Let’s Go Out and Play: Designing Interactive Outdoor Games for Children

Master's Thesis
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A mere 20 years ago, children used most of their free time playing outside with their friends. Back then children were masters of imaginary games and they created their own games that did not require costly equipment and parental supervision. The children from that time moved a lot and their sensory world was nature based and simple. The advances in technology have changed how children play. Today the majority of children's play is dependent on technology, typically video- and computer games. Sitting inside in front of a screen affects children’s health and is directly linked to some of the most disturbing childhood trends of today, such as Obesity, Attention Deficit Disorder (ADD) and Depression.

This thesis examines the impact of rapid prototyping with adding digital technology to traditional outdoor games, such as hide-and-seek and tag, through a series of two studies conducted with a Dutch unisex scout group aged 7-10 years old.

Two studies were conducted; the first explored how the use of an iterative design process affected the design of Head Up Games (interactive outdoor games for children), and the second explored the user requirements for an Integrated Game Development Environment, IGDE, for non-programmers.

Qualitative data have been collected during these studies in the form of interviews, observations, video and audio footage.

The thesis challenges the argument that the use of low fidelity prototypes is adequate when designing digitally enhanced outdoor games. By experimenting with technology and exposing high fidelity working prototypes to test with children at an early stage in the design process, it is proposed that this is a more effective method. It is also shown that there is a need for two different IGDEs. One for users who only want to play the games and perhaps change a few parameters in the game and a second one for users with no programming and interaction design skills who want to design Head Up Games.

Keywords: Children, outdoor, games, technology, Head Up Games


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För 20 år sedan tillbringade barn största delen av sin fritid utomhus med sina vänner. På den tiden bemästrade barnen fantasilekar och de skapade sina egna spel, som inte var bundna till dyr utrustning eller övervakning av föräldrar. Barnen rörde mycket på sig och deras sinnesvärld var enkel och baserade sig på naturen. Framstegen inom teknologi har ändrat på hur barn leker idag. Idag är en stor del av barns lek och fritid bunden till teknologi, så som video- och datorspel. Nackdelarna med att sitta inne framför en skärm är direkt sammankopplade till några av de allvarligaste hälsoproblemen hos barn, så som fetma, Attention Deficit Disorder (ADD) och depression. Ett intressant alternativ skulle därför vara att ersätta dator- och videospelen med utomhusspel kompletterade med ny teknologi.

Detta arbete undersöker inverkan av snabb prototyping då man lägger till digital teknologi i traditionella utomhusspel, så som kurragömma och nata. Arbetet är baserat på två undersökningar som är gjorda tillsammans med en nederländsk unisex scout grupp.

I arbetet har två undersökningar utförts. Den första undersökte hur användningen av en iterativ designprocess påverkade designen av Head Up Games (interaktiva utomhusspel för barn) och den andra undersökte användarkraven för en utvecklingsmiljö för spel (engelska Integrated Game Development Platform, IGDE) för icke-programmerare.

Kvalitativ data har samlat under undersökningarna i form av intervjuer, observationer, videon och ljudinspelningar.

Arbetet utmanar argumentet att "användningen av lo-fi prototyper är tillräckligt vid design av digitala utomhusspel". Vi hävdar att det är mer effektivt att experimentera med teknologi och då använda hi-fi prototyper för att testa spelen med barn redan vid ett tidigt skede av designprocessen. Vi har även visat att det finns ett behov för två olika IGDE. En för användare som vill spela spel och möjlichen ändra några parametrar i spelen och en annan för användare som vill göra sina egna Head Up Games, men som inte har kunskaper i programmering och interaktionsdesign.

Nyckelord: Barn, utomhus spel, teknologi, Head Up Games
On a Dutch Eindhoven’s Winter day in February 2012, I found myself 1,500 kilometers away from home, in a country I had never been to before, knocking on the door of my future. My biggest passion and goal was not only to learn more about Interaction Design for Children, a field, which the Eindhoven University of Technology in the Netherlands, specialised in, but also hopefully get to help out in projects within this field. There was one minor obstacle hindering my dream: the only exchange spot that had been available for me was at the department of Computer Science and Engineering, and my dream was at the Industrial Design department. However, I did not let this stand in my way and I decided to take a new friend’s advice and just go and knock on the door. It was my lucky day, because not only was the door opened by Prof. Dr. Panos Markopoulos, whose work I admired, but he even offered me my own project. The project was a part of Ph.D. student Iris Soute’s project: Designing Interactive Outdoor Games for Children. A project which I ended up loving so much, that when I was offered to continue with the project after my exchange for my master’s thesis, there was no way in the world I was going to throw away this amazing opportunity.

First of all I would like to thank my instructor Dr.Ir. Iris Soute and my supervisor at TU/e Prof. Dr. Panos Markopoulos for welcoming me to the world of Interaction Design and Children with open arms. A few weeks ago Iris said “You’re like a little version of me and Panos” and I remember feeling very warm in my heart to hear those words. I have learned a lot from the two of you and you have been a big part of shaping me to the confident designer and researcher I am today and I admire the work you have done, so hearing those words were really an honor for me.

A special thank you also goes to my supervisor Docent Kalevi Kilkki, who has helped me to shape this thesis. And to the scout leaders and children at Scouting Steensel, the Netherlands, you have been a great group of playful people to work with and without you this project would look a lot different.

I would also like to thank my family. My mother for pushing me to go outside as a child, even on those days when I thought that being indoors was much more fun. When looking back, what I remember are all the fun times I had out in the nature playing with my friends. My father for taking me out in the nature as a child and showing me the importance of it. Finally my sister Sonja for always encouraging me to take the path that felt right in my heart, even if people around me thought different.

Finally I would like to thank my partner Yves, who has been supporting me through everything. He has taught me that modern knights do not save you on a white horse, they fix your world when technology fails, and film your evaluation sessions and make amazing videos out of them that give you a lot of attention at the Interaction Design and Children conference 2013 in New York.

