UNIVERSITY OF TWENTE.

Re-Play

INTERACTIVE PLAYGROUND GAMES TO MOTIVATE PLAYING

BACHELOR THESIS

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Creative Technology

February – July 2018

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ACKNOWLEDGMENTS

Foremost, I would like to express my gratitude to the supervisor of this project, dr. ir. Robby van Delden, whose guidance, feedback and relevant suggestions for improvement, helped me to accomplish this task. I also would like to thank dr. ir. Dennis Reidsma not only for being the critical observer of this project but also for setting the beginning of the Creative Technology bachelor programme.

Furthermore, I would also like to show my appreciation to the client of this project, Allard Dijkstra from the Roessingh Rehabilitation Center without whom this project would not have been initiated.

Last but not least, none of this could have happened without the support I received from the people close to me. I would like to thank my family and friends for encouraging me in finalizing this project within the short timeframe.

ABSTRACT

Children with motor disorders have difficulties with fine and gross motor skills, which make it harder for them to perform a moderate-vigorous physical activity. Because it requires a lot of effort, children avoid doing physical activities outside of their rehabilitation sessions. Instead, they prefer to play video games, which are easier to master and make them feel competent. However, an increase in physical activity can help the children to overcome the difficulties associated with their disorder and improve their quality of life.

Within this research two interactive playground games have been designed – a single player game and a multiplayer game. The games can be used in pediatric physiotherapy sessions as a tool to encourage patients with motor deficiencies to be physically active while playing, even outside the scope of the rehabilitation. Both games are inspired by and include the elements of the well-known rock-paper-scissors game. Since the aim is also to inspire the children to play without technology, the multiplayer interactive playground game is transferable to a real-life setting.

The games were tested in order to evaluate how successful they are in the context of promoting physical activity. The multiplayer interactive playground game was evaluated also for the value it gives to the real-life play. The results showed that the single player game triggers different physical movements like running, jumping and sliding on the floor. The multiplayer game, on the other hand, was not fully successful due to limitations in its implementation and the technology of the interactive playground. However, a between-subject experiment with experimental and control groups showed that the interactive playground game influences the play of the real-life game as it gives insights to the players for additional rules and game elements.

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1. INTRODUCTION

The introduction chapter of this report will describe the motivation for the project along with the goal of it. Guiding research questions will be discussed, as well.

1.1. Motivation

Considering the presence of the attractive video/computer games, motivating children to be physically active is a challenging task. If it is difficult for ordinary children to get active, what about the ones with a motor deficiency, who get frustrated and lose interest every time they attempt to be active? Around 350 children every week go for a treatment in Roessingh[1] – a rehabilitation center in Enschede, the Netherlands. Usually, they have a sedentary lifestyle as they prefer to sit on the couch and play attractive video games instead of participating in physical interactions like playing in the park (Allard Dijkstra, personal communication, February 2018).

It is usual for children with a motor disorder to have a lower level of fitness due to (their condition and) the fact that completing simple exercises is most of the time extremely challenging for them. As a result, they are demotivated and no longer have a desire to participate. Nevertheless, being physically active is essential for the health benefit of these children. Involving them in physical activities improves the overall well-being as it promotes social engagement and trains the muscles and minimizes deconditioning [15].

1.2. Project background

This project is assigned by Roessingh – a rehabilitation center located in Enschede. Roessingh has treatment programs for all kinds of diagnostic groups. Depending on their condition the patients are treated differently. There are departments for adults, for kids and for people with pain. The clinical rehabilitation for children is complex. It includes multidisciplinary specialists as a general practitioner, who coordinates the medical care, a physiotherapist, who is responsible for assessing and treatment of motor functions, an occupational therapist, who is responsible for treatment of arm function, a speech therapist, who helps with the speech, eating and swallowing, music and drama therapists, who deals with psychologic and emotional problems, and a social worker, who helps parents and family with the care of the child. The rehabilitation process is complex and aims to help children and parents to be as independent as possible.

The Roessingh pediatric department offers a ten-week intervention program for the children in a motor detrimental situation. The problem, which the rehabilitation specialists encounter, is that the children in this program are living sedentarily - they prefer to play the attractive computer games over the physical activities like walking or playing in the park. The Re-play project is based on this intervention and

[1] "Roessingh Centrum voor Revalidatie", Roessingh Centrum voor Revalidatie, 2018. [Online]. Available: https://www.roessingh.nl/. [Accessed: 19- Apr- 2018].

aims to stimulate physical (re)conditioning in children in rehabilitation programs with the help of mobile coaching and game elements. The initial project consists of two parts: one that focuses on self-management and another that focuses on physical activity. The project, subject of this paper, *Re-play – interactive playground games to motivate playing* is built on the second part.

1.3. Goal

In the context of the project, devoted to motivating children with motor deficiency to remain physically active on daily basis outside the scope of their rehabilitation, interactive playground games will be created. Games wherein the player needs to perform some kind of physical activity as walking, running, jumping in order to proceed with the game.

It should be kept in mind that the target group is not limited to a specific diagnosed group and it is important that the game is suitable or adjustable for diverse profiles of players. Moreover, the game will be a part of rehabilitation sessions, meaning that it must evolve over time and meet the new needs of the young patients and their therapist. Achieving the goal of this project would mean that the children are inspired to continue playing the interactive playground games but without the technology.

1.4. Research question

The primary purpose of this project is creating a game, which fulfils the goal stated above. In order to do this, a set of demands needs to be taken into consideration. First, the game should be suitable for the target group – children with motor deficiency. Second, the game should be compatible with the interactive playground. Third, it should promote physical activity. And finally, it should be possible for the children to play a version of the game without the interactive floor. Based on these demands, the initial research question is formulated as follows:

> *How to design an interactive playground game which encourages physical activity among children with motor deficiencies and gives them insights how to play outside the boundaries of the playground?*

The main research question is supported by sub-questions, which serve as guidelines for the research phase of the project:

What are the components enhancing children's motivation to be active?
What game design elements can be used to trigger behavior change?
Which game mechanics motivate children to be physically active?

1.5. Report outline

In the next pages of this report, the steps that lead to the answer to the main research question are described in detail.

In the following section, Chapter 2: *State of the Art*, a background research is presented, including an analysis of the target group – description of the disorders, importance of physical activity, triggers that motivate children to be physically active and game elements can support these triggers. The background research is followed by a review of related work and an interview with the client of this project.

In Chapter 3, the research approach, composed of three phases, is introduced. Each phase is briefly described in this chapter. These phases are the ideation, design specification and realization, which are each chapter on their own. Chapter 4: *Ideation*, gives a full description of the ideation phase. During the ideation phase, 10 game design ideas are generated and described. These ideas are then evaluated and the most promising one is chosen. Chapter 5: *Design Specification*, gives a detailed description of the chosen game concept based on the game elements – story, mechanics, aesthetics and technology. Chapter 6: *Realization* sets the end of the research approach. This chapter depicts the implementation of the chosen game as the general choices of game design elements are justified and pictures of the end results are provided.

After that, Chapter 7: *Evaluation* focuses on the testing of the final game. In this chapter, the testing protocol is first described in detail. Then the actual performance of the testing is reflected until at the end the results are reported and analyzed.

The next chapter, Chapter 8: *Discussion*, presents a review of the conducted research with its limitations and suggestions for improvement and future work.

The report ends with Chapter 9: *Conclusion*, where an answer to the research question is given.

2. STATE OF THE ART

The State of the Art chapter contains, first, a description of the physical disorders that the children from the target group have and how physical activity can improve their situation. Then, a review of existing scientific papers and works, relevant to the project, is made.

2.1. Definition of the disorders

The focus is mainly on two physical disorders, namely – Developmental coordination disorder (DCD) and Cerebral palsy (CP). A brief description of both the conditions will be provided in order to get insights of the limitations they cause and the benefits of physical activities.

2.1.1. Developmental coordination disorder

Developmental coordination disorder (DCD) is a neurodevelopmental disorder with unknown etiology. It is characterized by poor motor skills, which causes coordination difficulties. Even though the disorder does not affect the intellectual abilities, it has a negative impact on the academic progress, social integration and emotional development [1]. Children with DCD are likely to be socially isolated, be excluded from group play activities, have a low perception of self-worth and experience symptoms of anxiety and depression [8]. Moreover, motor activities, important for the normal development of fitness and overall health, such as running, jumping, walking require a lot of effort and practice to be performed by children in such a condition[2]. Children diagnosed with DCD have troubles in learning and performing common everyday tasks which negatively affects the quality of life.

2.1.2. Cerebral Palsy

Cerebral palsy is a disorder caused by brain damage, which may occur either before or after a baby's delivery. It affects muscle tone, movement, and motor skills[3]. Affected children have symptoms like muscle tightness or spasms because of which patients take abnormal postures, difficulty with gross motor skills such as walking, running and stabilizing, difficulty with fine motor skills such as writing, grasping/releasing objects, poorly coordinated movements[22]. According to the part of the brain affected, there are 3 different types of CP.

The first type is called spastic cerebral palsy and it is characterized by having really tight or stiff muscles causing patients' movements to look convulsive. This type of CP is caused by an abnormality in the upper motor neurons, making the muscles over-excited (hypertonia).

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[2] "Developmental Coordination Disorder | CanChild", Canchild.ca, 2018. [Online]. Available: https://www.canchild.ca/en/diagnoses/developmental-coordination-disorder. [Accessed: 19- Apr- 2018].

[3] L. Hirsch, "Cerebral Palsy", Kidshealth.org, 2015. [Online]. Available: https://kidshealth.org/en/parents/cerebral-palsy.html. [Accessed: 19- Apr- 2018].

The second type of cerebral palsy is dyskinetic and involves damage to basal ganglia, which is a part of the brain initiating and preventing certain movements. As a result of the damage, patients can have involuntary movements in limbs or trunk – out of their control.

The third type of CP is called ataxic and is caused by damage to the cerebellum, which helps with coordination and fine movements. The diagnosed patients have clumsy or unstable movements and poor balance when doing something like walking or picking something up.

There is no cure for CP, but the disorder is non-progressive, meaning that it does not get worse over time and the symptoms can be improved with the help of medicines and physical therapy.

2.1.3. Importance of physical activity

Reversing deconditioning, optimizing physical functioning and enhancing overall well-being are only a few of the many benefits of physical activity among people with disabilities. In comparison to typical children, children with disabilities have lower fitness, lower muscle strength and prompt to an obesity and health conditions associated with it [11]. Rimmer [5] explores how the physical limitations of patients diagnosed with cerebral palsy can be minimized and concluded that physical activity is very beneficial because it helps to control or slow the progress of a chronic disease and improve overall health and functioning. "Physical consequences of inactivity for person with disabilities include reduced cardiovascular fitness, osteoporosis, and impaired circulation" [15, p.1058]. Moreover, physical inactivity can be a reason for decreased self-esteem and lower social acceptance. People with disabilities are usually dependent on others for daily living, but they can become more independent if exercise regularly. Dykens, Rosner and Butterbaugh [4] claim that physical activity can also heighten the psychological well-being of children with disabilities as it provides opportunities to make friendships .That is why physical activity, especially among children with different disorders, must be increased.

2.2. Motivational theoretical models

There are several theoretical models that can give insights what are the factors that can motivate physical activity. Kosma, Cardinal and Rintala [12] make an overview of several models that can be used as a tool for identifying strategies for motivating physical activity participation. The most important theories discussed in the study are *Achievement Goal Theory* (Nicholls, 1989), *Competence Motivational Theory* (Harter, 1978), and *Movement Confidence* (Griffin & Keogh, 1982).

First, according to the *achievement goal theory*, the use of specific motivational strategies depends mainly on how the individual is oriented. In the scope of this theory, a person can be task or ego oriented, or both task and ego oriented [12]. A task-oriented individual wants to self-improve and master a

particular skill so they tend to choose a challenging task which requires maximum effort. They experience positive affect when accomplishing the hard task and continue doing it because they want to improve. While for the ego-oriented individual it is important to outperform the others. In this case, a challenging task, which requires maximum effort, will have positive affect only when winning is the outcome.

Second, the *competence motivational theory* developed by Harter in 1978 is reviewed. Kosma, Cardinal and Rintala [12] explain that it is characterized by an initiation of mastery attempt in particular domain and a development of achievement behaviors such as perception of performance control, perceived competence, and positive affect. When a person successfully perform challenges (s)he will exhibit high levels of perceived competence and will be more likely encouraged by family and friends. Experiencing this positive affect will result in an intrinsically motivated person who uses internal criteria to evaluate success. In such a way motivation in more mastery attempts will be triggered.

Lastly, *movement confidence* is presented in order to help with the identification of strategies to motivate physical activity among people with disorders. The factors defining the movement confidence are movement competence and movement sense. The movement competence is the perceived ability of the skills someone has for a certain activity and the movement sense is the perceived positive or negative sensation towards physical activity participation. Increased movement confidence is an important element of motivation. However, if a person has a bad experience from physical activity participation such as negative attitudes from peers or unsuccessful attempts this will lower the movement competence and create a negative movement sensation [12]. This is why environments that reinforce successful experience, social skills development and enjoyment should be provided.

Combining the above-mentioned theoretical models, it can be concluded that each person has different value and enhancing motives that work for one may not provide a positive result for others. However, there are conventional factors that enhance physical activity. For example providing social support, setting realistic goals and expectations will increase children's belief that they are competent enough to participate in different sports activities. In the same way, if the kids receive positive attitudes towards their performance and are given equal opportunities for success, they are going to be more confident and experience positive sensations associated with physical activities.

2.3. Components enhancing children's motivation to be active

Motivation can be separated into two different types depending on what triggers it. According to Stuntz and Weiss [3], the form of motivation can be categorized as self-determined or controlling. Self-determined motivation is intrinsic and is triggered by internally driven reasons as interest and enjoyment in the task itself. In contrast, controlling motives are extrinsic, meaning that a person does an activity

because (s)he feels obliged to. Usually, controlling forms of motivation include participation because of guilt, pressure or simply to avoid punishment. Stuntz and Weiss [3] conclude that children who have self-determined motives for being physically active will persist participating for longer and will indicate higher self-esteem than children who are led by controlling motives. Thus, it is important to focus on nurturing high self-determined (or intrinsic) motivation in youth. Their desire to be active is triggered by an enjoyment of the activity itself and consequently, they are more likely to remain physically active in long term.

There are four components, based on psychological and social predictors of activity behavior, which should be considered in order to trigger self-determined motivation. The first component pointed out by Stuntz and Weiss [3] is a feeling of competence. In order to feel motivated to participate in physical activities, youth has to believe in their abilities and capabilities to accomplish the task. The competence motivation theory and the achievement goal theory mentioned in the previous section support the importance of believing in your qualities in order to increase physical activity motivation. Children who show higher perceived physical competence also show higher levels of self-determined motivation [3]. Sources such as *feedback* from parents, teachers, peers; *self-referenced*, sources as emotions or goal achievements; and *outcome sources* as external rewards or finishing place are affecting the children's perception of their abilities.

Another component important for the intrinsic motivation in children is supportive relationships. According to Weiss [14] parents, teachers, and peers have a vast impact on children's perception of a physical competence, self-esteem, enjoyment of physical activity and motivation. The parents, for example, provide and influence the physical experience for their children. If the parents exhibit positive attitudes towards sports activities, their role model influence the children and they as well express motivation to be active[3]. In the same way, teachers and coaches in the path of sport influence children's attitude towards activity with the way, they provide feedback. Children's relationship with their peers is another factor that can affect the physical activity enjoyment and the belief of physical competence. However, the peer relationships can have a negative impact if the children experience teasing, mockery or criticism by the same-age fellows (Kunesh et al., 1992 as cited by Stuntz and Weiss, 2010).

