projected on the ground. Only 1 out of 6 children mentioned the colors of Eldub, but at least if was done in a positive way.

The younger children at first did not want to let go of their parent’s hand, but after a while they found destroying a trigger more important than holding hands with their parent. The parents that joined guided their child through the game whenever they were too young to understand, which was good to see. Although, the younger children were very shy, children above the age of 6 especially were very obviously excited as they played the game. It was not uncommon that the children did not want to stop playing at all. One of the children, aged 8 years old, even nearly begged for his parent to continue playing until they had won the game. Sadly, they did not manage to do so. The children ran around and no one stood still on top of Eldub to catch every trigger easily. Luckily no children felt the need to take a break due to their asthma. Children aged above 6 understood the game even without extra explanation. Additionally, it was fun to see that some of the children became frustrated after losing a game, but overall they seemed to have a lot of fun and. From this can be concluded that children younger than 6 tend to be too young to be playing this game without their parents. However, having an audience (even when it is just one person) during the user test could have made them more shy than they would have been any other regular day.

Following from the previous section, some negative observations were made concerning the understanding of the game as well. For younger children (aged below 6), even when playing with their parent, it was very difficult to distinguish between the objects surrounded by a green or red circle. However, they were still very eager to catch all the triggers. This could be seen as a serious problem, however, the target group is between 6 and 9. And since they did seem to distinguish the red and green colors, this is not a problem for this specific target group. Some of the children were simply too young, or better said, too small. The tracking system did not work perfectly, which really frustrated the children. Although these emotional expressions were great to see, the tracking system itself is not a problem that should be solved in this graduation project. Therefore, this is not seen as a problem at the moment, but it is advised to make some adjustments to this. Especially since a lot of the children that are in the waiting room are very young and small. Another observation that was made during the user test is that the game does not necessarily speak for itself. As mentioned before, children aged above the age of 6 did understand after a while how to

play the game. However, the was not clear from the beginning. It takes quite a while until the first triggers enters the screen, especially in the second level. As of right now, it took about 15 seconds until the first trigger appeared on the screen in the second level, which is way too long. It was needed to tell that they just had to wait for a bit. This should be seen as a minor problem. Additionally, not all of the pictures that represent the triggers were clear to the participants. 2 out of 6 children seem to have a problem with this. For example, the inhaler and the cigarette were both seen as socks by one child. Since is a more serious problem, because this could work against the main goal of this project, which is supporting the self-management of the children by educating them actively. Another serious problem that could influence the education is the exercise element. Although the inhaler was understood perfectly by the right age group, even the shield was mentioned and understood, exercise was seen as a positive trigger throughout the entire game.

In this section each problem will be addressed and possible solutions will be given. The first problem that was mentioned was that younger children tend to catch every trigger instead of only the red ones. As already mentioned before, the target group is aged 6 to 9 and therefore this should not be seen as a problem at all for this specific project. However, it would be possible to design a game in the future for younger children in which it would make sense to catch every element. The second problem that was addressed, besides the tracking system, was that the game starts too slow. It might be necessary, especially in the second level, to make the triggers come faster. The third problem that should be addressed is that not every picture that presents a trigger is clear to the participants. This could be a challenge to fix due to the surprisingly limited possibilities that can be found online for these specific triggers. The last problem that was mentioned was that the exercise element was not clear enough. This problem could actually be fixed by introducing every trigger in a more fun way at the beginning of the game. This was already mentioned in Section 6.2.4. Additionally, this would hopefully also make the education that is implemented in the game more obvious. Although 33% of the children already mentioned that they were introduced to new triggers and the inhaler was understood by all of the children aged above 6, there are more educational aspects hidden in the game that did not come across as wanted, especially to the younger children.

6.4 Changes

Resulting from the evaluations mentioned in this chapter, three important changes have been made to the game. In this section, these adjustments will be shared. In the results more feedback was shared, however, due to lack of time only these three changes were made at the moment. First of all, a problem concerning the exercise element that was mentioned in section 6.1.4 has been solved. The circle that instantiates behind the exercise element has been programmed to be red when the health is below 50 and green when it is 50 or lower. Even though no one has noticed this bug during the user tests described in section 6.3, numerous people who were observed earlier, saw that a green circle could still be a negative trigger due to the changes in Eldub's health as the trigger moves across the screen. Therefore, an adjustment has been made in the code. No matter what Eldub's health, if the circle is green, exercise is a positive trigger and if the circle is red, exercise is a negative trigger. This way, the trigger is still dependent on Eldub's health, but the color no longer misleads the user. The second problem that has been addressed is the lack of feedback. In Chapter 5 feedback from the health bar, the score and Eldub's colors have already been discussed. However, both in section 6.1 and in section 6.2 advices concerning feedback were given. Firstly, speech bubbles have been implemented to express Eldub's thoughts and motivate the player to improve his or her behavior. These speech bubbles at first only showed up every 50 seconds. There are four different kinds of texts that Eldub can say. These test messages are shared in Table 2.

Text	When
Dutch: “Wow! Je beschermt me echt heel erg goed :)!” English: “Wow! You are protecting me very well :)!”	Each 50 seconds when Eldub’s health is above 90.
Dutch: “Het gaat goed met me!” English: “I’m fine!”	Each 50 seconds when Eldub’s health is above 50 and below 90.
Dutch: “Ik voel me niet heel erg goed :(.” English: “I don’t feel so well :(.”	Each 50 seconds when Eldub’s health is above 25 and below 50.
Dutch: “Oh nee. Ik voel me echt niet goed :’(.” English: “Oh no. I really don’t feel well :’(.”	Each 50 seconds when Eldub’s health is above 0 and below 25.

Table 2: Text of the speech bubbles.