Susanne Lagerström, Helsinki 24.11.2013
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Introduction

Actively playing outdoors is a healthy and important part of children’s lives. With the onset of technology influencing children’s lives more and more, maintaining this statement is becoming more complex, and is asking us to research and innovate towards finding novel ways to lure children back out of the house. This chapter introduces the background of this field, the scope of research, the research goals and questions and how this is all handled within the structure of this thesis.

1.1 Background

"I like to play indoors better ’cause that’s where all the electrical outlets are."

This is not an unusual expression coming from a child in this age today. Never before in history have children been so plugged in, and so out of touch with the natural world as children in developed countries are today. The lack of nature and being outdoors in the lives of today’s children is according to experts directly linked to some of the most disturbing childhood trends, like Obesity, Attention Deficit Disorder (ADD) and Depression. (Louv, 2005)
It is no news that children are interested in technology and thanks to the usability of some of today’s everyday technology even a few month old infant can manage to, to some extent, understand the use of smartphones and tablets.

During the past twenty years the use of technology in children’s entertainment and education has expanded drastically. Younger children are starting to use technology in their every day life. This has also awakened the question of technology and children’s health issues. For instance, Wii & Kinect offer novel ways of interacting with computers and the idea of taking technology outside has also started to emerge.

According to the World Health Organization, WHO, childhood obesity is one of the most serious public health challenges of the 21st century. In 2010, 42 million children over the world, under the age of five, were estimated to be overweight. Close to 17% of these children are brought up in developed countries. Child overweight and obesity is a serious problem since these children are likely to stay obese into adulthood and to have health problems like developing diabetes and cardiovascular diseases at a younger age. (WHO, 2010)

The main reason for child obesity according to the WHO is an energy imbalance between calories consumed and calories expended, in other words unhealthy eating combined with a low level of physical activity. Although children’s behavior is not alone to be blamed for childhood obesity, the problem is mainly a cause of changes in society. The problem is also strongly linked to social and economic development and policies in the areas of agriculture, transport, urban planning, the environment, food processing, distribution and marketing, as well as education. (WHO, 2010)

WHO has made some recommendations for the levels of physical activity for children and youth aged 5-17 years old. According to these recommendations children and youth should daily accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity. Most of the daily physical activity should be aerobic such as running, jumping and turning and it can be performed as a part of play, games, sports, transportation, chores, recreation, physical education, and planned exercise. (WHO, 2013)

Appropriate practice of physical activity affects children on many different levels, of which weight control is only one of them. Physical activity also develops healthy musculoskeletal tissues (i.e. bones, muscles and joints), a healthy cardiovascular system (i.e. heart and lungs), and neuromuscular awareness (i.e. coordination and movement control). It has also been seen to improving children’s and youths’ control over symptoms of anxiety and depression, and to assist in the social development of young people by providing opportunities for self-expression, building self-confidence, social interaction and integration. (WHO, 2013)
1.2 The Scope of this Research

The focus of this research is on designing Head Up Games, HUGs, for children. As the name indicates, HUGs are interactive outdoor games that are played with your head up. The games are designed to encourage interaction with other players, resulting in interaction comparable to traditional outdoor games like tag and hide-and-seek. HUGs aim to combine the best of both worlds: the fun of traditional outdoor games (running around, being outside, and being together with friends) with the attraction of digital games (interactivity, special sound-, tactile-, and visual effects). When starting the research for this study, RaPIDO, the rapid prototyping platform for HUGs, was just finished and ready to be used. However, no games had yet been fully designed for the platform and tested with children.

The study was done in two parts. The aim of the first study was to rapidly prototype outdoor games for children in an iterative design process. The data for this study was collected from observations of game play and interviews with children and leaders of a scouting group. The aim of the second study was to see what kind of user needs there would be for an integrated game development environment, IGDE. The data for the second study was collected by observing the leaders of a scouting group and interviewing them about the design-process and decision-making process. The studies are based on one group of scouts aged 7-10 years old and their scout leaders. All games developed for the studies were aimed at children aged 7-10 years old.

1.3 Research Goals and Questions

The aim of the first part of the study is to see if rapid prototyping can be used as a method when designing interactive outdoor games for children. In the second part of the study I wanted to find out the user requirements for an integrated game development environment, IGDE.

RQ1. How does using high fidelity prototypes affect the design process when designing Head Up Games?
   In this part of the study I wanted to find out how using high-fidelity prototypes in the beginning of the game design process affect the game design of Head Up Games.

RQ2. Can we use rapid prototyping when designing interactive outdoor games for children?

RQ3. Is there a need for an integrated game development environment, IGDE? If so, what are the user requirements for it?
   From the first part of the study I found that an IGDE would be needed to run the games smoothly. Therefore I found it important to see what kind of user requirements there are for an IGDE.
1.4 Structure

The study made in this Master thesis is closely related to the Ph.D. research, Head Up Games - On the design, creation and evaluation of interactive outdoor games (Soute, 2013), of Dr.Ir. Iris Soute. The research is done for Eindhoven University of Technology, the Netherlands in the research group User-Centered Engineering. The first evaluation in this thesis has been published both as a part of Soute’s thesis and at the international Interaction Design and Children 2013 conference, New York. The evaluations in the research were done in cooperation with the children and scout leaders at Scouting Steensel, the Netherlands.

This thesis is structured as follows: the current chapter presents the framework of this thesis. It frames the need for designing interactive outdoor games for children and presents the scope and aim of this study. The second chapter presents the theoretical background of the study to create an understanding of how to design interactive outdoor games for children in a user-centered design process. It creates an understanding of how to design for children and what to keep in mind when designing pervasive games for them. It also presents Head Up Games, the type of games designed, and RaPIDO, the technology used for these games. In the third chapter the two studies and how they were conducted will be presented. After that, the fourth chapter will present the results of the study. Finally the fifth chapter will conclude the work.
2 Theoretical Background

It is no news that children of today use technology a lot more than children in generations before them. This has lead to researchers to pursue the field of Interaction Design and Children. This year, 2013, was the 12th anniversary of the Interaction Design and Children conference and also the year for the first issue of the International Journal of Child-Computer Interaction to appear. In this chapter we will discuss what interaction design for children is and how it should be taken in account when designing interactive outdoor games for children. First we will describe what it means to approach a design from a user-centered perspective and specifically when designing technology for children. After that we will present how this design method can be used when designing Head Up Games for children.