The last two components mentioned by Stuntz and Weiss [3] are the perception of choice or autonomy and, of course, enjoyment of participation. The feeling of having choice and autonomy influence the physical activity motivation. In order to have a positive influence, the children must be provided with choices, rationales, collaborative decision making. Lastly, it was stated that the enjoyment of physical activity is one of the strongest factors predicting participation. "Youth who genuinely enjoy participating in an activity because it is fun, challenges their skills, or satisfies interests and desires will be motivated to continue their physical activity involvement." [3, p.435]

Overall enhancing self-determined motivation ensures prolonged participation in physical activities. In order to achieve this, physical activities should be enjoyable, optimally challenging and emotionally pleasant. It is important to provide opportunities for the children to feel capable of doing sports, connected to peers and encouraged my meaningful figures as parents or teachers.

2.4. Game design supporting motivation

In this section, game design elements that can be used to fulfill the psychological needs for motivation are discussed together with design requirements and principles relevant to the formation of physical habits. First, Sailer et al. state that there are seven game design elements that can have an impact on the self-deterministic needs of competence, autonomy and social relatedness, explained in the previous section of this paper. These elements are points, leaderboards, badges, performance graphs, avatars, meaningful stories, and teammates. In [13] it is examined how the psychological needs and game design elements can be matched. Results concluded that the *need for competence* can be addressed by points, performance graphs, badges and leaderboards. The *need for social relatedness* can be supported by meaningful stories, teammates and avatars. The *need for autonomy* is separated into two different aspects – experiences of decision freedom, and experiences of task meaningfulness. The hypothesis of Sailer et al. [13] suggests that decision freedom can be addressed with avatars and task meaningfulness - with the game element of meaningful stories. However, this hypothesis was not supported by the conducted experiment. The tests showed that the autonomy in regards to task meaningfulness can be increased by points, performance graphs, badges and leaderboards, while the autonomy of decision freedom may increase when multiple meaningful stories are incorporated into the game.

Figure 2.1: Game design elements supporting self-deterministic needs (based on Sailer et al. [13] findings)

Second, instead of building on existing theories, Campbell, Ngo and Fogarty [19] indicate a few game design principles for the formation of physical habits. From the existing literature relevant to the games promoting fitness and physical activity, the above-mentioned authors derived the following game design principles: core mechanics, micro goals, marginal challenge, social play and fair play. Core mechanics are the rules of the game and the possible interactions that a player does during a play. Easy challenge makes the game fun and since the mechanics of the games are the most repeated actions they are a good way to influence physical habits. Another game design principle that needs to be considered in order to make the players feel their progress is micro goals. These are short-term goals which are easier to achieve in comparison to long-term macro goals. Campbell, Ngo and Fogarty [19] state that achieving little goals can motivate the player by providing a path for achieving the big goal of the game, which otherwise seems overwhelming. Yim and Graham [7] also agree that providing short and long-term goals enhances player's belief of competence and ability to control events and complete goals. Usually overcoming challenges makes the games entertaining and significant so the principle of a marginal challenge is important for the formation of physical habits. It is essential that the challenges are neither too easy nor too hard but at the margin of player's ability. "If done correctly, marginal challenge is one of the most crucial pieces to invoke a fun and meaningful experience" [19, p.250]. Lastly, the social play and the fair play were specified. The social interactions in games can be internal or external. Internal roles come from the rules and structure of the game itself, while the external roles are brought into the game from real-world relationships with friends or relatives. Campbell, Ngo and Fogarty [19] state that utilizing internal roles can help in establishing new external relationships and develop strong social play. Making friends through games can ensure long-term play as the same works for physical activity participation. Similarly, Yim and Graham [7] declare that people prefer to be physically active together with friends, thus, it is important that games provide mechanisms that help players to find partners to play with or provide an opportunity for a group of friends to play together. "Social play requires a level playing field in which all players have an equal chance of winning" [19, p.251].This requires establishing of fairness in the rules and the core mechanics of a game. In such a way, competitiveness can be enhanced.

To sum up, the studies used different approaches to indicate what a game should include in order stimulating physical activity. However, there are two important intersection points. First, all the authors support the claim that the players need constant feedback on how they are performing and what progress they made. This can be supported by game design elements as points, badges, leaderboards, and performance graphs. Second, the three papers emphasized the importance of social support for motivating long-term participation in physical activities. Game design elements as teammates can influence this together with correctly implemented social and fair play game design principles.

2.5. Related work

In this section, existing works related to the *Re-play – interactive playground games to motivate playing* project are reviewed. They serve as an example and inspiration of what can be achieved with interactive playgrounds and how different game design elements can be implemented on them.

2.5.1. AIRplay - Asthma game

Figure 2.2: AIRplay in use © Gijs van Ouwerkerk

AIRplay is a project focused on improving the physical well-being of children diagnosed with asthma. It combines mobile application combined with a fitbit for monitoring the daily physical activity of the children and an interactive playground game, where both children without the disease and children with the disease can play together. The idea is that the application shows the progress of the children in achieving their goal and creates a ranking list accordingly (and ranks them according to the percentage of the progress). In such a way the users will be motivated to be physically active and to achieve the goals set by the application. When the goals are achieved, as a reward, the children can play new versions of the interactive playground game. This playground, consists of an interactive floor projection of about 5 by 5 meter, that responds to players positions as measured by top-down Kinects [16]. Such a system allows users to walk in and play without additional calibration or devices.

2.5.2. Interactive tag playground

Figure 2.3: Interactive tag playground in use © Hetty de Vries

The interactive tag playground is inspired by the well-known tag game. In the case of the project a contact free sensing technology is used, the same one used in Air-play project (See 2.5.1). When the user is inside the boundaries of the playground a circle around him/her is projected. According to the color of the circle the player is either a tagger (red circle) or a runner (blue circle). The tagger can tag other players by

approaching their circles as when this happens the runner becomes a tagger. By adding power-ups, adaptive circles sizes, arrows pointing to the closest runner and other mechanisms, the games attempts to steer the players behavior [17].

2.5.3. Gait Rehabilitation Games on an Interactive LED floor & Padwalk

Figure 2.5: Padwalk in use © LedGo

The aim of *Gait Rehabilitation Games on an Interactive LED floor* is to create games on an interactive LED floor, which are suitable for gait rehabilitation sessions and hereby improve patients' experience during the sessions. One of the created games is called Padwalk and the concept is very similar to the well-known game Floor is lava. The key element is that the player should reach the finishing line of the game by only stepping on platform-like objects which protect her/him from the deadly surrounding. In the case of Padwalk, the theme is completely new and different (if compared to the Floor is lava). The environment is a pool of water, on which a human being is unable to walk, and the "safe" platforms are lily pads, as the name suggests. The games require flexible and adjustable features which fit the needs of the patients in the different stages of their rehabilitation. That is why Padwalk has two different game modes – a normal one and a random one as the difficulty of both can be manually adjusted. Each of the modes has different explicit and implicit goals. The normal game mode helps training the step sizes, walking rhythm and walking speed, while the random game mode involves training of the balance, coordination, attention, speed of thinking and pushing boundaries [20].

Figure 2.4: Interface of the different interactive LED floor games © Silke ter Stal

Three other games had been implemented on the LED floor for the purpose of gait rehabilitation – Gatenkaas, SchatJacht and CrazyObject (Figure 2.4). Each game trains different gait rehabilitation domain. Moreover, the games difficulty can be adjusted according to the patient with a web interface that the therapist can access with a tablet or a phone [18].

2.5.4. User-tracking Mobile Floor Projection Game System for Paediatric Gait & Dynamic Balance Training

The Mobile Floor Projection uses a system composed by an optical infra-red motion capture system (MOCAP) to track user's 3D position and an ultra-short throw projector hanged on a belt driven linear motor to create a position-adjustable floor projection (Figure 2.6). The set-up is a 10 meters by 3 meters walkway and is used to create an interactive floor projection game for a pediatric gait and balance training [10]. The system allows the users to undergo therapy in the usual conditions, while experiencing the interactive floor environment. In order to precisely track users' movements, markers are put on each foot. Two games are designed for the system – Hop Hop Frog and Bubble Pop.

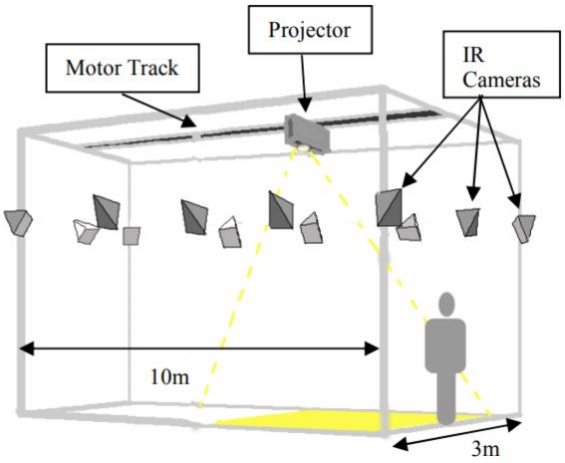


Figure 2.6: User-tracking Mobile Floor Projection System [10]

Figure 2.7: Child plays Hop-Hop Frog on User-tracking Mobile Floor [10]

In Hop Hop Frog, a frog and footprints behind it are projected on the floor. The player needs to follow the frog by jumping on the footprints as with every jump made by the player, the frog jumps further. To make it more entertaining the frog moves forward in different patterns – it rotates randomly when hopping. With this game it can be tracked if the player landed on a single foot or on both feet after hopping. This information is crucial for the therapist to keep track on the patients' progress.

Figure 2.8: Child play Bubble Pop on User-tracking Mobile Floor [10]

The other game – Bubble Pop targets both legs and hands. In this game crabs burrowing out of the sand are projected on the floor. When out of the sand, the crabs are blowing bubbles. The task for the player is to pop the bubbles so the crabs can burrow back into the sand. In order to pop the bubbles the user should either step on them with their feet or to touch them with their hands. The total number of bubble popped and the time taken are kept track on to monitor the progress of the patients.

2.5.5. iGameFloor - A Platform for Co-Located Collaborative Games

The iGameFloor is an interactive floor platform that uses a 12m^2 glass surface with bottom projection and four camera for tracking limb movements [9]. The setup provides opportunity for real-time sensing and feedback – the platform can track more than 10 users at the same time. This project has been established with an intention to explore the potential of the physical computer game platform in stimulating collaborative gaming among children in schools. For this purpose 3 games were developed – Pong, iFloorQuest, Stepstone.

Figure 2.9: Children playing Pong game on the iGameFloor [9]

The well-known Pong game was implemented on the platform. The mechanics of the original game were kept, so on the interactive floor version two players are standing in the opposite sides and each of them is controlling a "bat" with which to repel the ball. A counter is keeping track on the score and the first player, who scores 10 points, wins the game.

iFloorQuest is a floor game in which the players need to answer a set of displayed questions. The game is intended for four players, but more can participate as well. There are two modes – one where all the players play against each other and another where the players form teams and collaborate within their team.

Figure 2.10: Children playing iFloorQuiz on the iGameFloor [9]

Figure 2.11: Children playing Stepstone on the iGameFloor [9]

The other game created for the iGameFloor is Stepstone. This is a game where the participants need to answer to a posted question by placing their limb on a "stone" containing the correct answer. The challenges given are for example to construct a sentence, recognize a pattern, an object or a sound. For completing successfully the challenges, the players need to react and move quickly.

2.5.6. Bean Floor[4]

Beam Floor (developed by EyeClick Ltd.) is an interactive playground system which tracks body-movement within a defined area. The documentation of how the system works is not accessible due to the fact that the product is used for commercial purposes. On the playground, children can play numerous motion-activated games which are engaging the full body. Some of the games are Cheese Heist, where the player needs to catch the rats which are eating the cheese (see Figure 2.12), Recycle, where the player needs to sort the paper, plastic, glass and metal materials into the correct corners (see Figure 2.13), Balloons, where the player needs to pop the balloons coming from all the sides and be careful not to step on the dynamite (see Figure 2.14). Children can play football on the Bean Floor, too (see Figure 2.15).

Figure 2.12: Cheese Heist game being played on the Beam Floor © EyeClick Ltd.

Figure 2.13: Children play Recycle game on the Beam Floor © EyeClick Ltd.

Figure 2.14: Child "pops" balloons on the Beam Floor © EyeClick Ltd.

Figure 2.15: Children play Football on the Beam Floor © EyeClick Ltd.

[4] "Beam Interactive Floor Games, Table Games, Best Projector For Gaming", BEAM By EyeClick, 2018. [Online]. Available: https://joinbeam.com/the-games/. [Accessed: 17- May- 2018].

2.5.7. Relevance

Gamification of a rehabilitation process is not something new neither are the interactive playground systems as mentioned in the work above. All of these projects and systems are relevant to Re-play in different ways.

The concept of the AIRplay project is very similar to the Re-play project. The similarity between both is not only in the technology of the interactive playground but also in the fact that games are used for serious motives in the scopes of the projects. Even though the target group of AIRplay is children suffering from asthma, while Re-play focuses on children with different motor deficiencies, they both have one very important intersection – helping children to overcome their disabilities by making the rehabilitation a fun and enjoyable activity.

A good example of a system that is used to create games on an interactive floor for a pediatric gait and balance training is the User-tracking mobile floor projection system. A similar motive can be found in Gait Rehabilitation Games on an Interactive LED floor. The project has no focus on children and uses different technology for the playground, but has a goal to enrich the rehabilitation experience of the patients with the use of games, which is a point for the Re-play project as well.

Re-play has a number of practical constrictions to fulfil. The most significant are to steer children's behavior into physical activity and to design a game, suitable for the interactive playground, but which can be played without any technology, as well. The Interactive tag playground project gives good examples for both. First, it gives insights on how play can steer children's behaviour and, second, it shows how the mechanics of a famous physical game as the tag game can be incorporated into the interactive playground.

The iGameFloor and BeamFloor are other installations that intend to stimulate collaborative play among children by the use of motion-activated games. These games served as inspirations for the Re-play project. Overall all the works presented in this section served as examples of what kind of games can be incorporated into different types of interactive playgrounds.

2.6. Input from the client

In order to understand more in depth the situation of the children from the target group and the client's requirements and needs, a meeting with a physiotherapist was organized. Allard Dijkstra is a physiotherapist at the Roessingh rehabilitation center and he is the primary client of this project. During the session with him it was possible to observe how a rehabilitation session takes place and how the children diagnosed with DCD behave during it. After that there was a discussion, where the client answered questions about important aspects concerning the limitations and needs of the target group.

During the discussion, Dijkstra explained that the rehabilitation sessions are usually individual, but sometimes patients with similar conditions are put together in order to make the session more interactive. For the purpose of the Re-play project, it was clarified that the mixed sessions consist of 4 patients at most and the main focus is on children diagnosed with DCD, and some mild forms of CP which are characterized with symptoms identical to the Developmental Coordination Disorder.

Furthermore it was discussed and observed that the children from the target group do not adapt easily to the given exercises. They do not learn from previous unsuccessful tries to accomplish the task unless they are given proper feedback. Moreover, the young patients get easily distracted, which makes keeping their attention a very difficult task. The children cannot organize a game because it is hard for them to focus on one thing and as a result their play gets very chaotic.

Dijkstra emphasized on the fact that there are improvements in the condition of the children but a lot of repetitions and exercises are needed. The problem is that the children are not highly active; when they are at home, they are usually playing on the smartphone/tablet or computer. The client wants to use interactive playground platform games during the rehabilitation sessions to enrich children's experience and inspire them how to play a physical games outside the scope of the rehabilitation.