Nonetheless, as can be read in section 6.2.4, during the interview advices were given concerning this adjustment. Only the positive feedback was popping up when the game was shown to the interviewees. Therefore, another adjustment has been made to the speech bubbles. For the first time the Eldub’s health will go below 50 and below 25, the messages will pop up, no matter how much time has passed in the game. These values have been chosen to make sure that the user is aware of Eldub’s status and hopefully will to his or her best to make Eldub happier and healthier. Lastly, during the user tests a very annoying observation was made. Especially in the second level, it took around 15 seconds until the first trigger appeared. This was not because of the code. The first trigger did spawn after 5 seconds. However, since the trigger moves very slowly in the beginning of level 2, it takes a lot of time for the trigger to move from the spawn location towards the actual game view. Therefore, the spawn positions have been moved closer towards the screen. Now, the first trigger appears after 5 to 6 seconds, which is definitely an improvement.

It is important to note that most of these changes were made at the end. Only the first version of the additional feedback was implemented right after the first observations. As mentioned before, not every observation or advice has been taken into account due to lack of time. In Chapter 7 future work and recommendations are discussed and these observations and feedback is included there.

7. DISCUSSION

In this chapter, personal experiences will be shared and advices concerning the process of this project will be given. Afterwards, recommendations for future work will be given based on the evaluation of this graduation project, given feedback and related research. These recommendations are given to potentially improve the game experience of the player and hereby also the overall learning experience. Aside from recommendations concerning 'Eldub's Asthma Adventure', recommendations and alternatives will be shared in order to support the self-management of children with asthma who play the game on the interactive playground in a more general way.

7.1 Personal Experience

The past couple of months have been a new personal experience. As a Creative Technology student, I am not used to working by myself and working on bigger projects such as this one. Also, working with an external client is also not a usual occurrence. When looking back, there are a couple of parts that could have been handled differently in order for it to be more sufficient and well-organized. The most important improvement, as will be mentioned later, could be made concerning the preparations of the user tests. Although not all of the happenings could have been expected, it is important to take care of this in time in order to get the results that are wanted..

One more advice I would give to future me is that planning in general is very important when working on a slightly bigger project than usual. In order not to be overworked by the end of a module, it is important to be productive from the beginning. A better planning would have given the opportunity to implement one more user test in the beginning of this project, before the actual game was made. This way, instead of designing a game only based on related research, a user test could have been executed in order to find out the interests of children. For example, numerous Lo-Fi prototypes can be introduced to children that are in the target group and by collecting their opinions, the best prototype will be transformed into a Hi-Fi prototype

7.2 User Involvement

In this section the user involvement will be discussed. In Section 7.1 a possible additional user test was already mentioned, however there are three more important factors that should be acknowledged. First of all, during the user tests with the children a very important observation was made. Although the children were very enthusiastic to play the game most of the participants were younger than the intended target group. Due to this occurrence, two suggestions were made. For the younger children, the tracking system did not work perfectly. To not make them feel left out, this should definitely be fixed. Additionally, it has been observed that the game was too difficult for these children. For this graduation project itself this was not an issue, because the target group is older and did understand the game. However, since especially younger children wanted to participate and play the game, it could be favorable to also design a game for this age group.

Due to lack of time, two limitations were observed during his graduation project and especially the possibility to evaluate the game. The first limitation that was observed, is the lack of participants between 6 and 9 years old during the user tests with children. Only 3 children were the correct age for this specific project. Although some useful information was collected from these user tests, it would definitely be recommended to try and evaluate more user tests with test subjects who are in the correct age group. Aside

from the lack of correctly aged participants, one important aspects has not been tested. The main goal of this graduation project is to support self-management and whether this goal is achieved with the help of this project is unknown. This was impossible to evaluate in the scope of this project. Aside from assumptions collected from interviews and user tests and the use from related research, not much can be said about whether the game actually supports self-management.

Finally, feedback has been found greatly important in this graduation project. Numerous ways of feedback have been implemented. This has been done based on related research and interviews. However, it might be necessary to test more deeply whether the feedback actually has an influence on the player. A couple of observations have already been mentioned such as the importance of a score and the observed changing colors of Eldub. However, it could be interesting to collect more data about this subject and maybe better forms of feedback will be suggested on the basis of this.

7.2 Eldub's Asthma Adventure Suggestions

In order to make the gaming experience of the children even more fun and to give the game a greater chance of success, some advices will be shared in this section. These advices are based on observations or opinions given during interviews. The biggest suggestion that has been given is to make the game more personal by letting the user choose their avatar and combine every avatar with a specific theme. Personalization has been found to be stimulate behavior changes [52]. This is one way of personalizing the game. Also, the game could include personal data of the user such as age, gender or interests.in order to adjust the game to this. When doing this, it is important to consider ethical issues that come with it ones the player is no longer anonymous or if the data is saved. Another suggestion would be, to make the score a bit more of a challenge. At the moment, whenever the player destroys a trigger, 10 points are added to the score. However, the game will be more challenging if the user can earn more points by catching the trigger sooner. This will potentially motivate the user to play more active when necessary, since children really like to compete and play for a specific goal (see section 2.1.1 and 2.2.1).

More important discussion points concerning Eldub's Asthma Adventure is the images that are used in the game. For the education to be effective, it is very important that they are self-explanatory. During the user tests a lot of confusion has been observed concerning these pictures. However, this did not disadvantage the gameplay, because the red or green circle around the image did indicate well that the trigger should be caught or dodged. This confusion led to another suggestion. It could be possible to start the game with a 10 to 15 second long tutorial. In these 10 to 15 seconds, the player is introduced to every single trigger, and to support the education in the game more, every trigger could be explained very briefly. This way it could potentially be clearer why Eldub is reacting the way he is reacting and how the player can protect him. Also, including sources in the game, for example in such an tutorial, can help persuade the user. This sadly has not been realized in the final concept of Eldub's Asthma Adventure.

On another note, there is one important bug that needs to be fixed and an additional problem that should possible be taken care of in the future. After around 15 minutes, the game stops working and needs to be restarted. This is especially annoying, because the game potentially will be played by hospital visitors and this is only possible if the game is running on the playground. If the game crashes every 15 minutes, this will not become reality. Therefore, fixing this issue is definitely recommended. Besides the crash sensitivity, the game is always running (for around 15 minutes) even when no one is playing the game. Therefore a code in the game could be implemented to make sure the game only starts again when a player is tracked. This is especially important, because this makes it possible for a player to starts from the start whenever they like to.