2.1 Interaction Design

With the vast growth of the Internet, which has increased both work and leisure computing, and other digital interactive consumer products, the idea of user experience has started to emerge. The two cultures of design and engineering have gravitated to a common interest in discretionary use and user experience. During the past fifteen years the interest for interaction design, and how it is looking at technology from a designers perspective, has grown. Today designing interactive consumer products is not anymore only about pure utility and efficiency; it is also for example about considering aesthetic qualities of use. (Löwgren, 2013)
Interaction design is a relevant part of the human-computer interaction (HCI) field. There are a lot of different understandings on what interaction design is, however Löwgren has captured it in a very simple way:

“Interaction design is about shaping digital things for people’s use.”

This is a very simplified definition, but it also captures the most relevant things of interaction design. In interaction design digital things/materials, such as electronics, software and communication networks, are shaped to fit the end users needs. An interaction designer also tries to frame the problem and create different solutions. Although in some cases there is no actual problem, but pure exploration of the future, in other words come up with novel ideas. (Löwgren, 2013)

Interaction design is also closely related to user-centered design (UCD). UCD is a design process in which the end-user influences how a design takes shape. In user-centered design the wants and needs of the end user is put in the center of the design process. For a UCD process to be executed properly it is important that the designer is aware of user-centered design methods and how to apply them in the design process, and to have the ability to analyze and understand the end-users traits and needs. In a UCD process the user is taken in account in every step of the design process and changes to the product are made according to the user. (Löwgren, 2013)

Usability is a term that is widely used in UCD; it means how easy a product is to use and how close it is to the end-users needs and requirements. International Organization for Standardization provides guidance on usability in ISO 9241-11 and defines it as: (ISO, 2008)

“The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.”

Nielsen has defined usability in 5 quality components; learnability, efficiency, memorability, errors and satisfaction. With learnability he means how easy it is to learn to accomplish basic tasks with the product, efficiency: that once the user has learned how the system works, how quickly they can perform tasks, memorability: that if the user has not used the product for a while and again returns to it, how easy it is to reestablish proficiency, errors: sees how many errors the user makes, how severe the errors are and if the user can recover from the errors, and lastly, satisfaction: asks how pleasant it is for the user to use the product. (Nielsen, 1993)
2.2 Interaction Design and Children

As the role of information and communication technology becomes bigger in our society, it is no surprise that the trend also reaches children. In recent years the amount of children using this type of technology has increased remarkably. Children today grow up surrounded by technology, in a way that might surprise earlier generations, but which for children is a completely normal part of their habitat. In developed countries most children frequently use Personal Computers, video game consoles, personal music technologies and smartphones. As the market segment for children using technology grows, societies have also become aware about appropriate products and services, ones that support development and enhance wellbeing, being available for children. Children are not miniature-sized adults and therefore it is important to research the interaction between children and technology and about designing technology for children. (Markopoulos et al., 2008)

"Knowing about children's development and being aware of potential risks does not provide enough information to design technologies. Children need to be involved in some way as well." (Hourcade, 2007)

When it comes to designing for children, one should always try to get out in the field and see what children actually are doing and what they like. One should avoid thinking that they know what children want since they have also once been a child.

Jacob Nielsen states that there is a difference when designing for children and adults. He says that when designing for children one must be more specific about the target group, there is no target group as “children” and referring to all children in age 3-12 years old. A designer must at least decide whether he is designing for young (3-5), mid-range (6-8) or older (9-12) children. Each group behaves differently. Children are also very aware of age differences e.g. a 6 year old might think that something meant for a 4-5 year old is “childish”. (Nielsen, 2010)

2.3 Methods for Interaction Design and Children

The methods used in interaction design for children are closely related to the methods used in interaction design for adults. However, due to children’s cognitive development being on a different level than adults, we need to modify the methods so that they suit children.
2.3.1 The Role of Children in the Design Process

In a design process where children are the end users of a product, children can play various roles in the process. The role of children in a design process can be anything between the traditional role as an end user, where the end user is not involved in the design process, and the role of co-designer (Figure 1). Children can participate in the design process as users, testers, informants or design partners. From a user-centered design perspective the minimal requirement is that the product is at least tested with children and they have participated in an evaluation. Due to practical reasons, e.g. time issues and difficulties in requiting children, designers sometimes have to conduct an evaluation without using children. The evaluation is then often done by using experts from the field to evaluate the product. The experts can for instance be experts in children such as; educators, user-centered design experts and expert product designers. Since the opinion of an expert is only a guess, it is important to use children in an evaluation at least in the stage of the design process. (Markopoulos et al., 2008)

However, participating in an evaluation is not the only one way of involving children in the design process. Druin has suggested to use children as design partners, as equal partners in the design team, throughout the whole project. The idea is not that children tell the adult what to do, but rather the ideas for the design come from the collaboration of children and adults. According to the participatory design methodology, cooperative inquiry, that she has introduced, children contribute with their own ideas during the creative design process and stay in the project for a longer period of time. Though this type of involving children in the design process might give the adult designers a lot of valuable information on how
to design the product, it also comes with some challenges. Since children’s lives differ from adults, there are several things to take in account e.g. children cannot be recruited on request or paid a salary, miss large parts of school, or have their home routines disrupted. This means that when using cooperative inquiry, designers must be prepared to adjust to the lives of children and even take in account children’s working and learning styles. (Druin, 2002)