Requirements for the *Re-play - interactive playground games to motivate playing* project assigned by the client are:

- Create a transition between the IPP game(s) and physical activity in real life
- Include movements like running & jumping
- Attract children's attention
- Match for children with different skills and abilities so they can play together
- The difficulty of the game must evolve over time in order to keep challenging the children.

3. RESEARCH APPROACH

In order to answer the research question of this project, it is important to establish a research approach. This chapter gives a brief description of the research approach and its phases – ideation, design specifications, realization and evaluation.

3.1. Ideation

The ideation phase is the phase in which the ideas generation is happening. It is important to set some constraints which serve as a guideline for the process. The first two chapters of this report give a foundation for the ideation phase as they serve as an input to create criteria for viable game concepts. With these criteria in mind, a number of diverging game ideas are first generated and then evaluated. The game concepts are presented to the client in order to get feedback. Based on the evaluation and the input from the client, the most promising game concept is chosen.

3.2. Design Specifications

During the design phase, the chosen game concept is further elaborated. Definitive decisions, associated with the game elements and design, are made. The final idea of the game is clearly explained in order to proceed to the realization phase.

3.3. Realization

In the realization phase of this project, the final concept for the game is implemented. The realization is made in parallel with quick tests on the playability of the still-in-progress game, which give directions of what needs to be changed for the completed version.

3.4. Evaluation

During the evaluation phase, user testing of the final version of the games is performed. An observation of participants while playing the games with and without the interactive playground and interviewing them after their experience allows for extracting a valuable feedback for future improvements. This feedback together with a description of testing methods and protocols can be found in the chapter of this report devoted to the evaluation phase.

4. IDEATION

In this chapter the ideation phase of the project will be described. First, brainstorm and mind map were created considering different game mechanics including physical activities. Then, game concepts were generated. At the end of the ideation phase, a decision based on a play test and discussion with the client is made in order to continue with the realization phase of this project.

4.1. Mind mapping and idea generation

Before starting with the brainstorming, first, the criteria for this project was clearly set to "navigate" the free thinking and idea producing.

The criteria for this project are:

1. Game mechanics including physical activities
2. Re-playability of the game without the technology of the interactive playground
3. Single player & multiplayer/ difficulty adjustment
4. Fun

Game mechanics including physical activities

Game mechanics are the rules of the game that require some kind of interaction from the side of the player in order to progress in the game. The primary aim of Re-play project is the creation of a game (or set of games) that promotes physical activities; therefore, game mechanics to get children to jump, run, walk or dance are the most important element.

Re-playability without the technology

The interactive playground game(s) will be presented to children with motor deficiency during extensive rehabilitation sessions where and when the young patients will be able to play the games. However, being physically active only within the scope of the rehabilitation sessions is not enough. In order to improve their condition, the children from the target group should keep themselves active on daily basis. Therefore, an important requirement for the game(s) is to also be re-playable outside the scope of the rehabilitation and without the need of the interactive playground technology.

Single & multiplayer/difficulty adjustment

The game is designed to meet the needs for a 10-week intensive rehabilitation program. Usually, the sessions are individual, but in order to diversify patients' experience, there are group sessions involving 4 children at most. That is why the single player and multiplayer modes are preferred. Additionally, an option for adapting the difficulty level of the game for the needs of the different patients is wanted.

Fun

As already discussed in the state of the art chapter, intrinsic motivation is stronger than extrinsic motivation. A child that is involved in physical activity because they enjoy it is the goal of this project. Therefore, the game should be fun for the children to play - they should not feel obliged to play it only because it is a part of the rehabilitation session but because it amuses them.

Based on the criteria, first, a mind map was created.

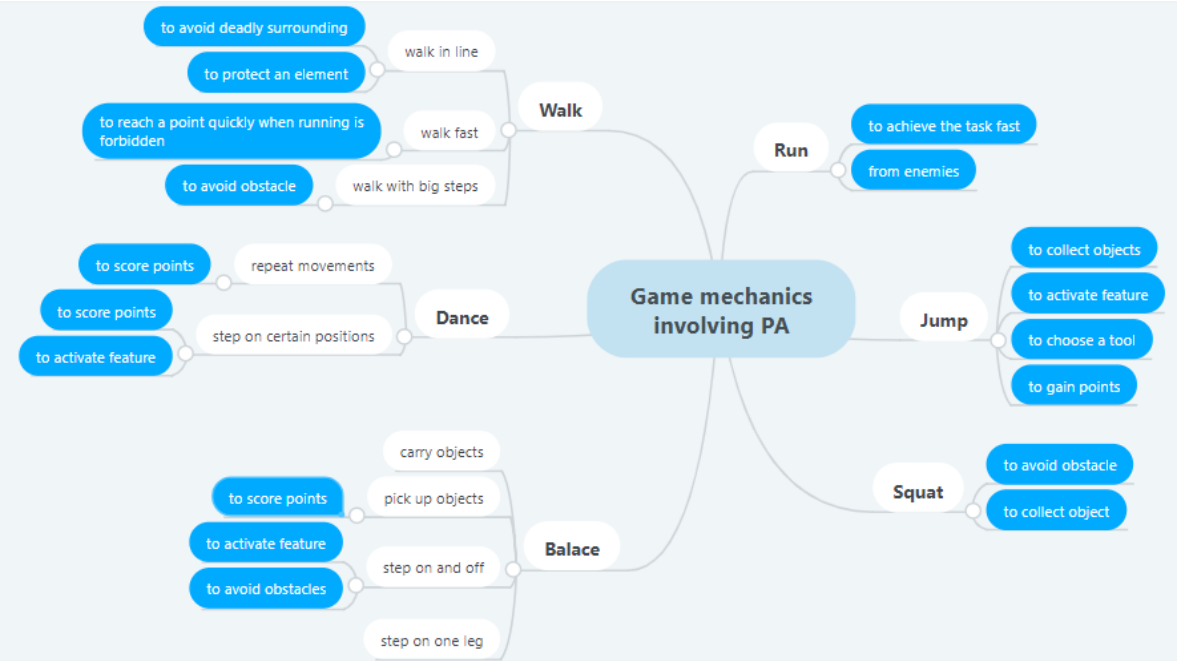


Figure 4.1: A mind map of different game mechanics including physical activities

4.2. Game concepts

Based on the criteria and the mind map, several game concepts were generated. For each concept, the game goal and game explanation are given. Then both a real-life version and a playground version and their single player and multiplayer modes are described when applicable. Technical difficulties and possibilities for difficulty adjustments are mentioned where they are relevant.

4.2.1. Concept 1: Rock Paper Scissors

Goal of the game

The goal of this game is to prevent the opponents from approaching your area by beating them in a rock paper scissors battle.

Concept explanation

This game concept is inspired by the famous rock paper scissors game. In the game, the player needs to run towards the enemies and repel them from a certain area indicated on the ground (as shown in figure 4.2) by beating them in a rock-paper-scissors game. With every lost battle, the enemies get closer to the protected area. The game ends if the enemies reach the indicated area.

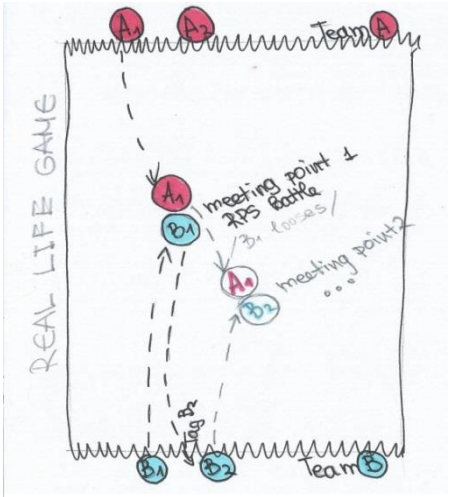


Figure 4.2: Real life version of Rock Paper Scissors game – multiplayer*

Real-life version – multiplayer*

The real-life version of this game is not suitable for a single player – at least four players are required. The players form two teams of two players. Each team protects their area and tries to invade the opponent's one. The players run towards each other and at the meeting point, they play rock paper scissors. The winner can take one step forward, while the loser needs to go back and pass over the turn to his/her teammate. The players play rock paper scissors battles until someone approaches the opponent's area.

Playground version

The playground version of the game is suitable for a single player and multiple players. In the single-player mode, randomly generated rock, paper or scissors enemies are moving from the upper corner of the playground towards the lower corner where the player's area is located. The player needs to select a proper response to enemies and run towards each of them in order

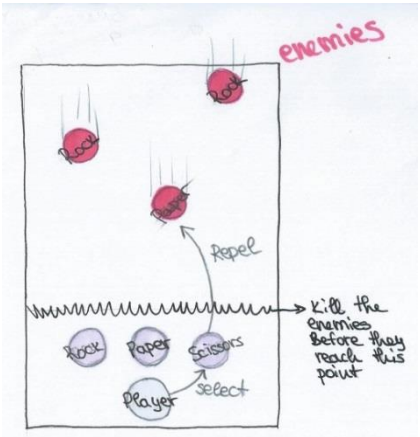


Figure 4.3: Rock Paper Scissors Single player game on the interactive playground

to destroy them. For example, if the enemy is a rock, the player needs to select paper as a response and run towards the enemy before it approaches the protected area.

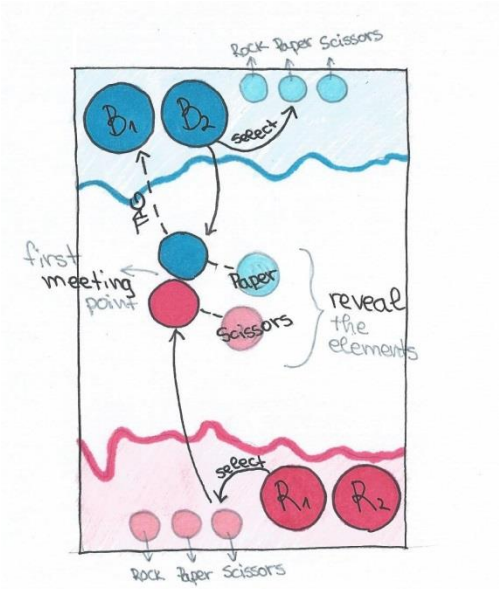


Figure 4.4: Interactive Playground version of RPS - multiplayer

Multiplayer option: The playground version of the game can be played with teams of two players per team. The idea is similar to the real-life version – the opponents meet at some point and play rock paper scissors. However, there are slight differences due to the fact that the technology cannot know how the rock paper scissors battle goes and which team is the winning one. That is why in this version the players first choose an element (rock, paper or scissors) before the battle is happening. At the meeting point, it becomes clear who the winner of the rock paper scissors battle is. The winner needs to freeze for 3 seconds, giving time to the loser, who needs to tag his/her teammate to pass over the turn. Now the losing team knows which element to select in order to destroy the opponent's one but fast reactions are required since meanwhile, after the advance time of 3 seconds, the winner can move forward. The game ends when a team approaches the opponent's area.

Difficulty adjustment

To increase (or decrease) the difficulty of the game:

- Increase (decrease) the number of enemies "falling" towards the players area simultaneously;
- Accelerate the speed with which the enemies are moving.

4.2.2. Concept 2: Tic Tac Toe and Connect the dots

Goal of the game

Fill the grid with as many as possible combinations of at least 3 consecutive characters/colors of your team (either in rows or in columns).

Concept explanation

This game concept is inspired by the tic-tac-toe, connect the dots and match-three puzzle games. The idea is that two opponents are filling up a n-by-n grid with their character (either X or O). Each player strives to place/draw at least 3 consecutive X or O as many times as possible. The game ends when the grid is filled and the winner is the one who has more combinations of 3 (or more) consecutive characters in rows/columns. (Figure 4.5)

Real-life version – multiplayer*

The real-life version of this game can be played outside and would require a chalk with which the grid can be drawn. The game is not suitable for a single player – at least four players are needed – two players per team. The players need to define a starting point for each team – this can be a few meters away from the grid. When the game starts one player of each team runs to the grid and puts the team's symbol in a chosen square. Then the players need to go back to the starting point and pass the turn to their teammates. The game ends when the grid is filled and the players need to count the combinations of 3 consecutive characters to see which team is the winner.

Playground version

The interactive playground version of this game can be played by one player and the computer (CPU) as an opponent. In order to keep the physical activity element, the player would need to run back to the starting point to get "charged" with an element, which can be placed in a chosen box of the grid. Placing of the character would happen as follows:

1) The player chooses a box of the grid and steps on it
2) The player squats or crouches to place their symbol in the box

Multiplayer option: Similarly to the real-life version, the playground version of the game can be played by multiple players.

Difficulty adjustment

To increase (or decrease) the difficulty of the game:

- Make the grid bigger (smaller).

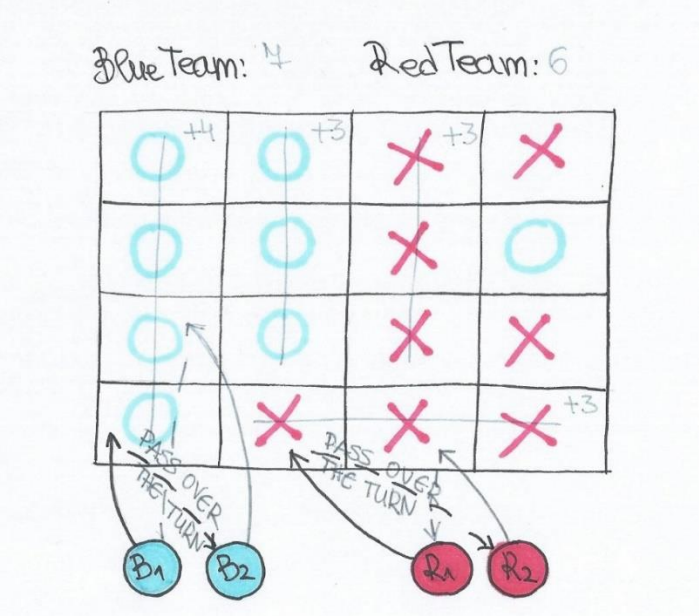


Figure 4.5: A player from each team places the team's symbol in a chosen box and pass the turn to their teammate; at the end the team with most consecutive (at least 3) characters wins.

Technical difficulties

There might be technical difficulties associated with the game mechanics for "placing" the teams' symbols on a chosen box on the grid. This would require squatting in order for the tracking system to differentiate this action from the others. However, the tracking might not work so well, which can cause bugs in the game and be annoying for the player.

4.2.3. Concept 3: Wooden sticks

Goal of the game

The goal of the game is to create a fire by collecting all the wooden sticks and bringing them to the fireball.

Game explanation

The player stands on the start position and after the countdown, a timer starts running. The player has a certain amount of seconds to collect the wooden sticks and bring them to the fireball in order to create a fire. The rule is that the player can collect only one stick per time.