7.3 Other Recommendations

Three more important recommendations should be acknowledge, one concerning the interactive playground, one concerning another game and one concerning giving feedback. During the first observations, opinions were gathered and a playground expert mentioned that the game will be much more visible when the ground is white. Also, the playground is more inviting when a sign is placed in front of the playground. Even though this is not especially part of this graduation project, the game needs be played in order for the goal to be achieved. Therefore, the interactive playground should be inviting. However, observations in the hospital did ensure that, when the curtains are closed, the playground is clearly visible. Nonetheless, this is a more general recommendation in case there is a problem concerning this.

Also, in section 3.5 was mentioned that a second concept was going to be realized if there was more time given. This game was a memory game with athletes to help the children and their parents accept the disease (read more about this in section 3.4). Although this game has not being chosen to be realized, it was believed that the intended visualizations and videos of highlights of the athletes' careers really has potential.

8. CONCLUSIONS

In this chapter the requirements that were set in Section 3.1 will be discussed briefly and conclusions will be made concerning the implementations of these requirements. Additionally, answers to the research questions will be given. These questions are based on related research and interviews.

8.1 Requirements

Besides the answering of the research questions it is also essential to look at the fulfillment of the requirements. The table below shows the requirements mentioned in Section 3.1 together with their MoSCoW classification and if they were met of not. If the requirement is not met there was either not enough time or it was impossible to evaluate in the scope of this project. As can be seen in Table 3, every 'Must have'-requirement has been met, every 'Should have' – requirement is either met or impossible to evaluate in the scope in this project and therefore marked as 'yes/no' meaning 'unsure'. The 'Could have' and 'Would have'-requirements are not met as much. However, in the end a game for children with asthma has been made and the most of the important requirements have been met.

	Requirement	**Yes/No**	**Explanation**
Must	The education subject must either be exercise, asthma attack including medication, avoiding triggers or acceptation.	Yes	Educational topics in the game include: medication, avoiding triggers and exercise.
Must	Strategies from the PSD model must be included in the game.	Yes	Strategies from the PSD model that are included are: likable, reduction, similarity, reminders and simulation.
Must	The game(s) must be able to be played by a child aged 6 to 9 by themselves.	Yes	During the user tests was observed that children from 6 and above understood the game.
Must	The game(s) must still be fun even though it is educative, especially since there are children without asthma in the waiting room as well.	Yes	During the user tests children without asthma played the game as well. Every user was very curious, and the older children were very enthusiastic and active on the game.
Must	The educational aspects of the game must be implemented according to Section 2.2.1.	Yes/No	The goal of the game is definitely achievable, but still challenging. However, not every characteristic is used.
Must	The location of the interactive playground must be taken into account when designing the game, especially since it is located in a hospital.	Yes	The game is playable with the sound turned off and is approachable for whoever wants to play.
Must	The doctors must be satisfied with the content of the game.	Yes	The client was very happy with the results and the opinions that were collected were very positive.
Must	The game(s) must be able to be played by a child aged 6 to 9 by themselves, but also playing with their parent(s) must be a possibility.	Yes	The game is still a lot of fun when played together, maybe even more fun.

Should	The game(s) and the complete AIRplay project should motivate the children to be more physically active.	Yes/No	This is impossible to evaluate in the scope of this project.
Should	The game should include numerous game characteristics liked by boys, girls or both, including genres such as mastery, competition, destruction, puzzles, emotion, fantasy, discovery, creativity, real-world experience and nurturing.	Yes	Game characteristics in the game include: Active, destruction, nurturing, emotion, cooperative gameplay, feedback, goals and repetition.
Should	When playing with peers, asthmatic children should not feel left out or different when playing the game.	Yes	Most of the children with asthma barely show any symptoms while playing the game. It does not slow them down.
Should	This game should stimulate behavior change for both the children as the parent and thereby improving their asthma control.	Yes/No	This is impossible to evaluate in the scope of this project.
Could	This project could consist of several games, all educating the children about different asthmatic topics.	No	This requirement is not met due to lack of time.
Could	This game could include cooperative gameplay.	Yes	The game can be played with at most 4 players.
Could	This game(s) could include competitive gameplay.	No	The players can only play together and not against each other.
Could	The game(s) could include the color blue to trigger happiness.	Yes/No	The color blue is used in the game, whether this actually triggers happiness is unknown.
Could	The game(s) potentially could motivate the children to be active outside of the waiting room as well by ensuring them that physical activity does not necessarily result in an asthma attack or other (severe) asthma symptoms.	Yes/No	This is impossible to evaluate in the scope of this project.
Would	The game(s) would save personal data of the children to make the game experience more personal;	No	This requirement is not met due to lack of time and additional ethical issues.
Would	Each of the educational topics will be included when given the time.	No	This requirement is not met due to lack of time.
Would	The game(s) would be designed all for specific ages and gender, especially since the interests of boys and girls differ a lot and different ages would like to be addressed differently.	No	This requirement is not met due to lack of time.
Would	The game(s) would be connected to the app (made by another Creative Technology student)	No	This requirement is not met due to lack of time.
Would	The game(s) would track the activity of the children with the help of a FitBit (as in the AIRplay project)	No	This requirement is not met due to lack of time.
Would	Optimally, children will be curious about their disease and actually ask questions during their appointment with the doctor	Yes/No	This is impossible to evaluate in the scope of this project.

Table 3: The requirements together with their MoSCoW classification and if they are met or not.

8.2 Research Questions

The research question of this graduation project was first mentioned in section 1.4 and is the following.

"What is a good educational game on the playground in the waiting room at 'Medisch Spectrum Twente' for children with asthma to support self-management?"

In order to answer the research question optimally, numerous sub questions will be answered beforehand. These questions will be answered based on research that has been done and will be answered very broadly. The answer to the research question will be a summary of these sub questions and additionally a more specified answered will be given concerning the actual game that has been made for on the interactive playground.