There are also other alternatives of getting more feedback from the children, than just user testing, and still being able to avoid the challenges in cooperative inquiry. Scaife and Rogers (1999) have proposed an alternative model called the informant-based approach. In this approach children are also involved throughout the whole design process, but instead of working as co-designers children work as informants. These children are consulted prior to the design of the product, they are also asked to test concepts, provide feedback and support the evaluation of prototypes that are improved iteratively. By increasing the involvement and input by children, the children also gradually become attuned to the needs of the designers. In other words they gradually start providing more insightful and critical comments, which they would not have been able to contribute at the first contact. Using children as informants provides a compromise, it gives children the chance to contribute their ideas to the design process at the same time as it gives flexibility to the project avoiding the cons of using children as design partners. (Scaife & Rogers, 1999)

When choosing what methods to use when designing for children one should be open to which methods are suited for children’s level of understanding, knowledge, interests, and particular location in the social world. (Waterman et al. 2001)

2.3.2 Observation

Depending on the field of science, the word observations can have several different meanings. In this thesis when we talk about observations we refer to observing the use of the product by the user. When it comes to evaluating products for children, observations can be very valuable. When observing children testing a prototype or product, the designer can obtain a lot of insights about how the children interact with the product. It can also give the designer solid evidence of what is and is not working with the prototype or product. Observations can be divided in to direct and indirect observations. Direct observations are about relying on the senses of the observer. The observer might be watching or listening to how the children use the product and make conclusions from this. In indirect observations, technology again plays a bigger role as it is used to create records of use e.g. user interactions and logs of eye gaze. In this thesis we are focusing on direct observations. A relevant issue to take in consideration when doing observations is the interaction between the observer and the users. Depending on what kind of information the observer wants from the evaluation he can choose to do participant observations
where he either engages with the users or remains more of a passive observer where the interaction with the users is minimal. Depending on which role the observer chooses to take, he should be careful not to influence the conclusions of the evaluation. When doing observations technology like voice- and video recording can be used to later on be able to go back to the situation, however it is important to note that going through voice- and video recordings later on can be very time consuming without actually getting any more relevant information. It is also important to note that children might feel uncomfortable if they feel like they are being observed, therefore in some cases it is good for the observer to sit behind a one-way mirror. (Markopoulos et al., 2008)

2.3.3 Interviews

Interviews with children can be done in several different ways. The interviewer or interviewers can choose to interview a single child or several children at the same time, as is done in the focus group method. The questions asked can be standardized questions or it can be more of an open discussion where the questions flow with the conversation. Between these two alternatives there is also semi-structured interviews, where the interviewers keep an open discussion, but at the same time leading the discussion with some predefined questions. Various other methods e.g. brainstorming can also be added to the interview. When interviewing children it is also relevant to note that the interviewer does not have to be human. It is also important to keep in mind that when interviewing children they do not always respond in the same ways as adults. A research done by Waterman et. al. showed that 76% of children gave an inappropriate “yes” or “no” answer to nonsense questions, e.g. “Is red heavier than yellow?”, compared to 20% of adults. The research suggests that children are very likely to give an answer to closed format questions, questions requiring a “yes” or “no” answer, and most children will answer “no” when they do not understand the question. From these results Waterman et al. suggest that interviewers should be very careful when interpreting children’s answers to closed format questions and that open questions should instead be used when possible. Waterman et al. also points out that children are used to being directed by adults, and therefore might answer questions in a way that they think they are expected to. (Waterman et al. 2001)

Some methods to interview children are Mission from Mars (Dindler et al., 2005) and Collages (Bekker et al, 2003). Mission from Mars is a fun and informal setting where a “Martian” asks the children to teach him about a subject which is non-existing on Mars. In the setting the Martian can see and hear the children, through a video camera, but the children can only hear the Martian, through a set of speakers. A researcher, located in another room, can see and hear the children and ask them questions as the Martian. The idea is to set the children in the expert role and make them feel free to share numerous details. Due to the setup this method requires a significant amount of effort in time and resources to execute and the success of the method is dependent on the age of the children. When making
Collages the children are given material e.g. paper, pens, glue, scissors, magazines and even cameras to take pictures with. They are then asked to in a group make a Collage on a big piece of paper for instance of their favorite game. While the children are making the collages the researchers can freely ask the children questions about their favorite games. Previous research done by Soute (Soute, 2013) shows that this is a method that generates a lot of ideas and the children were engaged in making the collages and openly spoke about the details of the games.

2.4 Children and Play

2.4.1 What is Play?

“Children are designed, by natural selection, to play. Wherever children are free to play, they do. Worldwide, and over the course of history, most such play has occurred outdoors with other children.” (Gray, 2011)

Before elaborating on theories about children’s play we should first note that the word “play” is quite ambiguous. Two examples are the statements “Let’s play doctor!” and “Let’s go outside and play tag”. Even though the word “play” is used in both statements, they refer to completely different actions. Both play and game, another word which is as ambiguous as play, are words which have been studied in several different fields e.g.: psychology, history and sociology. In this thesis we will look at theories of play related to children, since the main interest is children’s play and games.

Today it is strongly believed that play has an important role in a child’s development (e.g. Yawkey and Pellegrin, 1984; Sutton-Smith, 1997), however this has not always been the case.

In some of the earliest theories of play it was assumed that children play to release excess energy (Spencer, 1873). Another theory was that children play to restore their energy levels (Patrick, 1916). These theories were strongly related to the biological and physical aspects of play.

Later on new theories, based on insights gained in development psychology, were made. One of the most well known theories from this time was Piaget’s (1962). Piaget believed that children’s cognitive development goes through several distinct stages. From Figure 2 we can see how Piaget argued play having a significant role in children’s cognitive development.

Vygotsky’s (Vygotsky, 1976) thoughts about play were similar to Piaget’s, he argued that children actively learned through play. Vygotsky also believed that the social interaction in play, plays an important role in the cognitive development.
This thought differed from Piaget’s, who thought that the progress in cognitive development mostly was independent. Furthermore Vygotsky believed that engaging in make-believe play is a way for children to acquire social rules.