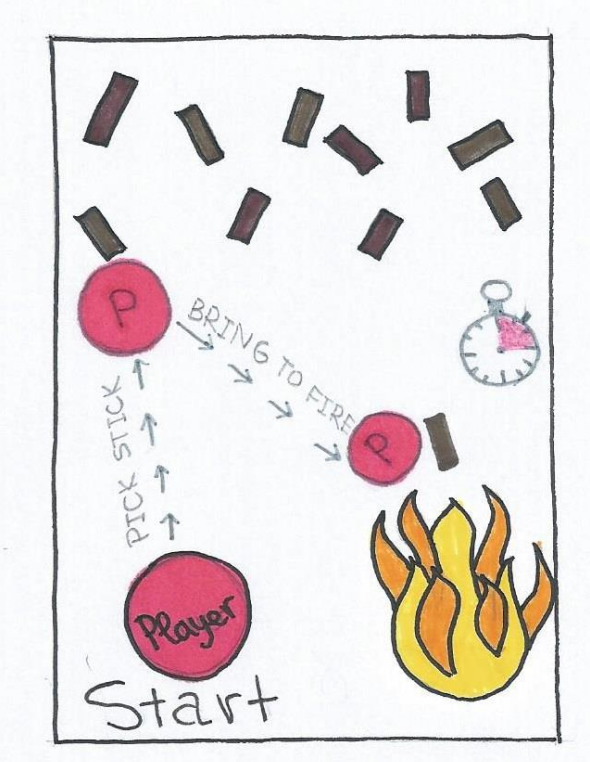


Figure 4.6: The player starts at the start position and runs to pick up a wooden stick and bring it to the fireball

Real-life version

The real-life version of the game requires wooden sticks or branches (other objects to collect can also do the job), a timer and relatively extensive space for playing. Before playing the game, the player needs to define a field (start position, fireball position and position of the wooden sticks), as shown in Figure 4.6.

Multiplayer option: The game can be played with multiple players. They all stand on the start position as the first player runs to collect a wooden stick, brings it to the fireball and runs back to the start position to give a high five to the next player, so (s)he can start playing. The players can as well form teams and compete on who complete the fire first (collects the wooden sticks quickest).

Playground version

This version does not require any extra equipment as the wooden sticks and the timer are digitalized and the path is already assigned.

Multiplayer option: The playground version of this game can as well be played by multiple players. The idea is the same as with the real-life version, only this time instead of giving a high five to the next player, the current one needs to tag them by getting close enough to their circle (this is the avatar of the player).

Difficulty adjustment

To increase (or decrease) the difficulty of the game:

- increase (decrease) the number of wooden sticks which need to be collected;
- decrease (increase) the timer;
- randomly change the position of the wooden sticks during play;
- randomly change the position of the fireball during play.

4.2.4. Concept 4: "Drunk carrot"

Goal of the game

Catch all the enemies and do not let them go to the other side of the field.

Concept explanation

This concept is inspired by a game that is played by at least three players. One of them stands in the middle and is given the nickname "drunk carrot", the rest of the players throw a ball above him/her. If the player in the middle catches the ball, (s)he changes places with the player who has thrown the ball.

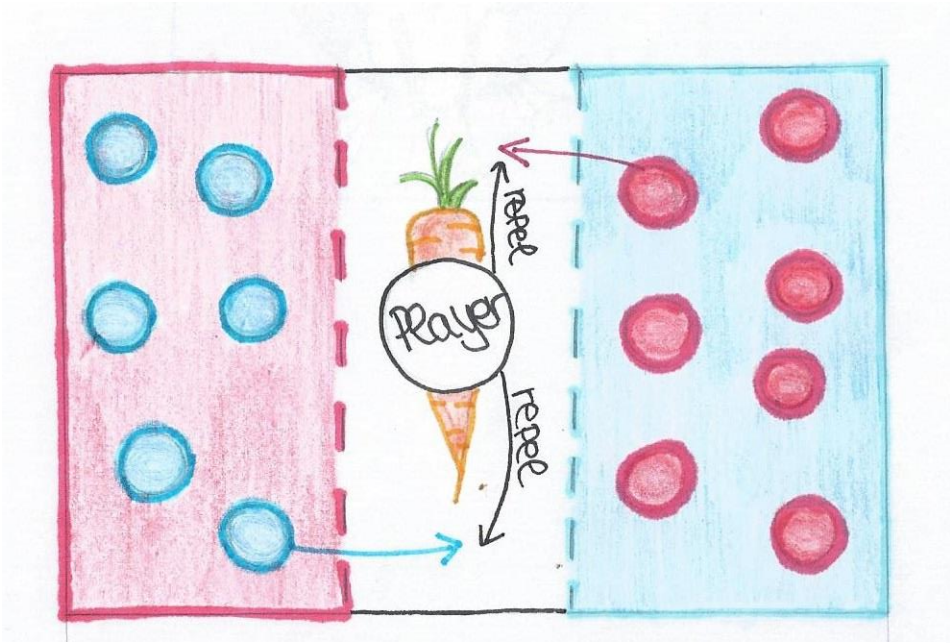


Figure 4.7: The player is the drunk carrot and needs to catch/tag all the enemies and prevent them from going to the other side of the field

In this case, the field is divided by 3 (as shown in Figure 4.7) - the middle part is for the player. The player is attacked from both sides by the enemies and his/her aim is to prevent the enemies go to the other side of the field.

Real-life version – multiplayer*

The real-life version of this game requires 4 players. Two of the players are positioned on both sides of the field and the other two stay in the middle. The players standing in the sides are from one team and one of them (thrower) has 10 balls which (s)he needs to pass to his/her teammate (catcher), who is standing on the opposite side of the field. The catcher player needs to catch balls in order to score points – each caught ball is equal to one point. The players in the middle (defenders) are the other team – they need to catch the balls to prevent the opponent team from scoring points. When all the 10 balls are being thrown the teams change their places and the defenders become thrower and catcher and the other way around. The game ends when one of the teams scores 10 points.

Playground version – single player*

The playground version of this game is suitable for a single player. The player stands in the middle part of the field and enemies from both sides are trying to pass through the middle part to get to the other side of the field. The player needs to destroy the enemies by stepping on them. If one of the enemies reaches the other side, the game is over. If the player manages to destroy all the enemies (s)he can continue to the next level.

Difficulty adjustment

To increase (or decrease) the difficulty of the game:

- Increase (decrease) the number of enemies that the player needs to repel;
- Accelerate the speed with which the enemies are moving.

4.2.5. Concept 5: Hopscotch

Goal of the game

Jump onto the blocks of the hopscotch grid in the correct order.

Concept explanation

This game concept is identical to the well-known hopscotch game. The difference is that instead of jumping on the blocks in the correct order of numbers, the player has to remember a certain sequence and repeat it. For example, first jump to 2 then 1,3,5,4,6,9,8,7,10 and then back in the same order.

Real-life version

This game can be played either inside or outside. The player can be creative with the drawing of the hopscotch (see figure 4.8) and with the sequences of numbers. If the player makes a mistake in between, (s)he needs to start from the beginning.

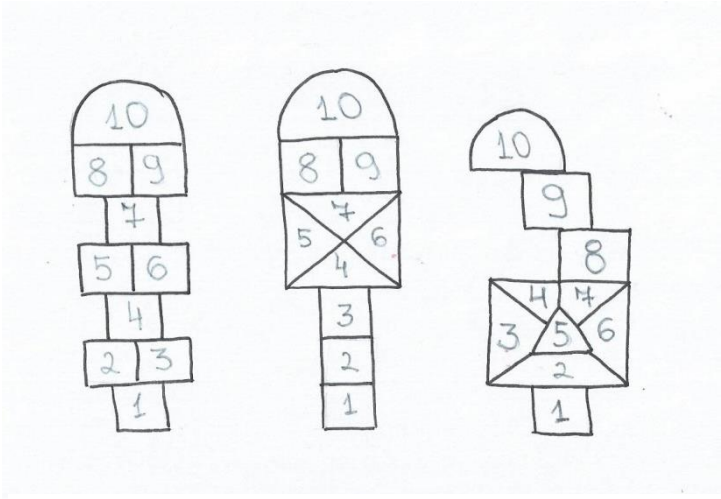


Figure 4.8: Hopscotch varieties

Multiplayer option: Each player suggests a sequence, which (s)he needs to do first and then the other player(s) should repeat it. If the other player(s) make(s) a mistake, a point goes to the player who suggested the sequence.

Playground version – single player

In the playground version of this game the hopscotch blocks light up in a certain sequence, which the player needs to repeat in order to score a point.

Difficulty adjustment

To increase (or decrease) the difficulty of the game:

- Add distance between the blocks;
- Increase (decrease) the number of the blocks;
- Make the sequence of blocks that the player needs to follow longer (with repeating block numbers);
- Arrange the blocks randomly.

Technical difficulties

This game concept might be difficult to implement because the interactive playground tracks the player from the top and this could be a problem when the player jumps over squares in order to land on the correct one. In cases like this the tracking system senses the position of the player on the wrong square, which can cause bugs in the game and be annoying for the player.

4.2.6. Concept 6: Catch the dragon's tail

Goal of the game

In this made-up game one player is assigned as the dragon's head and one is assigned as the dragon's tail and the rest of the players are the body of the dragon. The head player needs to catch the tail player as the players between them interfere.

Concept explanation

This is a multiplayer game where the players hold their hands to form a chain of people, representing the body of a dragon (or any animal). One side of the chain is a player, who is the head of the dragon, and the other side is a player, who is the tail of the dragon (as shown in Figure 4.9). The head player needs to catch the tail player. All players move as a puffer. Once the head player catches the tail (s)he becomes the tail and the second player in the line becomes the head.

Real-life version – multiplayer*

The real-life version of this game can be played either inside or outside. Three or more players are needed - the more, the better. As explained above, the players hold hands in a line and the first player in the line needs to catch the last player. When this happens the first player becomes the last and respectively the second player in the line becomes first. The game ends when all players had their turn.

Playground version – multiplayer*

In the playground version of this game again all the players hold hands in a line and each of them has a circle (as an avatar). The circles of the head player and tail player are in a different colour from the rest (see figure 4.9). In this case, the head player needs to tag the tail player (tagging is when the circles of the players touch). When this happens, the circles' colours update – the tail player's circle loses its colour, the head player's circle becomes in the colour of the tail and the second player in the line gets a circle with the colour of the head.

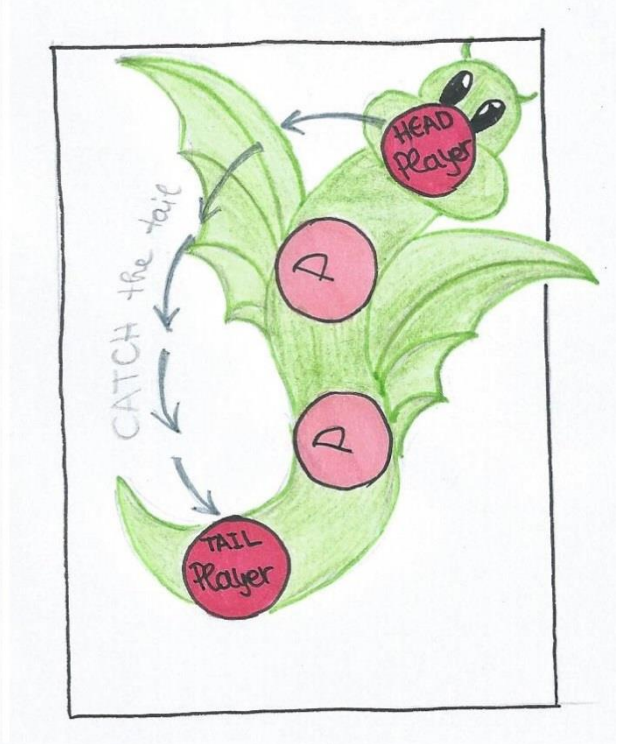


Figure 4.9: Catch the dragon's tail - the head player needs to tag the tail player

Difficulty adjustment

Not feasible

4.2.7. Concept 7: Jenga

Goal of the game

Remove pieces from the Jenga tower without making it fall.

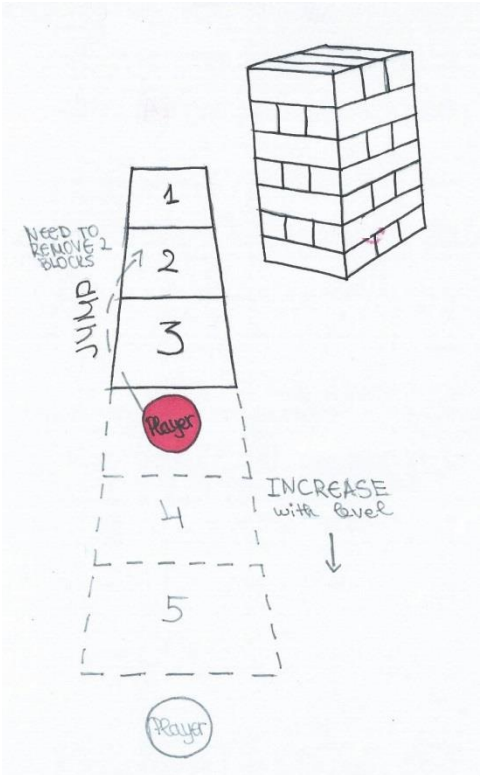


Figure 4.10: The player needs to jump on the target to select a number that indicates how many blocks should be removed from the Jenga tower

Concept explanation

For this game at least two players are needed. The original idea of the famous Jenga game is kept – the players need to take out one wooden block from a wooden tower per time and place it on the top of the tower, making the construction more unstable with each turn. In this version, however, instead of taking one wooden block per time, the players need to jump on a target which indicates how many wooden blocks they need to remove from the tower. The target is organized in such a way that the player needs to make a long jump in order to select a smaller number of blocks to be removed. The game can be made more difficult by adding a new number to the target (figure 4.10).

Real-life version – multiplayer*

For the real-life version of this game the players need to have the Jenga game (or wooden blocks with which to build a wooden tower) and need to create a target as shown in Figure 4.10 – this can be done with chalk or by improvising. When everything is set, the players can start playing as the game ends when the tower falls. The winner is the last player, who successfully has removed and placed the block(s) on the top of the wooden tower. The game can be played with teams of two (or more) people per team.

Playground version – multiplayer*

The game can be incorporated with the interactive playground as again a physical Jenga game is required. The rules are the same – each player jumps in order to select how many wooden blocks to remove and the game ends when the Jenga tower falls – the Kinect can sense that. The same as with the real life version, the playground version of the game can be played with teams of two people per team.

Difficulty adjustment

To increase (or decrease) the difficulty of the game:

- Add (remove) a number from the target – in such a way, the player needs to jump longer (shorter) in order to get a smaller number of blocks to be removed from the Jenga tower.

Technical difficulties

This game concept might be difficult to implement because the interactive playground tracks the player from the top and this could be a problem when the player jumps over the target.

4.2.8. Concept 8: Feed the frog

Goal of the game

Catch all the flies in order to feed the frog

Concept explanation

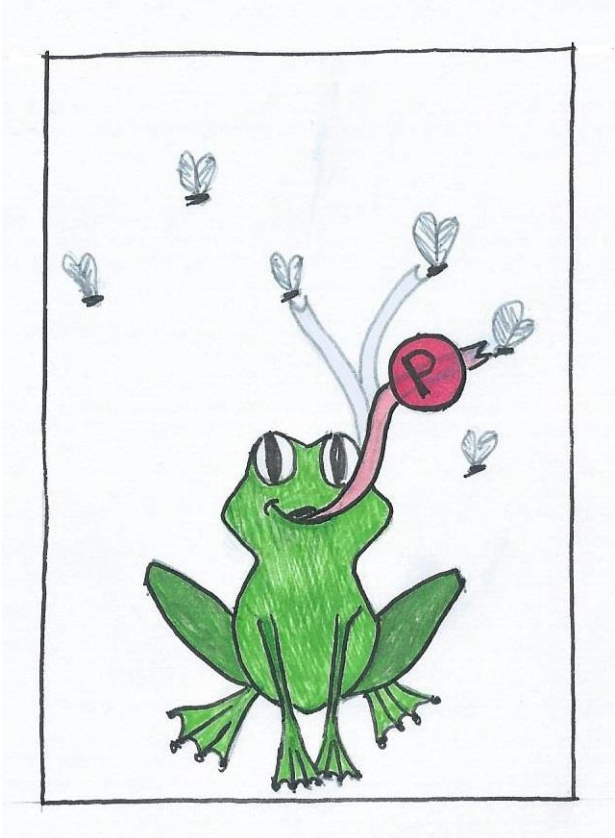
In this made-up game concept, the player is the tongue of the frog and needs to catch all the flying around flies.