★ *What are the circumstances in the waiting room?*

Children tend to not take their medication when they are supposed to, and instructions given during the interview is not taken too seriously. They either ignore the instructions and later forget about it or do not understand the importance of it at all. This problem suggests that improvement is definitely possible in this area, which potentially will be accomplished with the game that has been made. Also, during the interview has been mentioned that especially accepting the disease has been found difficult for the parent.

Another important conclusion made concerning this sub question are the circumstances in the waiting room. Children are around 15 to 30 minutes in the waiting room. In total around 50 children will visit the waiting room in a morning or afternoon, excluding siblings or peers that are brought along. On average, there are around 5 to 10 children in the waiting room at the same time and each child has an appointment with the doctor 3 times a year once they have passed the introduction phase. As expected, a lot of children with asthma that attend MST are overweight.

★ *Which elements of self-management are appropriate to learn in this game?*

Self-management is very important, because optimal asthma control can reduce asthma symptoms drastically. Three of the most important factors of asthma management include, keeping an active lifestyle, medication adherence and asthma education. All of these factors can be included in a way in the game. However, the focus should be on education. Especially, since the interactive playground itself already promotes full-body movement and therefore physical activity. Topics that could be included in the game are avoiding triggers, dealing with asthma attacks, medication, playing sports, acceptation and proper nutrition. If the user is educated significantly about these topics, they will have an better idea on how to manage their disease. This knowledge can be implemented in their daily life to reduce asthma symptoms and increase their overall quality of life. Although the focus should be on education, as mentioned, an optional education topic could be playing sports or medication. This gives the chance to include more factors that support self-management in the game.

★ *Which design elements should and should not be used to attract the specific target group?*

The game is designed for children between 6 and 9 years old and can be played with at most 4 players. From the age of 6, children learn how to read, however the information given in the form of a text should not be too difficult. Additionally, games start to become really important at this age and they tend to

have an opinion concerning games as well. Game characteristics that boys and/or girls tend to like, include: explorative, reality, problem-solving, emotion, destruction, challenge, puzzles, creativity and nurturing. Since the target group includes both boys and girls it is important to combine more than one game characteristic in the game, either preferred by boys, girls, or both. This will potentially attract a bigger group of children. On another note, colors also have an influence on the game experience. More specifically, on the emotions of the player. For example, blue tends to be interpreted as a happy color and red is associated with negative valence.

★ *Why will a physical serious game improve the learning experience of children?*

In order to make a game educative, engagement is especially important because this affects motivation. Additionally, game characteristics can be blurred with instructional content to create an educational game and improve the learning experience. These game characteristics include competition and goals, control, challenges, fantasy, immediate feedback and repetition. It is very important that at least some of these characteristics are implemented and mixed well together with the education, in order for it to be useful for the target group. These characteristics can influence the motivation and therefore the overall learning experience of the player. Also, strategies from the PSD model can be used in the game to persuade the user into playing the game and push them into the right direction. Strategies that could be included can be found in Appendix B. Adding full-body movement to a serious game potentially improves the experience of the user even more. Although there is not one experiment that confirms this, there are numerous theories. Most theories are built on the connection between body and mind, and the improvement of the learning experience due to an increment of motivation.

What is a good educational game on the playground in the waiting room at 'Medisch Spectrum Twente' for children with asthma to support self-management?"

A good educational game considers every aspect that has just been mentioned. This game has been made interesting for a reasonably large target group by implementing numerous game characteristics such as: feedback, an avatar, goals, active gameplay, sound, cooperative gameplay, destruction and emotion. Additionally, features from the PSD model have been implemented, such as the game is designed to be likable, playing the game will reduce the effort, reminders are implemented and the game has been designed in such a way that it is comparable with their own lives. These game characteristics should be divided equally with the education. The game includes educational topics: playing sports, avoiding triggers and medication. Potentially, implementing the educational topics in an active game will improve the learning experience and therefore support the self-management of the children.

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10. APPENDIX

10.1 Appendix A

Question concerning asthma

1) What is the most important information a child should know when it has asthma?
"The first thing I think that we need to get across is that they accept the diagnosis. It is just the first hurdle to take. That they have to really accept, and both parent and child, that they have it. Sometimes they said like., when does it go over or is it serious, so that's the first important thing I think that they should be aware of and that they accept the diagnosis."

2) Do they bring them only when they notice that their child starts having problems with his/her breathing or only when they have asthma attacks?
"Uhm… Well we do want that they inform us before they have an attack. Because once you have an attack it is very hard to reverse it so we want to. That is the challenge in asthma, to pick up the soft signals, not only we but also the parents and the child itself to uh… then you can anticipate attacks."

2b) So it depends, you might have for example children coming when they only have trouble breathing right? And they just tell you 'my child has a problem with it'?
"That is also another issue, most of the time you talk about things that happened in the past. So you are trying to get an picture of how things.. what the problems were. So that is also kind of a challenge to really get an objective opinion about the magnitude of the problems. Sometimes the parents of the children are very worried so they will exaggerate it. Sometimes it's the other way around of course."

3) Are parents well-informed of what is asthma before they consult with the doctor? How many do they know (a percentage)?
"No, they have to- when they accept the diagnoses, you have to explain them; what is asthma and what is the prognosis of it and, so they have to, they need to be informed about what it is. What they should recon with, how they should cope with it."

4) What are the steps after diagnosis when a child has asthma? What information does the child get when it gets diagnosed that it has asthma?
"So, when the child and the parents are informed and they accept the diagnosis, then, only then you can kick off with the management. How you can… management consists of course of medication, but also a lot around medication. And how to monitor the disease. This is like a work in progress."

4b) Because every patient is different right?
"Every patient is different and also, the parents, the child and the doctor has to- they are trying to get a learning curve to understand each other, to communicate on a higher level. And to learn to- how to interpret the symptoms of a child. And this is like- you have to improve, and- but with some patients it goes slow and sometimes it goes pretty quickly."

4c) So both of them need to get informed, right?
"The parent and the child both need to get informed, but the doctor also needs to learn the patient. Learn to know the patient."

4d) So you first make a history of the patient?
"Yes you check the history of the child (ticking the boxes of the form) but also of course you need to communicate with the patient while you manage the child. Of course it's very different when the child is four years old or sixteen, that's a very different situation."