Sutton-Smith suggests that there are several general functions of play in children’s lives. One of the functions that stands out is what Sutton-Smith calls the rhetoric of progress. In this rhetoric Sutton-Smith talks about play being good for children’s physical, emotional, cognitive and social development. He argues that play prepares children for the future. (Sutton-Smith, 1997)

Power’s (Power, 2000) thoughts about children’s play are also very closely related to Sutton Smiths.

“Children’s ...play has been hypothesized to contribute to cognitive, motor, and social development of children, including the development of perception, attention, memory, problem-solving skills, language, communication, creativity, logical operations, emotional regulations, self regulation, social skills, gender roles, social relationships, conflict resolution, coping with stress, and so on.” (Power, 2000)

It is common knowledge that animals use play as practice to hunt for food and defend themselves against enemies. Therefore it also makes sense to adapt rhetoric of progress in the research of human child play. Rhetoric progress is also something that does not only show up in older research, but also in the most current discussion on children’s play. (Harris, 2003; McCune, 1993)

In this thesis we are mostly looking at play from a positive perspective. However, it is important to avoid idealizing play and therefore it is also important to discuss bad play and play that is ambiguous with respect to whether it is good or bad. It is important to understand that by using the term bad play we are not judging whether a child is good or bad, but that some forms of play are harmful or potentially harmful to children and should therefore be stopped or prevented. (Sutton-Smith and Kelly-Byrne, 1984)

Bad play can be divided in several categories: risky, mean-spirited and misbehaving play. With bad play we mostly mean risky play, which includes play that puts or might put children at risk for serious harm. Risky play includes big and dramatic risks like lying down on a railroad track to wait as long as possible for oncoming trains, but also includes much more common risks with a less dramatic impact. These risks can be throwing sand on each other and rocks on cars, jumping off and in to something are also common examples. It is not very uncommon to see the less dramatic risky plays, all it takes is following children’s play for a while. (Scarlett et al., 2005)

Bad play also includes the many forms of play that makes someone else unhappy or terrified, this form of play is called mean-spirited play. This kind of play includes teasing, bullying and beating someone up “just for fun”. (Scarlett et al., 2005)
Certain forms of misbehaving play are also included in bad play. At this point it is important to note that not all misbehavior is bad, a child who never misbehaves is not healthier for being so good. A few examples of misbehaving play are; children who constantly gain attention by showing off at circle time and the ones constantly adopting the role of class clown. (Scarlett et al., 2005)

When judging if play is good or bad it is important to be aware of the fact that in a lot of cases the presumed badness of the play lies in the difference in taste and perspective. Children and adults do not think alike and therefore they have different opinions about what is funny and what is not. Children often take a delight in disgusting and offensive things, such as joking about nose picking and farting. These are common ambiguous examples of play being good or bad. At this point it is easy to make judgments, while it might be wiser to ask questions about the play. By asking questions one might find out things about the play that can tell if the play is unequivocally bad or ambiguous. (Scarlett et al., 2005)

### 2.4.2 The Development of Play in Children’s Lives

<table>
<thead>
<tr>
<th>Age</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 0 - 2</td>
<td>Practice play - is characterised by the repetitive practice of simple motor skills e.g., clapping of the hands.</td>
</tr>
<tr>
<td>Age 2 - 6</td>
<td>Make-believe and symbolic play - children imitate actions of others, and engage in fantasy play. They will use objects to symbolise something different than the intended function (e.g. pretend that a broom is a horse)</td>
</tr>
<tr>
<td>Age 6 - 12</td>
<td>Games with rules - children’s reasoning becomes more logical and play becomes more structured. Games played with peers are preferred, such as tag.</td>
</tr>
</tbody>
</table>

Figure 2. Piaget’s stages of play, with approximate ages

Play changes a lot throughout the lives of children, from being a toddler to late childhood, Figure 2. The development of play is strongly related to children’s physical, cognitive, and social-emotional development. Infants for example often play in a non-symbolic way since they still have an undeveloped ability to symbolize. It is also often difficult to distinguish their play behavior from nonplay behavior. The reason for this is partly because their play emerges from other kind of behavior like exploration. The early childhood, 3-5 years, are again the golden
years for make-believe. During this period of children’s lives whatever way they are playing in, make-believe is used in the playing. It is believed that make-believe in play helps young children to understand reality. Children start by reconstructing familiar events like eating, driving a car and going to sleep, perhaps because the repetition of these events will help the child to better understand them. (McCune-Nicolich, 1981) Even though children’s make-believe might be very imaginative the physical and psychological rules in the imagined world are still mirrored to the physical and psychological rules of the real world. This also shows that make-believe play re-presents and reflects reality. (Harris, 2000) Make-believe play is also believed to support young children’s emotional development. Like adults children also have a lot of emotions, but compared to adults children lack the developed tools with which to express and manage their emotions (Scarlett, 1994).

Make-believe play is strongly related to preschool years and a lot of observers and theorists assume that make-believe play progressively disappears after the age of 5. Older children are seen to grasp reality better and to not have the need to pretend anymore. Singer again suggests that children do not stop with make-believe play, it just changes. According to him at this age children often incorporate pretense into their games with rules. At this age children also, in their mind, develop fantasies and alternative scenes to real life situations. (Singer, 1994 & 1995)

During elementary school years a lot of changes happen in children’s social life, they spend less time with their parents and start spending more time with their friends. This is a change that happens both at school and during free time. At this age children refine their social skills. (Schaffer, 2000)

At this age children’s play also changes due to increased cognitive and social maturity creating the conditions for a new play based on rules. In this play the children take more control of the game, they choose whether they use their own new rules or use ones that are already established. The children are the ones deciding what is acceptable and what is not, what is fair and what is not fair. At this age children become more flexible in a very mature and informed way and rules can change shape or be modified. For this to happen, however, the modifications must be accepted and justified by all participants. During this process games become very complex and many different versions of the game might also develop. Which way to play, becomes a common question that has to be answered before the children can start to play the game. This is a phenomenon that can often be seen with older children. (Piaget, 1965)