Real-life version – X

This game concept is more appropriate for the interactive playground platform as the effect of moving objects on the ground can be hard to accomplish in real life setting.

Playground version

The game can be played on the interactive playground. The task of the player is to catch the flies, as only one fly can be catch per time. The player needs to bring the fly to the frog's mouth and run back to catch the next fly.



Figuur 4.11: The player is the tongue of the frog and needs to catch all flies (one per time) and run back to the frogs mouth to feed it

Difficulty adjustment

To increase (or decrease) the difficulty of the game:

- Increase (decrease) the number of flies that need to be collected in order to feed the frog;
- Decrease(increase) the time until the frog starves to death;
- Make the tongue of the frog shorter so the player needs to catch the flies before they go too far.

4.2.9. Concept 9: Fruit ninja

Goal of the game

Do not allow an uncut fruit to fall on the "board". You have 3 lives.

Concept explanation

The player should cut all the appearing fruits by running through them. The fruits appear randomly and the player should be fast enough to cut them before they fall down.

Real-life version –X

This game concept is more appropriate for the interactive playground platform as the effect of moving objects on the ground can be hard to accomplish in a real-life setting.

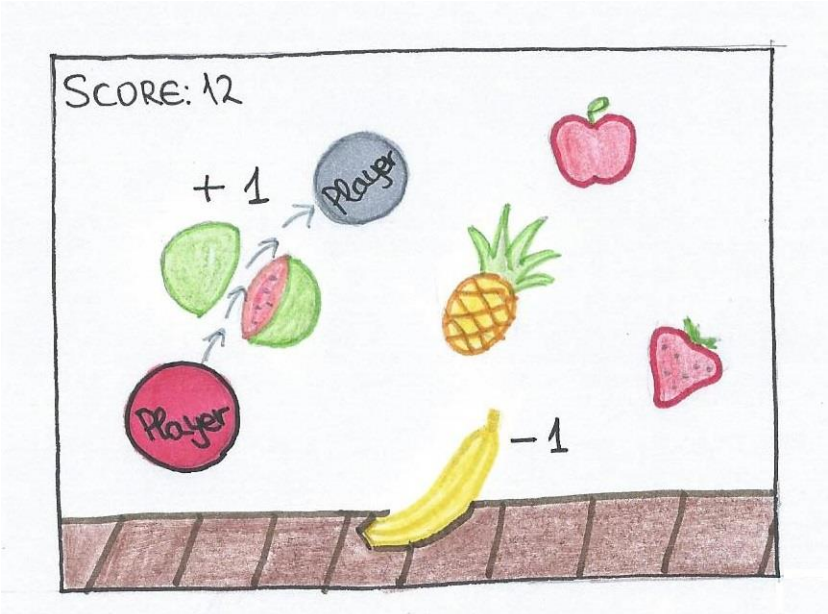


Figure 4.12: The player needs to cut the fruits by walking over them

Playground version

The game can be played on the interactive playground as the player needs to walk/run over the fruits to cut them before they fall.

Difficulty adjustment

To increase (or decrease) the difficulty of the game:

- Increase (decrease) the number of fruits to be cut;
- Accelerate the speed with which the fruits are "falling".

4.2.10. Concept 10: Snail

Goal of the game

The goal of the game is to jump over the boxes without touching the lines and fill in your initials.

Concept explanation

The concept is very simple – the player needs to jump on one leg in the boxes of the snail (see Figure 4.13) without touching with her/his feet the lines of the boxes. In the center of the snail the player needs to jump with both legs and then go back to the starting point but this time jumping on the other leg (optional). If done correctly, the player can draw his/her initials in one of the boxes. The game ends when all the boxes are filled with letters.

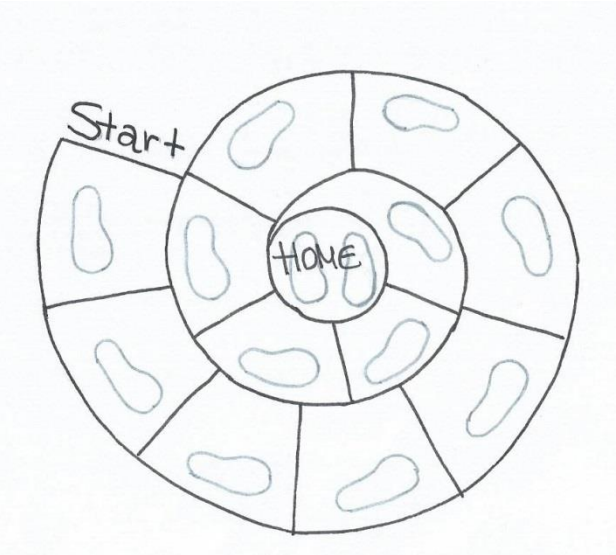


Figure 4.13: Snail game - shell outline

Real-life version

For the real-life version of this game, the player would need to draw a snail shell and then short lines so as to make boxes (as shown in Figure 4.13). After the drawing is done the game can start. The player needs to bounce on one foot from box to box, not touching the lines outlined; if (s)he does – (s)he has to start over from the beginning. The aim is to reach the center of the snail (the home) where the player can step with both feet. After that, the player needs to jump on one leg again back to the start. If the player reaches the beginning without stepping on a single line, (s)he can put their initials in one of the boxes. The game continues until all the boxes are filled in.

Multiplayer option: This game can be played by more than one player. In this case, when a player steps on a line (s)he needs to give the turn to the other player. The players should jump over the boxes that are filled in with initials of the other players and should step with both feet on boxes with their own initials. If a player makes a mistake, (s)he loses the turn. The winner is the one who has the most boxes.

Playground version – X

The interactive playground technology does not allow implementing the rules of this game concept. It is not possible for the playground technology to know if the player is jumping on one foot or if (s)he has stepped on a line.

Difficulty adjustment

Not feasible

4.3. Decisions

All the generated ideas should be evaluated and one game concept should be chosen. The ten concepts are evaluated based on the criteria mentioned in the subchapter 4.1 of this paper – mechanics involving physical activities, re-playability without the interactive playground, single player & multiplayer modes, difficulty adjustment. Additionally, the technical difficulties that may arise are looked at as a major factor in selecting the most promising game concept. Table 4.1 gives an overview of the ten game concepts and their fulfilment of the criteria.

Concept	Physical activities	Real Life version		Interactive Playground		Difficulty adjustment	Technical difficulties
		SP	MP	SP	MP		
C1: Pock Paper Scissors							
C2: Tic Tac Toe/ Connect the dots							
C3: Wooden sticks							
C4: Drunk Carrot							
C5: Hopscotch							
C6: Catch the dragon's tail							
C7: Jenga							
C8: Feed the frog							
C9: Fruit Ninja							
C10: Snail							

Tabel 4.1: Game concepts vs. Criteria

As it can be seen from the table, concept 1: Rock Paper Scissors, concept 2: Tic Tac Toe/Connect the dots, concept 3: Wooden sticks, and concept 5: Hopscotch are the concepts fitting with the most requirements.
Concept 1, concept 2 and concept 5 are game ideas inspired by existing popular games – Rock Paper Scissors, Tic Tac Toe, Connect the dots and Hopscotch and as these concepts bring back to life popular traditional games, they became favourite.

4.3.1. Concept testing

Figure 4.14: Participants play the Tic Tac Toe/Connect the dots concepts

The Rock Paper Scissors and the Tic Tac Toe/Connect the dots concepts were tested in order to see which game concept works better. The real-life versions of the game concepts were tried out by individuals over 18 years old in order to quickly arrange a research testing. The testing was recorded with the consent of the participants, as pictures can be found in Figure 4.14 and Figure 4.15.

After playing both of the games, the participants were asked which game they prefer and why. The Rock Paper Scissors game was chosen because, as the participants stated, it includes more interaction between the players and it is more visible and intuitive who the winner is. In contrast, while playing the Tic Tac Toe/Connect the dots concept, none of the teams had a clear idea who is leading. Moreover, the participants found it annoying to count their scores after the game was over.

Figure 4.15: Participants play Rock Paper Scissors concept

4.3.2. Discussion with the client

The four game concepts and the result from the quick testing were presented to Allard Dijkstra, the physiotherapist in Roessighn and client of this project. He mentioned that games/exercises similar to the wooden sticks and hopscotch concepts are already used in the therapy sessions and it would be nicer if the children are given the opportunity to play something different. The therapist liked the idea of including elements from universal games as Tic Tac Toe and Rock Paper Scissors in the interactive playground games as the children most likely already know them and can associate the new games with something familiar. Overall, the client was pretty positive about the Rock Paper Scissors game concept and liked it better than the Tic Tac Toe/Connect the dots one.

With all the gathered information from the concept testing, client's input and supervisor's advises, the Rock Paper Scissors game concept was chosen.

5. DESIGN SPECIFICATION

In this chapter the final game design decisions are documented with the help of four basic game elements: Story, Game Mechanics, Aesthetics, and Technology, introduced by Schell [6].

5.1. Rock Paper Scissors - Single Player

This section provides a description of the basic game design elements for the single player game.

5.1.1. Story

There is no story presented to the player, however, there is always a possibility to make up a story around the game. This game is about beating enemies in rock paper scissors battles and repelling them.

5.1.2. Game mechanics

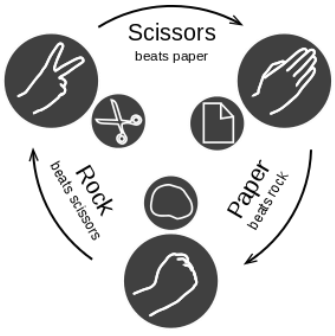
- **Goals**

The game has no long-term and short-term goals, however, the game has explicit and implicit goals. An explicit goal represents what the task of the player is and an implicit goal represents what skills the user can gain while playing the game. The explicit goal of the Rock Paper Scissors game is to destroy enemies and do not let them invade your area. The implicit goal of the game is to train coordination, speed and cognitive reaction.

- **Elements**

Enemies

The enemies should be destroyed before they reach a certain area. The enemies are the rock, paper, and scissors elements and can be destroyed with the respective opposite defence element (Figure 5.1):



> The rock enemy can be destroyed with a paper defence element;

> The paper enemy can be destroyed with a scissors defence element;

> The scissors enemy can be destroyed with a rock defence element.

Figure 5.1 A chart showing the rock-paper-scissors interaction. © Enzoklop

Behaviour & Adaptability:
The enemies are falling from the top to the bottom of the playground and need to be repelled before they reach the player's area. In order to increase or decrease the difficulty level of the game, the amount of generated enemies and their speed can be adapted accordingly.

Defence elements

The defence elements are the rock, paper, and scissors elements which the player can select as a response to an enemy. If the player does not select the right element, the enemy is not destroyed and continues moving.
Behaviour:
The defence elements have a fixed position and they are needed to repel the enemies.

Score & progress bar

The score (and the progress bar) increases or decreases with 10 points every time an enemy is destroyed or an enemy reaches the player's area, respectively. When the score decreases to 0 points the game is over and when the score hits the target score of the level the player wins and can continue to the next level. The target score for the first level is 100 points and with every level the target score increases with 100 points, making it more difficult for the player to finish the level. In order to reinforce players' motivation and give them a boost, the score and the progress bar start with 30 gift points. This, as well, reduces the chances of losing the game, before even start playing.

Sound and visual effects

To enhance the play experience and provide a feedback to the player, sound and visual effects are incorporated into the game. When the game is on, there is a background music, which adds some rhythm to the play. Depending on events, different effects are added as well.

Event	Sound effect	Visual effect
Player selects defence element	✓	✓
Player destroys an enemy	✓	✓
An enemy reaches the player's area	✓	
Game is over		✓
Player wins	✓	✓

Table 5.1: Sound and visual effects on events for the multiplayer Rock Paper Scissors game

5.1.3. Aesthetics

The style of the game is minimalistic with not too many elements. The reason for this decision is elicited by the fact that the game is displayed on the floor with a projector. This means that the intensity of the picture is not too high since the room where the interactive playground is positioned cannot be completely dark. The simpler the elements are, the better they can be seen on the playground.

5.1.4. Technology

The games are developed with the Unity 3D game engine and programmed in JavaScript with MonoDevelop. The games are developed for an interactive playground, which is an installation that is composed of four Kinects, that track players positions inside the playground; two projectors, which are displaying game elements on the floor; and two PCs, that process the game logic. Additionally, speakers are used for producing sound effects. All these components are mounted on the ceiling 5.3m above the playground area, which allows for playing area of 7 x 6m [2]. The code that makes the link to the interactive playground installation and the tracking algorithm were initially provided.

5.2. Rock Paper Scissors - Multiplayer */extension/*

This section provides only a description of the game mechanics for the multiplayer game. The rest of the basic game design elements - story, aesthetics and technology, overlap with the single player game.

5.2.1. Game Mechanics

- **Goals**

The goal of the multiplayer Rock Paper Scissors game is based on a teamwork, agility and fast reactions. To win the game, a team needs to win in rock-paper-scissors intermediate battles and reach the opponent team's area.

- **Elements**

Teams & Team areas

The game is played by two teams – blue team and red team. Each team is composed of two players and has its team area where the players stand. Inside the team area are, as well, the defence elements –rock, paper, and scissors, which a player from each team needs to select before the game begins.

Instructions

The game itself gives instructions to the players how to play. When four players are inside the boundaries of the playground, the first instruction scene loads and shows to the players that they need to get positions, which are pointed at with big arrows. At the moment when both teams get their positions, the second instruction scene appears and gives an indication to the players that they need to select a defence element. Once the defence elements are selected, a countdown starts and the game begins.

Feedback

A feedback is given to show which team is the winner of the intermediate rock-paper-scissors battle.

Sound and visual effects

To enhance the play experience and provide feedback to the player, sound and visual effects are incorporated into the game. When the game is on, there is a background music, which adds rhythm to the play. Depending on events, different effects are added, as well.

Event	Sound effect	Visual effect
Player selects defence element	✓	✓
Both teams have selected defence element		✓
Blue player and red player meet	✓	✓
Player loses/wins Rock Paper Scissors battle		✓

Tabel 5.2: Sound and visual effects on events for the multiplayer Rock Paper Scissors game

6. REALIZATION

In this chapter the actual realization and design of the Rock Paper Scissors games from a game concept to a working game is presented.

6.1. Design sources

Images

For the realization of the game design of the rock paper scissors games, images from the Internet were used. When needed, these images were modified with Pixlr Online Photo Editor in order to fit better with the general design of the games. All the images are in two-dimensional style and with a simplistic design. Table 6.1 shows the icons used for the single player game and Table 6.2 shows the icons used for the multiplayer game.

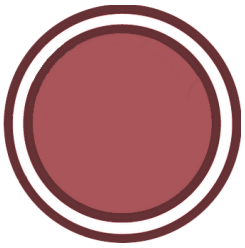
	Single player avatar without selected defence element
	Single player avatar with selected defence element – rock, paper and scissors, respectively
	Rock Enemy
	Paper Enemy
	Scissors Enemy

Table 6.1: Icons used for the single player game ©2018 Camp Canary Ltd

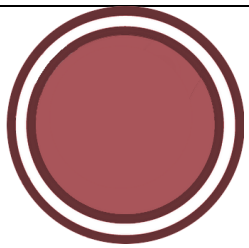
	Blue team avatar
	Blue team avatar with selected defence element - rock, paper and scissors, respectively
	Red team avatar
	Red team avatar with selected defence element - rock, paper and scissors, respectively

Table 6.2: Icons used for the multiplayer game ©2018 Camp Canary Ltd

Fonts

The font style used in the Rock Paper Scissors game is called "Angry Birds" and as the name suggests this font is identical to the one used in a famous video game. This font was chosen because of its playfulness and bold style. White colour has been chosen for the text in the games because it stands out from the rest of the colours in the games.