4e) Children that come here are between four and sixteen years old?
"Asthma can only be diagnosed when you're like four years old, because then you have a proper lung function, then you can say for sure."

6) How many appointments with the doctor should the child have per year about its condition?
"*On average I would say like 3 times but it can be 10 and sometimes it can be 1, it depends."*

7) How long does the session take in order to get informed about asthma?
"It also depends on the patient but this is also a growing process. Usually the first time you see the patient, you will see them for a second and third time in a time spare of like 6 to 8 weeks. You will see them 3 times because you need to do the diagnose properly and you have to explain it and the patient has to absorb the information, so it takes like 3 appointments to really get the plan started."

7b) Only in the session? Each time you meet? Is there any difference between time as well I guess? Roughly?
"We do it differently here than in other places in Holland. The first appointment is like 15 minutes and usually you will send the patient for a diagnostics session and that is like maybe half an hour or an hour. And then you also start off therapy if you have a plan and the third session is the first time you will hear the feedback of the parents and the child after starting the therapy. This is also in the time slot of 4 weeks and this will be like also about 15 minutes."

7c) And is it only with the doctor or is it with a whole team?
"Usually the first and third is only with the doctor, well.. sometimes also the first visit is with the nurse and it takes longer and it is like 30 minutes, this can depend sometimes. One of the three there will be a nurse there, an asthma nurse. So usually there can be a nurse on the first and third visit. And the second visit which is the diagnostic visit is with the team of like other people as well, such as lung function, exercise test, allergy test, sometimes x-rays, sometimes blood sampling."

7d) And on the third session then you understand what kind of asthma the child has right?
"*After the first visit I get a really good picture of what the size of the problem is."*

8) Do the children get an asthma action plan when they go home?
"Sure, yes."

9) How many children come here because of an asthma attack per year in the MST hospital?
"We have thousand patients, about thousand patients, and about 50 so 1/20 will be admitted in a year for an asthma attack. Mostly asthma attacks can be solved with medication so they come here for like an emergency visit and then they don't have to be admitted. So 1/20 children will be admitted in one year."

9b) 1000 patients are children right?
"Yeah.

So the cost of.. no the budget is one million, so on each child you spend about 1000 euro but some, if if they get admitted, it is 7000 euro. That is the average amount you spend in a hospital for a child that is admitted to the hospital, so you want to try and avoid admitting children of course for the quality standard point of view and also from money point of view."

10) After the session is done, how does the child feel? Is it overwhelmed with the information, does it care?
"You try not to make the child overwhelmed. I think that is also a big challenge for the doctor, you can go on and on with the information but you know when my car is broken, I will bring it to the garage and they try to make it, sometimes the guy will explain to me what is wrong with it and sometimes I will have a quick explanation, sometimes I am not that interested really So to some people sometimes you have to give the information that they need of course but sometimes enough is enough."

11) After the session is done, how does the parent feel? Is he overwhelmed with the information?
"Well we have of course parents with very different educational levels so that is what you have to always take into consideration. As a doctor you have to really try to adapt to the level of the child, but also the parent, your explanation. That's a big challenge for educational point of view. One size does not fit all. Because for example when the explanation is too simple for a parent with a high level is also annoying for them. So you will have to really adjust to the patient."

11a) So the parents are only from the Twente region?
"We are having welcome visits to the hospital. Today we had parents from Arnhem. So we can have parents from outside the region of Twente as well, but usually they are from Twente."

12) As a doctor are you satisfied with how children are treated in this hospital? Do you think something could be improved?
"Sure, I think the modern technology is really something that can improve things. Now it is possible to communicate on another level really, so it should be employed in care but still it has not been done so hopefully one day. But we are trying to convince everybody that it is possible but we need to be also sure that when you do something that it is as good as you did before."

12a) So you are positive on combining medicine and technology together?
"Sure because the children are young, they are comfortable with technology, but the parents of the children are also relatively young. They are people like between 25- 40 so they have been growing up with modern technology. Well technology here is 20 years or something. So they have been growing up with it."

12b) One important thing you mentioned that it should be as good as the current treatment. So you want to replace it or do you want to use it as tool to improve the current treatment?
"I would like to replace it but sure the parents have to also want this kind of treatment. But we have had experiences with trials, with wearables and stuff and other ways of communication and 8/10 parents did like to do it. Because most of the families in the Netherlands, both of the parents work so... the old kind system is very slow and is not flexible as well, the patients are fixed to a certain time. It is much easier to have your pediatric nutrition in your pocket or your smartphone. That is very easy. Like how you communicate with your friends. I think it is for parents very attractive but also we have to, as caregivers, we have to select the relevant information."

13) What is the biggest threat in the Netherlands that causes children to have severe asthma?
"Well at the basics of therapy like taking your medication and take it in a right way.. I think also accepting is also a big thing. Sometimes people, parents, they don't like, they don't fully accept it and then your

motivation to comply with therapy is low. If you say well, I am not sure about this doctor saying that my child has asthma then maybe you are not so prone to take your medication all the time."

13a) So if they don't accept it they don't get treat it well right?
"Yea, sure."

13b) It's not because they are not well informed?
"Also maybe because of that. It could be different things. I think acceptation is very important and also uh, it is all linked together so they need to be informed. Writing a recipe is not enough, you might as well tear it apart. It is no use, you have to give the full package. Medication is just something in it. It needs to be handled in full package."

13c) The parent will only get alarmed when the child has something very severe, then they are shocked he has a problem, I need to take him to an hospital and do something about it.
"Yeah, but sometimes parents are also too worried. They go to the hospital too quickly. That's also a problem. So they have to learn how to manage their child themselves."

14) How many children after the treatment show less asthma symptoms?
"Well the medication we use is very effective. So, I think those children get much better."

14b) Can you give me a percentage?
"Like 70% will do very well, 10-20% acceptable, and 5-10% not so well for various reasons."