2.5 The Importance of Outdoor Play

When observing neighborhoods today there are not that many children outdoors at all, and if they are they are likely to be wearing uniforms and following the
directions of coaches while their parents dutifully watch and cheer. These changes have been documented by other historians of play as well as by Chudacoff. (Chudacoff, 2007)

The seductive qualities of television, computer games and Internet activities are often blamed for children not playing outdoors anymore. Even research has shown that that technology has had an affect on children’s play. According to a study done by Clements (2004) 85% of mothers stated that television viewing and 81% stated that playing computer games were among the reasons why their children play outdoors so infrequently. The survey however also showed that the parents of the children were a reason for the children not to play outside. In the survey 82% of the mothers admitted that they restricted their children's outdoor play due to safety concerns including fear of crime. Another survey done by Clements showed that 78% of parents stated that the fear of molestation by strangers and 52% stated that fears of road traffic were reasons for them to restrict their children's outdoor play.

An international study done by Singer et.al (2009) showed that 58% of children prefer to play outside. From the children who participated in the study 89% said that they preferred outdoor play to watching television and 86% preferred it to playing computer games. Gray argues that the reason for children spending so much time watching television and playing computer games is partly because they are prevented from playing freely outdoors. He also believes that once children are allowed to play outdoors, they have a hard time finding attractive places to play in and/or other children to play with. (Gray, 2011)

Spending more time outdoors in the natural environment has become popular in Scandinavian kindergartens. Several of these kindergartens have experienced a lot of positive results from being outdoors. The natural environment challenges children in motor activity and also positively affects their ability to concentrate. The playscapes are very dynamic and rough compared to a normal city playground. Slopes, rocks and trees are natural obstacles that children have to cope with and the uneven ground with roots, holes and soft moss and grass force children to be aware of their surrounding. The vegetation provides places to hide and trees to climb. (Grahn et al., 1997)

According to a study done by Grahn et al. (1997) considering two kindergarten groups in Sweden, where one was playing in the nature and the other one at a playground, children become more creative in their play when playing outdoors in the natural environment. They also saw an increase in play activities and play forms. According to their research the children who were playing in the natural environment were less absent due to sickness (2,8%) than the children who were playing in the traditional playground (8%, which is normal for day nurseries).

Playing outdoors in a natural environment also improves children’s motor fitness. Playing and climbing on uneven ground compared to playing on flat ground
without trees seems to have a pronounced influence on children’s motor skills. According to a study done by Fjørtoft (2001) in Norway, similar to the one done by Grahn et al., with one group of children playing in outdoors in the natural environment and the other one in a traditional playground, a significant difference could be noticed between the two groups in both coordination and balance. Fjørtofts study confirms the findings from Grahn et al.’s study that children’s coordination and balance is improved from playing outdoors in a natural environment.

Grahn et al. has also found that playing outdoors affects children’s ability to concentrate. Other studies have also shown that green outdoor spaces relieve the symptoms of attention-deficit disorder, ADD. A study made by Faber Taylor et al. (2001) shows that by playing outdoors in a natural environment children exhibit fewer ADD symptoms and the greener their surroundings, the fewer symptoms they show.

2.6 Head Up Games

Before technology was introduced in children’s’ gaming and toys, children’s play was fairly straightforward. Children played both inside and outside with toys and their friends. Children were playing many different kinds of so called traditional (outdoor) games, from which some are still popular, like hide-and-seek and different tagging games. What these games have in common is that they are rich in physical activity and they are played with a few basic materials that children can easily carry with them, like a ball or a skipping rope. These games are also rich in social interaction, since several players play the games, and they often consist of a few simple rules. As technology has become more popular in children’s lives, children today spend more time indoors e.g. playing video- and computer games. The advances in technology have however made it possible to take it with us outside and use it in gaming. (Soute, 2013)

Using technology in outdoor games for children has so far received little attention in the research and game design world. Two well-known examples are Savannah (Steve Benford et al., 2005) and Ambient Wood (Rogers et al. 2004). In Savannah children act as “lions” on a virtual savannah, which is overlaid on a school field. The aim of the game is to learn more about the behavior of lions. In the game players get lion behavior tasks, e.g. hunting prey and marking their territory, on a PDA equipped with Wi-Fi and GPS. In Ambient Wood children explore a real environment augmented by technology. With the help of a PDA and a Walkie-talkie, the children get more information about the environment e.g. plants and ground in the forest they are exploring. What these games have in common with most other outdoor pervasive games for children is that they use a display to interact with the user.
Traditional outdoor games played by children e.g. hide-and-seek and tag are often rich in physical activity and social interaction. In the games players look each other in the eye, and communicate with body language and of course talk to each other. The games also often involve a lot of running around and chasing each other. If a display is placed in the hands of a child, the child will automatically have to look down at the device leading to head down behavior being encouraged. This also leads to less social interaction and physical activity. From realizing the problem with displays being used in outdoor gaming a new genre of pervasive games, “Head Up Games”, was introduced in 2007 by Soute and Markopoulos (2007).

As the name indicates Head Up Games, HUGs, are games, which are played with your head up. The games combine the best out of two worlds; the fun of traditional outdoor games, like running around and being outside with friends, with the attraction of digital games like interactivity and special sound and visual effects. The idea behind HUGs is for the technology to become more invisible and give players more freedom to run around, use their imagination and socialize with their friends. (Soute and Markopoulos, 2007).