Sounds

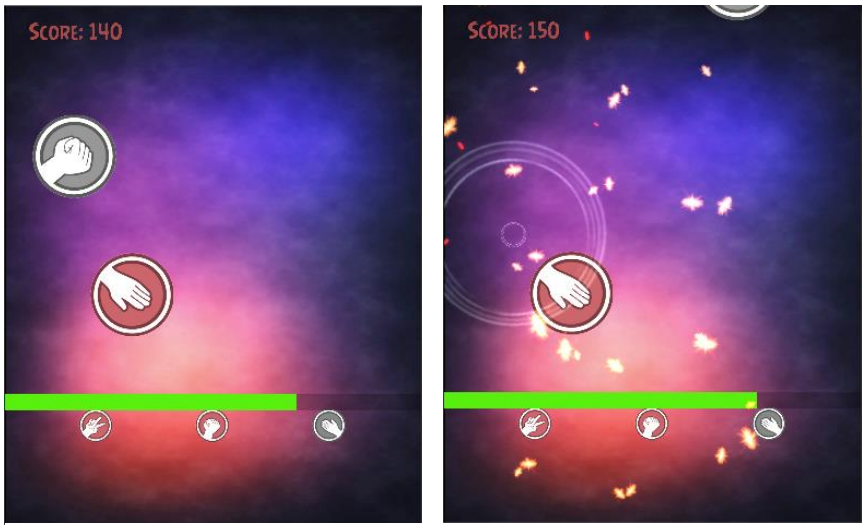
The sounds used to emphasize important events in the game are royalty-free sounds. Dynamic tones have been chosen in order to fit with the tempo of the games.

6.2. The working games

In this section, first, the implemented elements of single player game are described. Then the functions of the multiplayer game are reported.

6.2.1. Rock Paper Scissors - Single player

The single player game consists of three screens: a play mode screen, a game over screen and a winning screen, which lead to the next level of the game. Currently, there are 2 game levels implemented.



(a) (b)

Figure 6.1: Rock Paper Scissors - Single player (level 2) - the play mode screen

The play mode screen is shown in Figure 6.1. The player selects a proper defence element. This event is indicated with a sound effect and a visual effect – the selected defence element turn into grey colour (Figure 6.1 (a)). This way the player can make sure that (s)he has selected the right element. When the enemy is destroyed, this event is followed by a visual effect showing destruction (Figure 6.1 (b)) and a sound effect, which is different for each element –(if paper destroys rock, a sound of paper crumbling is produced, if rock destroys scissors, a sound of rock hitting metal is produced and if scissors destroy paper, a sound of cutting with scissors is produced). The score and the progress bar increase as well.

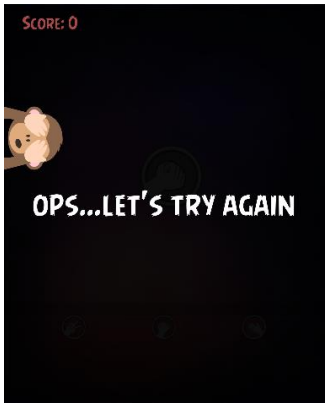


Figure 6.2: Game over screen RPS- single player

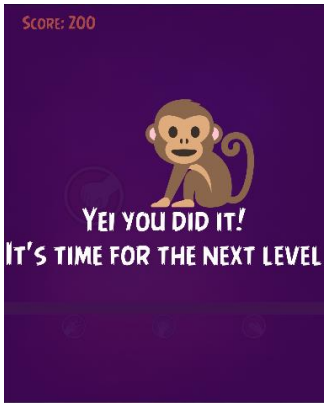


Figure 6.3: Winning screen RPS - single player

Figure 6.2 and Figure 6.3 show the game over screen and the winning screen, respectively. The game over screen, intentionally, does not include the phrase "game over", but more playful phrase. This way the player does not get demotivated. The winning screen also includes a cheerful phrase in order to boost players' motivation.

Pictures of the implemented game on the interactive playground can be seen in Figure 6.4.

(a)

(b)

(c)

Figure 6.4: Rock Paper Scissors single player game implemented on the interactive playground; play mode screen (a); winning screen (b); game over screen (c)

6.2.2. Rock Paper Scissors - Multiplayer

The multiplier game consists of multiple screens: a few instruction screens, a play mode screen, a feedback on the winner of the rock-paper-scissors battles screen, and a screen showing who the winner of the game is.

The instruction screens are shown in Figure 6.5. The first instruction screen gives directions to the players where they need to stand (Figure 6.5 (a)). Once all the players have got positions, the next instruction screen is loaded showing the players that they need to select a defence element (Figure 6.5 (b)). All the defence elements pulsate until the players select one of them. When a player from both teams has selected a defence element, a countdown starts (Figure 6.5 (c)). After the countdown screen, the players can start playing.

(a) (b) (c)

Figure 6.5: Instruction screens: get position screen (a); select element screen (b); countdown screen (c).

When the players meet for a rock-paper-scissors battle their avatar change and reveal what defence element each team has chosen (Figure 6.6). At the same time, a feedback screen showing which team is the winner of the battle is activated. This screen as well gives hints to the loser of the battle to run back and tag his/her teammate and pass over the turn.

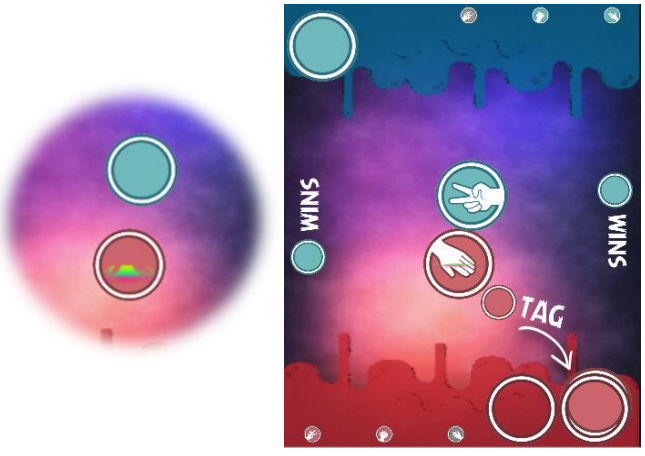


Figure 6.6: Feedback screen - at the moment the players meet the defence elements are revealed and the winner of the rock-paper-scissors battle is known.

Figure 6.7 shows the winner of the game screen, when the red team is the winner (a) and when the red team is the winner (b).

(a) **(b)**

Figure 6.7: The winner screen; The red team wins (a); The blue team wins (b)

A picture of the implemented game on the interactive playground can be seen in Figure 6.8.

Figure 6.8: Rock Paper Scissors single player game implemented on the interactive playground

7. EVALUATION

Now that the games are finished, testing needs to be performed in order to evaluate the extent to which the research is successful. In this chapter, the preparation of the usability tests is explained by the goal, participants, method, and observation & questionnaire. Then the execution of the tests is described. And finally, the results of the observations and the questionnaires are reported.

7.1. Testing Protocol

A testing protocol is prepared to ensure that the testing sessions are executed according to plan. This protocol contains a goal, a description of the testing method, and a meaning of the observation & questionnaire.

7.1.1. Goal

The goal of the user test evaluation is to test the effectiveness of the interactive playground games in inspiring a play without technology. And moreover, to give answers to sub-questions with the help of which an answer to the main research question can be extracted:

> Is the real-life game or the interactive playground game liked more?
> Do the users understand how to play the game without extensive explanation?
> Do the users get insights on how to play the game outside after they played it on the interactive playground?
> Do the users want to play the game again (either on the playground or outside)?
> Does the playground game enrich the real-life game?

7.1.2. Participants

The interactive playgroup platform is not going to be installed in the Roessingh Pediatric Department in time to conduct the user tests with the target group of this research – children with motor disorders. However, in order to check the influence of the interactive playground games to trigger physical activity and inspire a real-life play, the evaluation is going to be made with students as users.

7.1.3. Method

The methods used for the evaluation of the single player game and the multiplayer game differentiate, but they are both composed of three stages. The first stage is the introduction, where the participants are explained the rules of the games and how the interactive playground works. The second stage is the observation, where the participants play the game and their reaction and behaviour are observed. Afterwards, during the third stage, the participants are requested to fill in a short game experience questionnaire.

In order to test if the children are going to play the multiplayer game without the playground, it is needed to evaluate how transferable the interactive playground

game is in a real-life setting (without any technology). This is going to be achieved with two groups of users – a control group and an experimental group. The control group is going to play in a real-life setting, while the experimental group is going to play on the interactive playground and in a real-life setting.

Stage 1: Introduction
Before start playing both groups are given the following written instructions of the rules of the game:

"This game is played by 4 players who are divided into two teams. Both teams stand against each other in the opposite corners of a defined field. Each team has a little outlined area, which the opposing team needs to conquer. When the game starts, two players, one from each team, start running towards each other. At the point they meet, they play Rock Paper Scissors battle. The battle looser needs to run back to the team's area and pass over the turn to his/her teammate. The winner needs to count to 3 (giving some time to the looser) and continue running towards the opponent team area. The winner is the team which first approaches the opponent team area."

Besides these instructions, the groups are not going to be given any additional explanations in regards to the games. The experimental group, however, is going to be briefly explained how the interactive playground works.

Stage 2: Observation
After reading the instructions both groups can start playing the game. The participants in the control group need to decide for themselves how to organize the game, given only the instructions.
For the experimental group, the game is already settled on the playground. When the participants have already played once the game on the playground, they are asked to play the game without the interactive playground.

Both the groups are going to be observed and a comparison between the control group and the experimental group's observable experience, while playing the real-life version of the game, will be made.

Stage 3: Questionnaire
In the end, both groups are given a general questionnaire about their experience and opinion about the game. The questionnaire devoted to the user experience is inspired by IJsselsteijn, de Kort and Poels [21].

RPS – single player

The single player playground game is not transferable to a real-life game and it is going to be evaluated in a different, from the multiplayer game, manner. However, the stages for the user test remain the same. In this case, one participant per testing is required – there are no control and experiment groups.

Before start playing, each participant is verbally introduced to the rules of the game and explained how the interactive playground is working (Stage 1). After the introduction stage is over, the participant can start playing the game. Meanwhile, an observation is conducted to see how the participant is interacting with the playground game (Stage 2). In the end, when the play is over, the participant is given a questionnaire to fill in (Stage 3).

7.1.4. Observation & Questionnaire

Observation:

While playing the interactive playground games participants will be observed in order to see:

- If the participants understand how to play the game on the interactive playground or they need more extensive explanation;
- If the participants give indications of confusion during the play (because of the playground or because of the game itself);
- If the participants get too tired during the play;
- If the participants give indications of excitement when scoring points/ winning rock paper scissors battle;
- If the participants look motivated to complete the total score/ to win the games;
- If the participants have fun while playing the interactive playground games.

Questionnaire:

To test the experience that the participants had while playing the games, a questionnaire was used. This questionnaire was derived from the Game Experience Questionnaire (GEQ) by IJsselsteijn, de Kort and Poels [24]. 19 out of the 33 questions in the core module of the GEQ were selected because they were fitting the best with the needs of this evaluation. Additionally, 2 questions were added separately. The final questionnaire consists of 5 dimensions. The five dimensions provide insights into the immersion, the flow, the positive and negative affection of the game experience, and the physical activity involved in the games.
A Likert scale, combined with a Smileyometer, was used to gather the opinion of the participants. The participants could choose from a range of 1(Strongly Disagree) to 5 (Strongly Agree), figure X. The questionnaire form used for the evaluation can be found in Appendix A.

7.2. Execution

In this section, the setup for the evaluations is briefly presented together with the amount of participants that took part in the testing.

7.2.1. Setup

The testing took place in the Design Lab, located in the Gallery building of the University of Twente. In the Design Lab, there is an interactive playground platform, which was used for the testing. A camera was positioned next to the interactive playground in order to record the experience of the participants who gave their permission to be recorded – the consent form can be found in Appendix C.

7.2.2. Time Frame & Amount of participants

The testing took 3 days, in which 30 participants, in total, tested both games.

7.3. Results

The results of the user testing are divided into two sections – analysis of the observation and analysis of the questionnaire. The most significant observations and results from the questionnaire are discussed in the following sub-sections.

7.3.1. Observation

- **Single player game**

During the testing of the Rock Paper Scissors game, a few observations points were made. The participants who tested the single player game could figure out the game by themselves very easily. All the participants got to the second level of the game and managed to complete it successfully. None of the participants lost.
It looked like the game was easy for the players. They had enough time to select a proper defence element and repel the enemies. Some of them were even curious to see what happens when they do not repel an enemy. The participants jumped around, run, slide on the floor or combined all these movements during the play. Due to the fact that the game was easy for the participants they were able to explore the game on a deeper level than expected.

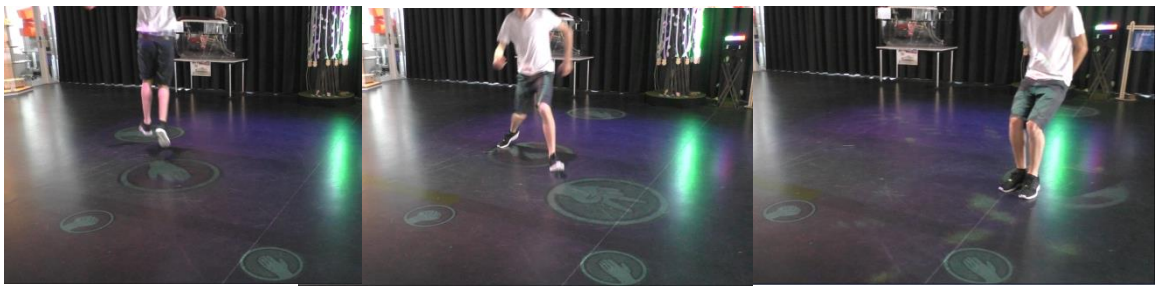


Figure 7.1: Participant plays the Rock Paper Scissors single player game

- **Multiplayer game**

The instructions given to the participants before playing the multiplayer game on the interactive playground were not enough for them to fluently play the game and experience it on the playground. Due to that reason, the participants were further explained how to play and what steps are needed in order to successfully play the game on the interactive playground. Even though that the playground game itself included instructions to the players, they were still confused and didn't really know how to interact. The intensity of the playground projection on the floor was as well not strong enough for the participants to see the boundaries of the playground and they often went out of it.
Since the tracking system cannot know from which team is each player, the avatars of the players often switched in the points where two players are meeting to play the rock-paper-scissors battle.

The positive aspect is that the participants were enthusiastic to experience a play on the interactive playground platform and they were happy to try again with the game despite the technical difficulties and limitations of the game itself.
Overall, the interactive playground platform has its limitations; however, the game still can be improved to fit with the limitations of the playground. Suggestions for improvements can be found in the discussion chapter of this report.

Experimental groups and the control groups were compared while playing the real life version of the game.