16) What kind of technology exists already in the hospital MST that treat children with asthma?
"Then we have to go to the other room, oh we have some stuff here already. I think this is a big innovation, it's brand new, and it has to be used with this tablet. This is a powder inhaler, so you just open up and you have to inhale and the medication comes out. And there is a device where you can put it in and it will work. And the device will registrate if you use it, to make sure that the parents see that it is good, but the device will also measure the flow with which you inhale the powder. It is very important that you inhale it in a proper manner. Children are taught how to do it, but they need to do it in a proper way. They can also get feedback on this iPad, which is signalized with our own computer. So the doctor is informed about the child taking the information, but also taking it the right way, but this is brand new. There is other stuff. We are using this in trials. It is not on the market yet.

This is on the market already, you know puffers right. Every time you click, it will count. It registrate the time and if you took it. Sometimes, what does happen, children come to the hospital and I ask them to take their medication all the time. So when they come here and it is empty, it should be empty, but they might have used all of the medication on the parking lot in front of the hospital. Of course you also inform the patient about it, it is not like a secret.

So this is a big innovation I think because then you also measure the flow (first one). If somebody naturally inhales too forceful then you can change it to another inhaler which needs more forceful inhalation."

16a) Is it real time, so you can get a graph on the display?
"It is real time, yeah, yeah. Brand new stuff. There was a camera team from NY filming us with this new thing. We did not make this product. It was made by a small firm in Italy and now they have been connected to a bigger firm which is producing this thing. We are the first one who do trials with it, so we will see. But this will be a big step I think, because as a doctor you also, if you want to convert to eHealth, you have to be sure if the patient is taking the right things. You have to know."

16b) What's the name of this?
"Respiro (?), and we also have like lung function devices that the children can take home and we use accelerator meters so we know their physical activity. We also use heart rate measures/things and respiration rate. There is one sticker and if you use it you can measure its heart rate and respiration rate in real time. If the child plays at home, playing soccer or something, during playing his heart rate and respiration is higher, but if it does not come down quickly, the recovery takes longer, then you know that the asthma is not well controlled. That's also an important thing. So we have different tools and wearables to convert to eHealth, but now that we have this thing (again first thing), now I really dare to take the jump."

Questions concerning this graduation project

14) What's the average waiting time?
"Oh… that's a very good question. Actually, I don't know, but I think, in my clinics it will be maybe 15-30 minutes or something?"

15) How many children/(people?) are there in the waiting room?
"Usually there is about 4 people doing clinics. So this will be in total maybe 50 children in, the morning. But they are there not at the same time. They come and go. So there will be on average maybe 10 children or something. 5-10 maybe."

16) Do you notice that a lot of the children are overweight?
"We know that they are overweight, sure, although if everybody is overweight, then you are not overweight anymore. 1 out of 7 children is overweight. And children from an immigrant background it's 1 in 3. There is a connection between their background and overweight. And the WHO had pronounced that since last year more people in the world die from overweight than from starvation. It used to be the other way around but now the tables have turned. Even in Africa a lot of people die from overweight. There are also countries were they have enough food and people are really overweight. The variety they eat is very bad. Like, South Africa there is a lot of overweight."

17) Out of all kids that have asthma, how big is the percentage of children that also has EIA here at the hospital?
"Well we know from children who have asthma, which we measure I think 50-60% of the patients with asthma we see so that's 1000 have EIA. In the normal population of asthma it would be like 80-90 but, because we control it, it is less."

18) Is it a possibility for patients to make an appointment 10 minutes longer and schedule a session with the playground beforehand or afterwards?
"Sure, you will have to ask them before, but you can ask them if I have a normal consult. Depends what the child has to do, if it is something the child likes they will quicker."

18) Do you maybe have some ideas for a game which the children will enjoy?
"Well actually last Saturday, we had the hospital open door, so everybody could come in and all the things were shown that the hospital has to show. So we were also showing our playground to the people of Enschede, so there were loads of people coming here. It was interesting, I was there, to see how explorative children are with games. They do not ask a question even if you are there, they just go in and try and look. There was a very young child, maybe 3, and he was looking, then he was looking at the ceiling. He was trying to understand it. Maybe he knows it from at home, but it was interesting like 'what's going on here?'.

So yeah it's interesting, because we only did one game, gathering coins, but it was interesting for all the ages. Of course, the older child will get fed up easier, so uhm yeah I don't know what is attractive to kids. I am not a kid anymore, but I know they like it. That is what I know, I think it is a very effective way to teach children, it is their way to get knowledge. It has a big impact because it is visual. So I think it can be very powerful to hopefully increase the knowledge of the parent and the children. And in the end when the child grows up and will be an adult and has to manage his asthma for themselves. So I think investing knowledge for himself is always very important."

19) Is it genetically dependent, do children also have parents with asthma?
"Sure, from the mother it's stronger. If your mother has asthma the chance is 67%, your father 34% and both then 90 or something."

10.2 Appendix B

Table 1. Postulates behind Persuasive Systems
1. Information technology is never neutral.
2. People like their views about the world to be organized and consistent.
3. Direct and indirect routes are key persuasion strategies.
4. Persuasion is often incremental.
5. Persuasion through persuasive systems should always be open.
6. Persuasive systems should aim at unobtrusiveness.
7. Persuasive systems should aim at being both useful and easy to use.

Table 2: Postulates behind Persuasive Systems [52].