The aim of Head Up Games is to create: “outdoor, co-located, multiplayer pervasive games that encourage social interaction, stimulate physical activity and support adaptable rules, creating a fun experience.” (Soute, 2013)

In Head Up Games less emphasis is placed on creating a virtual world that is combined with the real world, but instead on using technology to support the game play. According to Vygotsky (1976) make-believe play is crucial for a child’s mental development, giving a child the possibility to freely discover his perceptions. Current game technology bases most of the interaction with the player on audio and visual feedback, which competes with children using their own imagination. In Head Up Games the focus is on using different interaction styles like haptic, motion, contact and proximity, instead of focusing on visual interaction with the technology. With Head Up Games the idea is also to, as with traditional outdoor games, be able to play it anywhere and at any time. All that is needed to play the games are: the players, the knowledge of the game rules, and possibly some simple and portable game objects. The aim is to assume as little as possible from the pervasive technology infrastructure e.g. not assuming that there will be GPS coverage or Wi-Fi connectivity. (Soute, 2013)

2.7 Designing Digital Games

2.7.1 The Process of Designing Digital Games

Game design literature (e.g. Adams and Rollings, 2007, and Salen and Zimmerman, 2006) sufficiently covers the user-centered design process of regular computer
games; games that use a screen to interact with the player. The design guidelines found in the literature mostly concerns software tools, methods and development techniques that suit designing for display interaction. Since interactive outdoor games is a relatively new field, very little information can be found on how to design these types of games, especially the ones without screen interaction. Therefore in this thesis we have decided to pick the pieces from digital game design literature that we found relevant to designing Head Up Games.

When designing games the design process typically starts with an idea. In some cases of game design the idea of a game is already known before starting the official design of the game, but in other cases an idea generation phase is needed. Game ideas can be found anywhere at anytime, the key is to actively look for them. There are also a lot of methods and tools available for kick starting the designers’ creativity. One of the oldest known and still widely used methods of generating creativity is brainstorming. The idea of brainstorming is to focus on a problem or a proposal either alone or in a team. There are two phases of the activity; in the first one ideas are generated and in the second one they are evaluated. A well-prepared brainstorming session can generate a lot of new ideas and concepts, however there are studies that show that issues also can appear from brainstorming. (Kern et al., 2006; Valk et al., 2012)

When designing Head Up Games there are a few issues that should be taken in consideration during the idea generation. One issue that Soute bumped into through two brainstorming sessions that she held, was that even though a lot of ideas and concepts were generated the participants had trouble to think “outside the box” when meaningfully including technology in their concepts. A lot of the ideas were already fun in themselves and adding technology would not really give the game any extra value. Another thing that came up during the brainstorming sessions was that the session generated an extensive number of rules and details for the games. From creating previous Head Up Games Soute had experienced that from a game design perspective this was undesirable. According to her, games do not typically benefit from having many rules. At this point it is however good to keep in mind that concepts are not games yet and from that perspective generating a lot of ideas in the brainstorming session was successful. (Soute, 2013)

2.7.2 Involving Children Early

Like in all other user-centered design processes, where the focus is on the user’s wants and needs, also when designing Head Up Games the focus should be on the end user, the children. Therefore when designing Head Up Games children should be involved in an early stage of the design process. Children can be involved in several ways e.g. as informants or co-designers. When choosing the right method one should take in consideration; how much time in the process is available, how much children are desired to be involved in the process and the practical point of how easily children are accessible. When designing with children there are a lot of
different methods to choose between and it is a jungle that one can easily get lost in. Therefore it is important to keep in mind that it is advised to seek to create a fun experience for children when involving them in a design process. (Gielen, 2008; Markopoulos et al. 2008).

2.7.3 Playtesting

Game design literature (e.g. Fullerton et al., 2004) often emphasizes the importance of an iterative design process, which includes a considerable amount of play testing. According to literature it is nearly impossible to predict the game experience and to design all the rules and mechanics of a game beforehand. Soute also acknowledges that the game experience cannot be predicted beforehand and therefore all rules cannot be decided beforehand, several iterations are needed to design a definitive set of rules. She recommends to first set a limited, basic set of rules. When playtesting there will be situations when the game “breaks”. When these situations arise, the designer should rely on the children's tactical knowledge of a well-played game and trust that the children will come up with new or changed rules to fix the game (Soute, 2013).

2.7.4 Playtesting with Adults

In a user-centered design process the ideal is to evaluate prototypes or products with the intended end-user. When it comes to designing for children this is however not always possible due to practical reasons. Testing with children often requires a significant amount of time and effort to arrange. To make sure that the time spent testing with children is well spent, it is important to root out early usability issues before testing with children. Even though adults are used to test the games with, one should still keep in mind that children should not be treated as small adults (Markopoulos et al., 2008). Soute (2013) however reverses that statement and states that in some extent we can see adults as oversized children when evaluating Head Up Games prototypes. Comparing the experiences of evaluating both with children and adults she has found that there are some similarities and some differences:

First the behavior before playing the game differs between adults and children. Where adults were often calm and less excited about playing the game, the children were again eager to try out the game. This also resulted in adults patiently listening to the explanation of the game details and rules, while the children were too eager to listen to the rules once they understood the game idea. Once the game started the behavior of the adults changed and became a lot like that behavior of the children. Both groups were physically active, players were interacting with each other e.g. cheering and shouting and they both responded similar to setbacks in the game. When asking for feedback after the game the groups behaved differently again. The adults provided feedback more fluently than the children. (Soute, 2013) This however is not surprising since reflecting on a meta-level is
something that develops with age and children might also lack the vocabulary to do so (Markopoulos et al., 2008). Adults and children were also giving different kinds of feedback. Children were mostly focusing on the events of the game. They did not have trouble to fix non-working game rules, but they did have trouble giving feedback on a more abstract level. Adults were again focusing more on the tactics of the game and coming up with new ways of playing the game (Soute, 2013).