Experimental groups	**Control groups**
organized the real-life game faster	took a bit more time to organize the game
defined a smaller field for the game– *probably influenced by the dimensions of the interactive playground*	defined large field for the game (twice or more larger than the experimental groups)
One of the groups included the mechanics of selecting a defence element beforehand instead of playing the physical Rock Paper Scissors battle.	
Always kept the rule for giving precedence to the loser of the Rock Paper Scissors battles.	Sometimes forgot about the rule of giving time to the loser of the Rock Paper Scissors battle.
One of the groups introduced the rule of taking small steps towards the opponent's area until the looser reaches/tags his/her teammate.	In general, the control groups' play included more dynamic movement in comparison to the experimental group.

Figure 7.2: The results from the comparative observance of the experimental and control groups

Both experimental and control groups played the game more than once, without being asked. The participants laughed a lot while playing, which is an indication of having fun and experiencing some sort of happiness.

7.3.2. Questionnaire

- **Multiplayer game**

The results from the questionnaire were analyzed with Cronbach's alpha tests, which are usually used to see if multiple-question Likert scale surveys, like the ones used in this evaluation, are reliable[5]. Once the reliability of the questionnaire is confirmed, the average results of the experimental and control groups are compared with an independent two-sample t-test. With the t-test it can be measured how significant the differences are and if these differences happened by chance[6]. When needed, the data collected from the questionnaire was checked for normality before undergoing a t-test analysis. The results of the normality checked confirmed that the data collected from the questionnaire is approximately normally distributed.

Positive affect

The first section of the questionnaire is meant to evaluate the level of positive affect that the participants experienced while playing the games. This section contains 5 statements (*I felt happy* etc.) with which it was aimed to evaluate if the game triggered a positive feeling in the participants. A comparison of the average results from both experimental and control groups can be found in Chart 7.1.

The consistency of the answers was checked with the Cronbach's alpha and the obtained values were as followed:
Experimental group: 0.887;
Control group: 0.709.
The high values of the Cronbach's alpha for both of the groups mean that the questions in this dimension measure a single construct. The mean of the answers for the positive affect dimension is 3.83 ($\sigma = 0.78$) for the experimental groups and 4.32 ($\sigma = 0.34$) for the control groups, which indicates that the real-life version of the game has a slightly bigger positive affect on the players than the interactive playground game. However, the statistical significance was tested and the results ($t(22) = -1.96$, $p = 0.063$) showed that there is no significant difference between the positive affect of the interactive playground game and its real-life version.

[5] "Cronbach's Alpha: Simple Definition, Use and Interpretation", Statistics How To, 2018. [Online]. Available: http://www.statisticshowto.com/cronbachs-alpha-spss/. [Accessed: 09-Jul- 2018].
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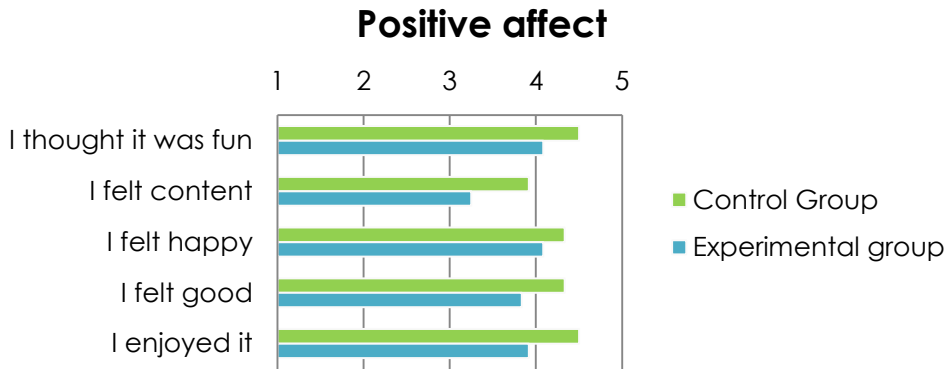

Chart 7.1: The average results of the answers the participants from the control and experimental groups gave for the positive affect dimension of the questionnaire (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

Immersion

The second section of the questionnaire is meant to evaluate the level of immersion. This section as well contains 5 statements (*I felt imaginative* etc.) with which it was aimed to evaluate the level of immersion that the participants experienced. However, 4 out of 12 participants from the control group did not give an answer to one of the statements, namely - *It was aesthetically pleasing*. Because of this, it was decided to remove the question from the dimension. However, the average results for this question are still present in Chart 7.2, as the participants who did not give an answer were removed from the average calculation.

	CONTROL GROUP Cronbach's Alpha if Item Deleted	EXPERIMENTAL GROUP Cronbach's Alpha if Item Deleted
Q6	.571	-2.665E-15[a]
Q7	.677	.253
Q8	.535	.512
Q9	.361	.325
Q10	.484	.445

Figure 7.3: Cronbach's Alpha if question removed for control and experimental groups

The consistency of the all the answers was checked with the Cronbach's alpha and the obtained values are as follows:
Experimental group: 0.390
Control group: 0.586
The Cronbach's alpha does not improve if Q6* is deleted as it can be seen in Figure 7.3. However, the low alpha values for both the experimental and control groups suggest that all the questions from this dimension are not fitting well in the evaluation of this game. As a result, the data obtained from this dimension of the questionnaire is not eligible for t-test analysis and a conclusion is not made.

* *It was aesthetically pleasing*

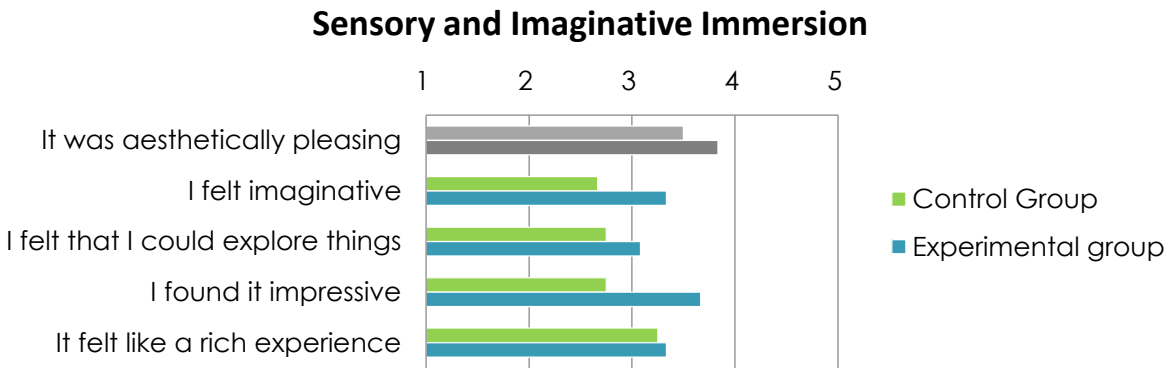

Chart 7.2: The average results of the answers the participants from the control and experimental groups gave for the immersion dimension of the questionnaire (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

Flow

The third section is aimed to gain insights about the flow of the games. This section contains 5 statements (*I was deeply concentrated in the game* etc.) with which it is aimed to measure how occupied the participants were with the game.
The consistency of the answers was checked with the Cronbach's alpha and the obtained values are as follows:
Experimental group: 0.891
Control group: 0.860
The high Cronbach's alpha numbers for both the groups imply that there is a strong correlation between the items in this dimension. The mean for the experimental groups is 3.35 (σ = 0.86) and for the control groups is 3.6 (σ = 0.78) showing that the game flow was slightly better for the control group but overall fairly good for both the groups. The lower result for the experimental group can be explained by the flaws of the interactive playground game, which sometimes caused confusion among the players.
The t-test results (*t (22) = -0.75, p = 0.46*) showed that the difference between the means of the experimental and control groups result are not statistically significant.

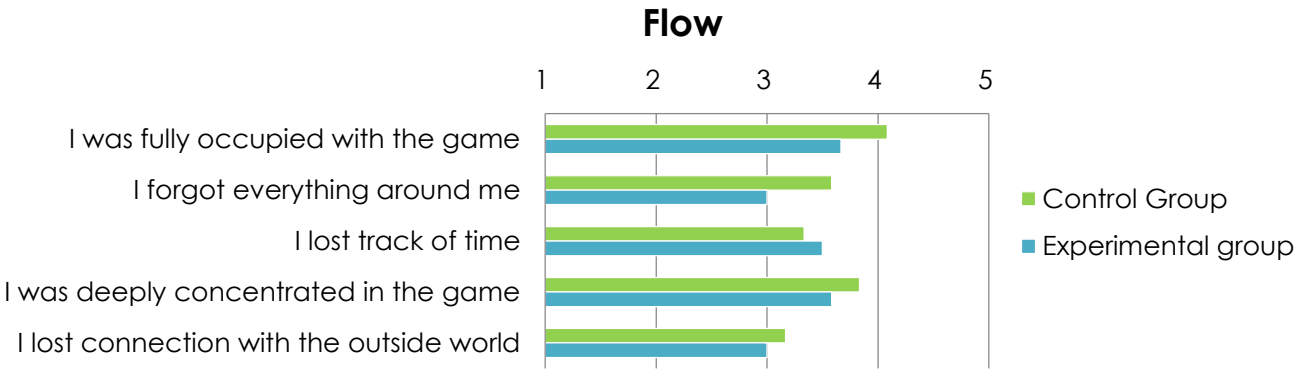

Chart 7.3: The average results of the answers the participants from the control and experimental groups gave for the game flow questions (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

Negative affect

The forth section of the questionnaire is meant to evaluate the level of negative affection that the participants experienced while playing the game. This section contains 4 statements (*It gave me a bad mood* etc.) with which it was aimed to evaluate if the game triggered negative emotions in the participants.
One of the questions in this dimension and namely - *I found it tiresome* could be interpreted differently than aimed. Since the GEQ is initially designed for an evaluation of computer games, this question has an implied meaning of getting sick of playing a certain computer game. However, in this situation the game involves physical activity and the question can be interpreted as actually being physically tired. Looking at the Chart 7.4, which shows the average results from both experimental and control groups, it can be noticed that the values for *I found it tiresome* question are quite higher in comparison to the rest of the questions.
The consistency of the answers were checked with the Cronbach's alpha and the obtained values are as follows:
Experimental group: 0.828
Control group: 0.694
The mean for the experimental groups is 1.85 (σ = 0.65) and for the control groups is 1.83 (σ = 0.64) showing that the participants from both the experimental and control groups did not experience negative affect caused by the interactive playground game or the real life play. As expected, the t-test (*t(22) = 0.08, p = 0.938*) showed that there is no significant difference between the experimental and control groups in regard to negative emotions triggered by playing either the interactive playground game or its real life version.

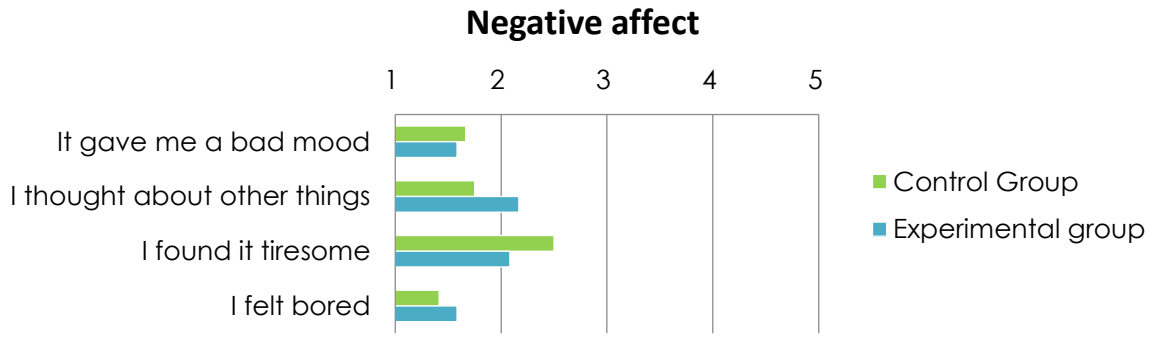

Chart 7.4: The average results of the answers the participants from the control and experimental groups gave to the negative affect questions (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

Physical activity & the game

The fifth section is for the amount of physical activity required for playing the game. Two questions were asked here – "*Do you think that this game promoted physical activity?*" and "*Do you think that this game required a lot of activity/movement?*". This section is excluded from the Cronbach's alpha test since it contains only 2 questions. The results show that both experimental and control groups agreed that the interactive playground game and its real-life version require a good amount of physical activity (Experimental group m = 4.04, σ = 0.78; Control group m = 4.08, σ = 0.59). There is no difference between the groups. The average result for each question can be seen in Chart 7.5.

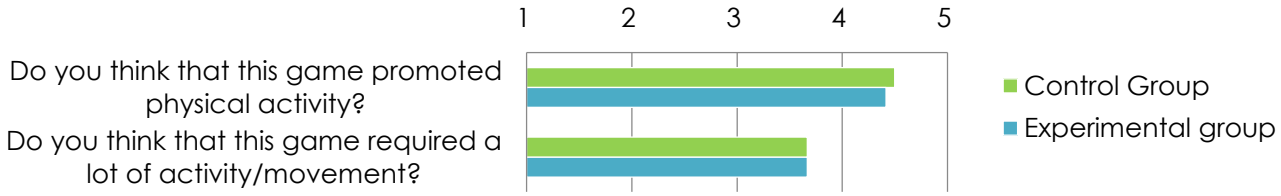

Chart 7.5: The average result of the answers the participants from the control and experimental groups gave to the questions related to the physical activity (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

- **Single player**

The participants who played the single player game were given the same Game Experience Questionnaire (GEQ). Because of the low number of participants (n = 6) these results are not statistically analyzed. The results of each dimension are presented below.

The results for the **positive affect** dimension show that the participants experienced positive feelings while playing the game (m = 4.16, σ = 0.71).

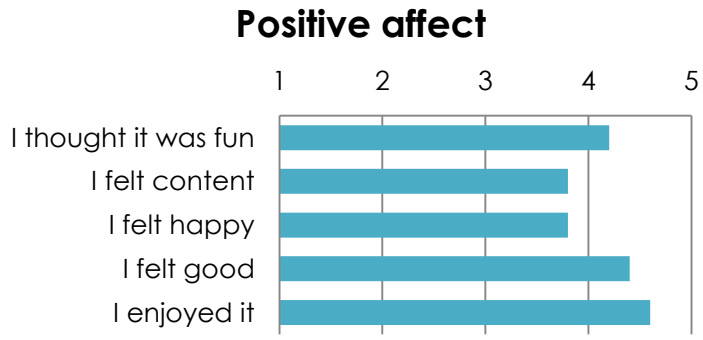

Chart 7.6: The average results of the answers the participants gave for the positive affect dimension of the questionnaire (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

The score for **immersion** is moderately high as well (m = 3.6, σ = 0.65), meaning that the game is successfully attracting the attention of the players.

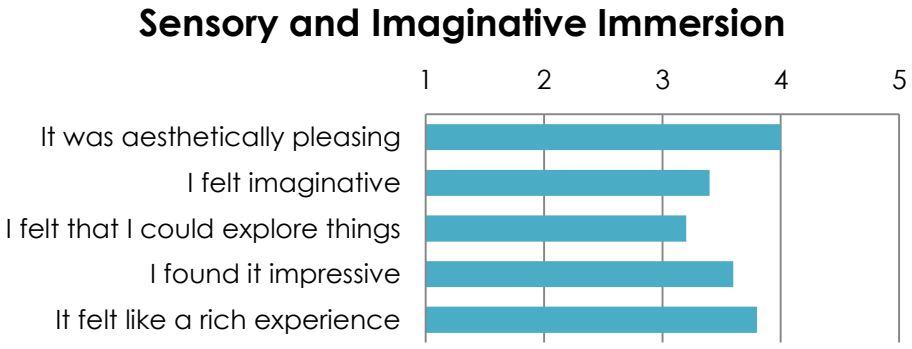

Chart 7.7: The average results of the answers the participants gave to the questions about immersion (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

The low results for the **negative affect** dimension (m = 1.55, σ = 0.65) indicate that the participants did not lose interest or get bored while playing.