Table 2. Primary Task Support		
Principle	Example requirement	Example implementation
Reduction A system that reduces complex behavior into simple tasks helps users perform the target behavior, and it may increase the benefit/cost ratio of a behavior.	System should reduce effort that users expend with regard to performing their target behavior.	Mobile application for healthier eating habits lists proper food choices at fast food restaurants [Lee et al. 2006]. Smoking cessation Web site provides an interactive test that measures how much money a user will save with quitting.
Tunneling Using the system to guide users through a process or experience provides opportunities to persuade along the way.	System should guide users in the attitude change process by providing means for action that brings them closer to the target behavior.	Smoking cessation Web site offers information about treatment opportunities after a user has taken an interactive test about how addicted (s)he is on tobacco.
Tailoring Information provided by the system will be more persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group.	System should provide tailored information for its user groups.	Personal trainer Web site provides different information content for different user groups, e.g. beginners and professionals. Web site for recovering alcoholics presents stories that are close to the user's own story.
Personalization A system that offers personalized content or services has a greater capability for persuasion.	System should offer personalized content and services for its users.	Arguments most likely to be relevant for the user presented first on a professional Web site rather than in random order.
Self-monitoring A system that keeps track of one's own performance or status supports the user in achieving goals.	System should provide means for users to track their performance or status.	Heart rate monitor presents a user's heart rate and the duration of the exercise. Mobile phone application presents daily step count [Consolvo et al. 2006].
Simulation Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect.	System should provide means for observing the link between the cause and effect with regard to users' behavior.	Before-and-after pictures of people who have lost weight are presented on a Web site.
Rehearsal A system providing means with which to rehearse a behavior can enable people to change their attitudes or behavior in the real world.	System should provide means for rehearsing a target behavior.	A flying simulator to help flight pilots practice for severe weather conditions.

Table 3: Primary Task Support [52].

Table 3. Dialogue Support		
Principle	Example requirement	Example implementation
Praise By offering praise, a system can make users more open to persuasion.	System should use praise via words, images, symbols, or sounds as a way to provide user feedback information based on his/her behaviors.	Mobile application that aims at motivating teenagers to exercise praises user by sending automated text-messages for reaching individual goals. [Toscos et al. 2006]
Rewards Systems that reward target behaviors may have great persuasive powers.	System should provide virtual rewards for users in order to give credit for performing the target behavior.	Heart rate monitor gives users a virtual trophy if they follow their fitness program. Game rewards users by altering media items, such as sounds, background skin, or a user's avatar according to user's performance. [Sohn and Lee 2007]
Reminders If a system reminds users of their target behavior, the users will more likely achieve their goals.	System should remind users of their target behavior during the use of the system.	Caloric balance monitoring application sends text-messages to its users as daily reminders. [Lee et al. 2006]
Suggestion Systems offering fitting suggestions will have greater persuasive powers.	System should suggest that users carry out behaviors during the system use process.	Application for healthier eating habits suggests that children eat fruits instead of candy at snack time.
Similarity People are more readily persuaded through systems that remind them of themselves in some meaningful way.	System should imitate its users in some specific way.	Slang names are used in an application which aims at motivating teenagers to exercise. [Toscos et al. 2006]
Liking A system that is visually attractive for its users is likely to be more persuasive.	System should have a look and feel that appeals to its users.	Web site that aims at encouraging children to take care of their pets properly has pictures of cute animals.
Social role If a system adopts a social role, users will more likely use it for persuasive purposes.	System should adopt a social role.	E-health application has a virtual specialist to support communication between users and health specialists. [Silva et al. 2006]

Table 4: Dialogue Support [52].

Table 4. System Credibility Support		
Principle	Example requirement	Example implementation
Trustworthiness A system that is viewed as trustworthy will have increased powers of persuasion.	System should provide information that is truthful, fair and unbiased.	Company Web site provides information related to its products rather than simply providing biased advertising or marketing information.
Expertise A system that is viewed as incorporating expertise will have increased powers of persuasion.	System should provide information showing knowledge, experience, and competence.	Company Web site provides information about their core knowledge base. Mobile application is updated regularly and there are no dangling links or out-of-date information.
Surface credibility People make initial assessments of the system credibility based on a firsthand inspection.	System should have competent look and feel.	There are only a limited number of, and a logical reason for, ads on a Web site or mobile application.
Real-world feel A system that highlights people or organization behind its content or services will have more credibility.	System should provide information of the organization and/or actual people behind its content and services.	Company Web site provides possibilities to contact specific people through sending feedback or asking questions.
Authority A system that leverages roles of authority will have enhanced powers of persuasion.	System should refer to people in the role of authority.	Web site quotes an authority, such as a statement by government health office.
Third-party endorsements Third-party endorsements, especially from well-known and respected sources, boost perceptions on system credibility.	System should provide endorsements from respected sources.	E-shop shows a logo of a certificate that assures that they use secure connections. Web site refers to its reward for high usability.
Verifiability Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources.	System should provide means to verify the accuracy of site content via outside sources.	Claims on a Web site are supported by offering links to other web sites.

Table 5: System Credibility Support [52].

10.3 Appendix C

Second interview with a doctor (blue) and a GT specialist (red)

1) What are your first impressions of the game?
D: "Positive. I also really think that it is something that motivates children to be move and be physically active."

"Yeah me too, very positive. Especially because it is fun and interesting for numerous age groups. I definitely think that the children will be very active on it."

2) Is the information that is given in the game representable and correct?
"The information is correct in terms of medical content. The triggers that are named are the most known triggers. You have made it more visible to show what the positive and what the negative triggers are."

"What is also really well is that you include exercise in such a way. Exercise is good for you if you are healthy, but if you are not doing so well it actually can be a negative trigger. That is also very well… I'm not sure, but did you really explain this in the game? Did you give some information during the game about this? Something like: also be aware right now of…?

When the ball spawns for the first time, a text is initiated that explains the player that exercise is good for if you are feeling well.

"Ahh yeah, I remember. That is fine. Just to make sure that the children do know about it and that they are not surprised to see a red ball instead of a green one."

"It would be nice if you have a very good 'one-liner' for every item. That you can read it and hear it. Repetition is simply very educative."

3) At this moment I have tried to include as many triggers as possible. Do you think it will be a problem that Eldub is allergic to so many triggers or is this believable?

"In a way it is definitely believable. Every child is allergic to something else, or not allergic, but all of them are triggers. So it is definitely possible that these triggers influence of someone's asthma. So I think that it is good to implement as many triggers as possible. Else there could be children who can not relate to the game, because they are missing triggers that influence their asthma."

"Some triggers are always bad, such as smoke and exhaust gases, air polluters are always bad. And old air is also always stimulating for asthma. And you also have exercise, which can be either good or bad. Anyways, for example, although a child might not be allergic to a cat or dog, they could be allergic to another animal. The cat and dog can represent every animal."

"So this does not mean that is would be bad to include the cat and dog picture in the game."

"You could add a 'one-liner' to generalize the element."

"Indeed, you could add information that says, "I am allergic to some things", but still every triggers should be implemented in the game."

3b) Right now I have the start screen on which every trigger is introduced. Do you think this is good enough?

"Right now you have dogs and cats right? That's fine right?"

"Yeah, that should be fine. One more thing. You have chronical allergies, but you also have seasonal allergies, such as pollen. Here also a 'one-liner' could be added. "I have to me more careful in the hay fever season" (or in Dutch since the game is in Dutch: "In het hooikoortsseizoen moet ik beter oppassen")."

Don't you think that in order to do this, too much information has to be given? Making the game boring?

"No I don't think so. If you just show the information one time for each trigger which consists of 1 sentence, and continue the game after, it should not be too much."

"Yeah I also think that it is possible."

"Or you could add some sort of tutorial at the start of a level that the player has to play for 10-15 seconds. Every one-liner appears here and every picture should be introduced, and then the actual game starts. I am not sure if that will be too complicated."

"The power of education can be found in repetition. However, repetition can be boring. And this way you can repeat the information without making it boring. When the children are told what to do, it keeps going wrong even though they have been told about if for at least ten times. Although they are instructed to take care of their asthma in some ways, they ignore this and this way they eventually forget about it. Teaching the children while they are actually playing makes education more interesting and could help as a reminder."

4) Should something be added?
"No, you should try to keep is as simple as possible. However, there is one thing that you could do. Messages such as "Wow, you are protecting me very well". And I really like this, because children are very sensitive to such feedback. Maybe you should make this more diverse. "Good job!" Because that is really simple to do right?"

"Not necessarily more feedback is needed, but the feedback should be more diverse."

Right now there are actually four different kind of messages, this is connected to the health of the little creature. When he is healthy, the message is positive. "Wow, you are protecting me very well." However, if he is very close to having a heart attack he says something like, "I don't feel so well". But if you play the game really well, there is only a very small chance that all of the messages will show.

"Maybe the messages then need to pop up quicker when an asthma attack is nearby."

5) Is the game designed optimally for on an interactive playground?
"It would not surprise me if a lot of children are going to stand in the middle to stop all of the triggers the most sufficient way. Yeah, I can't really come up with a solution right now. Maybe an element can be added to 'force' them to move."

“A second avatar!”

And then hope that they play alone.

“Or else they are both going to stand on 1? Yeah. Maybe the avatar can pop up at different locations. That he jumps.”

“For 20 seconds he stands on one location and then he jumps… that’s also possible. But yeah, maybe you should just see what happens and what the children will do. If you see them play and they actually stand still at that position, yeah then something should be changed. But if they are very active then there is no problem.”

“They might want to catch the triggers as soon as possible.”

“Oh yeah, that could be a good one. If you want to go for a high score; the faster you destroy a trigger, the more points you get. That could be told beforehand or maybe write it down on the main screen of the game. Then they have to run. I really think that that could be a great addition.”

“Makes it more fanatical. Then you start running as soon as you see it.”

6) What elements of my game have potential but could be improved easily to attract the target group more?
“I really think that the concept itself is great.”

“I think it is also well extended.”

“Definitely. What we already said before (the interview), to personalize the game, to let the user choose their avatar. This gives the possibility to attract different age groups. An older child would choose another avatar than a younger child.”

“Although it is a bit difficult if you play the game with more than 1 player and have to pick the avatar together, but that is part of it.”

“I can even imagine that if you pick for Ronaldo for example, that the game can be played in a football theme.”

“The background could be a lawn.”

“Or instead of the sounds that are used now, you could implement cheers for a goal when you destroy the right trigger. And if a little girl decides to pick a princess as the avatar, the background could be changed to pink clouds and the oDverall theme could be Disney.”

10.4 Appendix D

Questionnaire (in Dutch)

Vragenlijst User test 06/2018

Leeftijd kind: …… , Geslacht kind: …….

(dit is belangrijk omdat de spellen gemaakt zijn voor bepaalde leeftijdscategorien)

Vragen:

1. Heb je nieuwe dingen geleerd over astma? Ja / nee ; Indien ja, wat?

……

……

2. Wat vond je het leukst?

……

……

3. Wat vond je minder leuk?

……

……

4. Wat vind je van hoe het eruit ziet?

……

……

5. Zou je dit spel vaker spelen hier? Ja / nee

Brochure (in Dutch)

06/2018

Een leerzaam spel voor kinderen met astma

EXPERIMENT

Als u hier al eens eerder bent geweest dan heeft u de playground vast al eens gezien. Kinderen, maar ook volwassenen, kunnen hier actief spelen terwijl ze wachten op een afspraak met de dokter. Het spel wat gespeeld kan worden op de playground wordt mogelijk vernieuwd.

Het nieuwe spel is gemaakt speciaal voor kinderen met astma die graag wat meer willen leren hierover. Tijdens het spelen op de playground kunnen u en uw kind leren over positieve en negatieve factoren die astma (mogelijk) beïnvloeden. Tegelijkertijd is het ook een super leuk en actief spel die gespeeld kan worden tijdens het wachten in de wachtkamer net zoals het vorige spel.

Voor de beste resultaten is het zeer belangrijk dat de doelgroep het spel probeert voordat dit project wordt afgerond. Uw hulp wordt daarvoor zeer gewaardeerd.

Het experiment duurt ongeveer 15 minuten.

Eerst zal ik u vragen om het spel te spelen en vervolgens wil ik u en uw kind graag een aantal korte vragen stellen. Deze informatie wordt vervolgens verwerkt in een verbeterde versie van het spel.

Hartelijk bedankt!

Screenshot van het spel op de computer.

Wie ben ik?

Mijn naam is Denise van Ingen en ik studeer Creative Technology aan de Universiteit in Twente. Ik ben 21 jaar en ben op het moment bezig met afstuderen. Uw hulp wordt zeer gewaardeerd.

Heel erg bedankt voor u medewerking!

UNIVERSITY OF TWENTE.