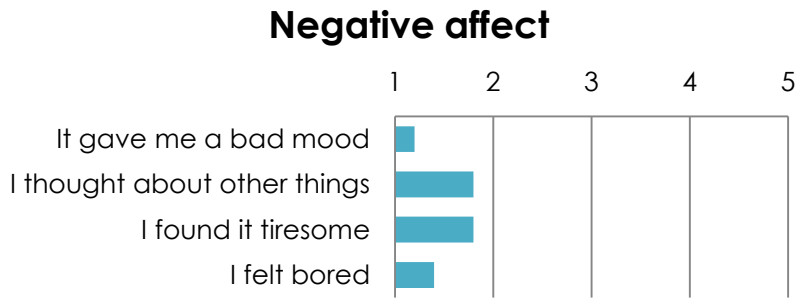

Chart 7.8: The average results of the answers the participants gave to the questions related to negative affect (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

The results for the **flow** dimension are relatively high (m = 3.48, σ = 0.6), showing that the participants were fully focused on the game and accomplishing its goal.

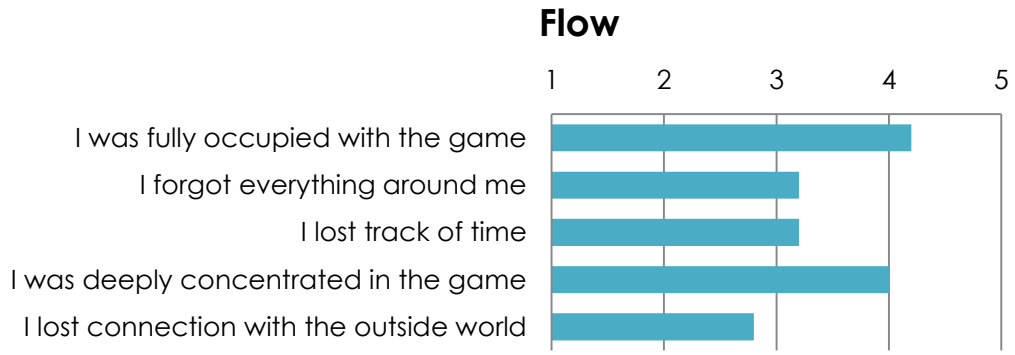

Chart 7.9: The average results of the answers the participants gave for the game flow questions (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

Finally, the participants were asked if the game requires **physical activity** and if it encourages movement. Here the majority of the participants strongly agreed (m = 4.2, σ = 0.5) that the game is promoting physical activity and requires a good amount of movement.

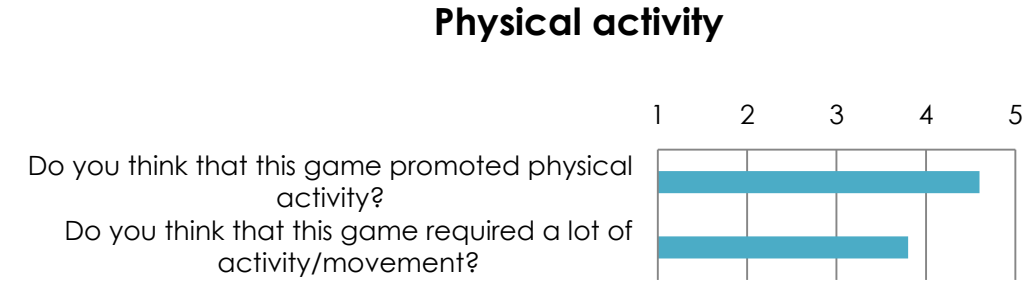

Chart 7.10: The average result of the answers the participants gave to the questions related to the physical activity (strongly disagree = 1, disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5)

7.3.3. Analysis and conclusions

Within the evaluation, it was aimed to find answers to a number of questions mentioned at the beginning of this chapter. Each question is discussed separately and a conclusion is drawn.

Do the users understand how to play the interactive playground games without an extensive explanation?

The evaluation showed that the single player game has simple enough mechanics that are intuitive to the user. The participants did not need additional explanation besides the one given to them at the beginning of the evaluation.

For the multiplayer game, the case is different. Even though, the participants received written instructions, which they were allowed to use throughout the whole evaluation and the game itself included instructions for the players to follow, still, the participants got confused and needed an extra explanation of what they need to do in order to play the game.

Do the users get insights how to play the game outside after they played it on the interactive playground?

The comparative observation of the experimental and control groups showed that the interactive playground game brings value to the real-life play. Not only the experimental groups were faster in organizing the real-life game, but they also included additional game elements, which were not expected for the real-life version of the game. The experimental groups, as well, followed the rules of the game more strictly as, for example, the control groups often forgot the rule of giving precedence of 3 seconds to the loser of the rock-paper-scissors battle.

Does the playground game make the real life game more engaging?

The observations showed that the experimental groups visibly had better fun while playing the real-life version of the game than while playing the interactive playground game. Yet, the reasoning for that might be the limitations of the interactive playground game itself, not that the playground experience makes the player even more excited about playing the game in a real-life setting.
On the other hand, all the groups (experimental and control) played the real-life game more than once, without being asked for. This can be an indication that the participants find the real life play entertaining and engaging. However, this information cannot prove that the interactive playground game makes the real-life play more interesting.

Is the interactive playground game or the real life game liked more?

The results from the questionnaires for the experimental and control groups indicated that the real-life game gave the players a better overall experience than the interactive playground game. However, the statistical analysis showed that there is no significant difference between the results of the control groups

which were answering the questions in regards to the real-life version of the game and the experimental groups which gave answers for the interactive playground game. The observations of the experimental groups showed that the participants laughed more and were more engaged with the real-life version of the multiplayer game.

8. DISCUSSION

The conducted evaluation, described in the previous chapter, concludes this study and allows reviewing its outcome. In this chapter, the encountered difficulties and limitations of the study are discussed together with suggestions for improvements and future work.

8.1. Difficulties

For this project, it was important to create a game or games that:
> promote physical activity,
> are suitable for children with developmental coordination disorder,
> fit with the interactive playground technology,
> are transferable to a real-life setting, meaning without any technology
> can be played either by a single player or multiple players.

During the ideation phase, it was a challenge to come up with a concept that fits all these demands. The most problematic was the one for a game that can be played on the interactive playground and in real life setting and especially for a single player. In general, there are not many games that include physical activity and are fun for playing alone. Even though I came up with many concepts suitable for the interactive playground and for a single player also, they include elements moving by their own, or appearing suddenly that cannot be realised in real life setting and consequently cannot fully meet the mentioned above demands.
Then I changed my strategy. In order to come up with a game that is suitable for the interactive playground and in the same time can be played outside without any technology, I decided to first think of a real-life game and try to adapt its elements to the interactive playground. However, many times this was restricted due to the limitations of the interactive playground which do not allow for certain game mechanics that are possible in a real-life setting.

Overall, the ideation phase of this project was full of unsolvable dilemmas, which lead to some compromises with the game demands. In the end, after a consultation with the supervisor and the client of this project, it was decided to put more emphasis on creating a single player game for the interactive playground and a multiplayer game that is transferable to a real-life setting.

8.2. Limitations of the study

As already described in the evaluation chapter of this report, the multiplayer version of the Rock Paper Scissors game was tested with a between-subject approach. Three experimental and three control groups took part in the testing. The experimental groups played first the interactive playground game and after that tried out the real-life version of the game, while the control groups played only the real-life version of the game. Both the experimental and control groups were observed while playing the real-life version and were compared to see if the interactive playground game adds value to the real-life playing. Furthermore, all the groups were asked to fill in a questionnaire as the experimental groups were

answering the questions in regards to the interactive playground game and the control groups – in regards to the real-life game. In such a way it was aimed to see which game experience is better – the one on the playground or the one in the real-life setting, without technology involved.

However, in regards to the questionnaire, the evaluation could be done in a better way. It would make more sense if both the experimental and control groups fill in the questionnaire about the real-life version of the game. This would allow us to statistically prove if the interactive playground actually enriches the real-life game experience or not.

Another encountered limitation of the study is related to the technology used in this project. Throughout the process of implementing the chosen multiplayer game concept and trying it out on the interactive playground, I realized the flaws of the game and the playground. The game was improved from the first try out on the playground and the final user testing, however, the time constraints of the project did not allow for pilot testing of the final game and it directly underwent user tests. The results from the user tests were notably influenced by the shortcomings of the interactive playground.

Nevertheless, all wanted functionalities of the game were implemented, there were still issues occurring because of the playground tracking system. Many times players' avatars were switching and respectively the players were changing teams unintentionally. This caused a disturbance in the play as the players could not go back to their original team and the game lost its sense. Another problem was that sometimes the players were not tracked at all since they were standing in the corners of the playground, which was required because of the game concept itself.

Even though the performance of the tracker was evaluated and showed a low *probability of track switch* (9.81%) and *percentage of time a player is not tracked* (2.63%) [2], yet these flaws are ruinous for the Rock Paper Scissors gameplay. That is why, it is advisable in the future to reconsider the game concept and change it into one, more suitable for the interactive playground.

8.3. Suggestions for improvements and future work

- **Single player game**

Even though the single player Rock Paper Scissors game received very positive results from the evaluation, there is still space for improvement.

> A feature that is required but was not implemented due to time constraints is the option for adjusting the difficulty level of the game before playing. This can make the game more suitable for rehabilitation sessions as it would give the therapist an opportunity to adjust the game to the needs of many different patients.

> Moreover the game can be made more exciting by adding a new element for each level. For example, among the falling enemies, there could be added a power-up element that destroys all the enemies on the current screen when the player steps on it, or a freeze element that freezes all the enemies so the player can easily destroy them, or a granite element that destroys the player if (s)he steps on it.

- **Multiplayer game**

The results for the multiplayer Rock Paper Scissors game were not as positive as the results for the single player game, but they provided insights of the limitations of the game and the interactive playground which lead to the following suggestions for improvement:

> The visibility of the floor projection should be improved. This can be achieved by installing an interactive playground in a very dark room with a light coloured floor.

> An option for the players to "charge" themselves with the colour of their team in case of avatars switching when playing the rock paper scissors battles.

> The borders of the playground should be defined so the players do not go outside of its boundaries since this can cause bugs in the game and frustration.

> The instruction scenes can include a voice commands so the players notice them better.

9. CONCLUSION

The last chapter of this report is the conclusion. This chapter provides an answer to the research question and concludes the research study.

The main research question of this project is as follows:

> *How to design an interactive playground game which encourages physical activity among children with motor deficiencies and gives them insights how to play outside the boundaries of the playground?*

Re-Play – Interactive playground games to motivate playing project deals with encouraging children with motor conditions to peruse physical activities by playing fun games on an interactive playground. In order to design a suitable for this purpose game, a number of steps were carried out, all described in this report. From getting familiar with the situation of the children with DCD and the importance of physical activity for improving their quality of life to making definitive game design decisions, until at the end the final games were implemented. To enhance the motivation for physical activity among children with motor deficiency and encourage them to re-play the games, they include the following characteristics: simple and self-explanatory rules, realistic goals, relevant feedback on performance.

The evaluation of the games with students showed that the interactive playground Rock Paper Scissors games trigger different movements like walking, running, jumping or sliding on the floor. Furthermore, despite the limitations, the interactive playground multiplayer game provides valuable guidance for a real-life play, as it was found, out of the testing. It was observed as well that different groups of players include new game elements and rules when organizing the real-life game after they had played the interactive playground version. Considering this, it can be claimed that the interactive playground game adds value to the real-life play.

However, the final games implemented for this project are still subjects of improvement. By implementing the future work suggestions made previously in this report, the game design can already be very much improved.

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APPENDIX A: Game Experience Questionnaire

Game experience questionnaire

How you felt while playing the interactive playground game

Positive affect:

	Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
I thought it was fun	○	○	○	○	○
I felt content	○	○	○	○	○
I felt happy	○	○	○	○	○
I felt good	○	○	○	○	○
I enjoyed it	○	○	○	○	○

Flow:

	Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
I was fully occupied with the game	○	○	○	○	○
I forgot everything around me	○	○	○	○	○
I lost track of time	○	○	○	○	○
vas deeply concentrated in the game	○	○	○	○	○
it connection with the outside world	○	○	○	○	○

Sensory and Imaginative Immersion:

	Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
It was aesthetically pleasing	○	○	○	○	○
I felt imaginative	○	○	○	○	○
I felt that I could explore things	○	○	○	○	○
I found it impressive	○	○	○	○	○
It felt like a rich experience	○	○	○	○	○

Opinion about the game:

Do you think that this game promoted physical activity?

Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○

Do you think that this game required a lot of activity/movement?

Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○

Negative affect:

	Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
It gave me a bad mood	○	○	○	○	○
I thought about other things	○	○	○	○	○
I found it tiresome	○	○	○	○	○
I felt bored	○	○	○	○	○

APPENDIX B: Information brochure

Information brochure HMI Department

Dear reader,

In this letter, we would like to inform you about the research you are about to participate in. The testing will take place in the time frame from 06-06-18 to 06-07-18, in Design Lab (UT), Enschede. In the proposed research, the participants are going to play games on an Interactive Playground Platform. These games are created for Graduation Project called "Re-play – interactive playground games to motivate playing". This project is focused on designing and building an interactive playground game or set of games that promote physical activity among children with motor disorders. The interactive playground platform consists of an interactive floor projection, which responds to players positions as measured by top-down Kinects. Such a system allows users to walk in and play without additional calibration or devices.

The purpose of this project is to motivate children with motor deficiency to play physical games outside and be more active. The games will be presented to the children during rehabilitation sessions and they will be able to play them first with the Interactive Playground Platform. Ideally, the young patients will be inspired to play the games outside, without the technology.

The aim of this testing is to identify the flaws of the created games and identify a way to improve them before presenting the final project to the target group.

For participation in the experiment, it is important that you are not taking any substances that can affect your performance during the testing of the games. Furthermore, you can decide to stop at any point in the course of the experiment without this having any consequences for yourself and without giving any reasons. Another relevant aspect is that your data will be handled in a confidential manner; your anonymity is guaranteed and will never be disclosed to third parties without your permission.

If you have any complaints about this research, please direct them to the secretary of the Ethics Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science at the University of Twente, mw. J.M. Strootman-Baas, P.O. Box 217, 7500 AE Enschede (NL), telephone: +31 (0)53 489 6719; email: ethics-comm-ewi@utwente.nl.

Yours sincerely,

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APPENDIX C: Informed consent

Informed Consent for standard research

'I hereby declare that I have been informed in a manner which is clear to me about the nature and method of the research as described in the provided information brochure. My questions have been answered to my satisfaction. I agree of my own free will to participate in this research. I reserve the right to withdraw this consent without the need to give any reason and I am aware that I may withdraw from the experiment at any time during the experiment. Moreover, I am aware that I may still withdraw the information I provided during the conduction of the experiment up to 48 hours and my data will not be a subject of this research anymore. I give my consent to be recorded during this testing. If my research results are to be used in scientific publications or made public in any other manner, then they will be made completely anonymous. My personal data will not be disclosed to third parties without my express permission.'

Signed in duplicate:

…… *……*
Name subject *Signature*

'I have provided explanatory notes about the research. I declare myself willing to answer to the best of my ability any questions which may still arise about the research.'

…… *……*
Name researcher *Signature*