From this we can make the conclusion that using adults to test the games is beneficial and can help to identify usability issues in the games, but they should definitely not replace all tests with children. In the end children are still the main end users and their wants and needs in gaming and playing are totally different from adults’ wants and needs. (Soute, 2013)

When designing with children Soute concludes that even though children are experts in playing games, they are not experts regarding the technology. She states that it is difficult for children to understand how technology can be used in games. This can result in children coming up with ideas that are not possible with the technology, or then they do not understand how the advantage of technology can be used in the interactions of the game. She also proposes that by observing children when they play games, the designer can get valuable hints on how to continue designing the game. (Soute, 2013)

### 2.7.5 Low-fi versus High-fi Prototypes

When designing interactive technology, the generally accepted approach in human computer interaction and game design is to start the design process with a low-fidelity prototype e.g. a paper prototype of the game and to slowly through iterations increase the fidelity of the game. This is something that was also done in the early stage of Head Up Games. From designing several games going from low-fi paper prototypes to high-fi prototypes Soute recommends to start with high-fi prototypes when designing Head Up Games. According to her there are elements of the games that could not be tested with low-fi prototypes. The low-fi and high-fi prototypes do not interact in the same way with the player and therefore the game experience can be totally different when using the two different prototypes.

### 2.8 RaPIDO

#### 2.8.1 What is RaPIDO?

RaPIDO is a prototyping platform that enables easy prototyping of tangible and embodied interaction for groups of users, Figure 3. It is mainly used for designing and testing outdoor games for children. The RaPIDO consists of several independently functioning, identical devices that offer a wide range of (mobile) interaction possibilities, for example, an RFID reader for detecting RFID tags; a
sound processor and speaker for auditory feedback; RGB LEDs for visual feedback; and an XBee chip (radio) for wireless communication between devices, Figure 4. The devices have been created in such a way that they can function stand-alone (i.e. without wires attached) and are not dependent on an existing infrastructure as for example a wireless network. Furthermore, the devices contain ample battery power for the devices to run at least 2-3 hours straight, while the size of the device remains wieldy for children’s hands. Finally, a software library is provided to facilitate programming of the devices. (Soute, 2013)

When starting the design of RaPIDO, there were many platform requirements. These requirements had come from designing previous Head Up Games. These requirements were: distribution, portability, connectivity, robustness, interaction, extensibility, easy to program and transparency of hardware control. (Soute, 2013)

RaPIDO

- 4 LEDs
- Audio
- RFID reader
- Vibration
- Accelerometer
- 2 touch buttons
- Rotation wheel
- XBee
- Battery
- Software library

Figure 3. RaPIDO, finished prototypes

Figure 4. Content of RaPIDO
One of the things that make RaPIDO unique is that it is not dependent on the existence of infrastructure, like GPS coverage or availability of Wi-Fi network. This combined with the small size and weight of the device makes it portable and easy to pick up at any time and play with it anywhere, in the same way as traditional outdoor game equipment and toys like a ball or a hoop. Another reason for the size and weight of the device to be important is that the device should not interfere with physical activity that is common in outdoor games; it should be easy for children to run around while carrying the device. Since the prototypes are used in the real play environment, which in this case is outdoors in all kinds of weather, and handled quite roughly as players are running around with them, they also need to be as robust as a final product would need to be. (Soute, 2013)

The devices are designed for games with several players and communication is seen as essential as in traditional outdoor games; therefore connectivity between the devices was thought to be essential for the game play. Being able to share and relay game events between devices also gives game designers flexibility when designing the games, compared to stand-alone game devices. (Soute, 2013)

Due to the characteristics of HUGs’ physical play and social interactivity, leaving out the display from the design of RaPIDO was a deliberate choice. It was thought that if a display was added it would push designers to design traditional screen based graphical interaction, which again is outside the intended use of RaPIDO. This hypothesis was however not explicitly tested, but it can clearly be seen in related work (Benford et al., 2005) where games were developed on PDAs and smartphones. Even though other technologies were available the designers still chose to use the screen to interact with the players, which again left less room for head up interaction similar to traditional outdoor games. Instead, audio and visual feedback was seen as important interactions to signal game events. It is difficult to foresee all types of interaction and to include them in the platform. Therefore the platform has been made extensible so that additional sensors and/or actuators can be connected. (Soute, 2013)

2.8.2 Hardware Architecture

The RaPIDO device consists of one Arduino Mega microcontroller board (Figure 5). Since the standard Arduino Mega was physically too big, a dedicated printed circuit board (PCB) was designed for the prototypes. This resulted in both a smaller design and a more robust device, since the components are soldered to the board instead of being separately wired like they would be in a normal Arduino. This was done since a lot of different components needed to be integrated and that would have led to a complex manufacturing process and a less robust prototype with wires that can come loose. (Soute, 2013)
It also comes with a LiPo battery, which is similar to mobile phone batteries. A lot of effort was put down to select the battery. This was done since the device needs to be portable by children and therefore it needs to be small and lightweight, while a considerable amount of energy was needed to power all the components on the board for a few hours of play without recharging the device. (Soute, 2013)

2.8.3 Software Architecture

The software of the platform was designed for games to be programmed with programming language C. The reason for choosing C was that the platform needed to match the general skills of interaction designers and C was seen as the most widespread and supported programming languages available. C was also seen as convenient since the designer can pick the programming environment that suits his/her needs best. A novice programmer might choose to program in the Arduino environment and a more skilled programmer might choose an advanced environment like Eclipse. The software is also developed in layers. A novice programmer can use the most simple interface and the advanced programmer can suit their needs by using the more advanced functions. A software library, with the most common functionalities, is also provided to shorten development time and encourage reuse. (Soute, 2013)

In Figure 6 an overview of the general architecture of the software is shown. A layer of dedicated software libraries is built in C++ and using an object-oriented approach they are directly linked to the hardware. Each component of the used hardware is addressed to from a particular library. The libraries are strictly separated and they are not dependent on each other.

By doing this, the process of replacing hardware components from another brand is made easier, since only the corresponding software library needs to be changed without affecting the rest of the software.
The hardware abstraction layer (HAL) uses the component libraries. The HAL manages the creation of all objects instantiated in software directly matches the components in the actual hardware. The HAL also offers general functionality such as a scheduler, and battery management functionality. Neither the component libraries nor HAL are accessed directly by the end-user.

Finally, on top of the HAL the application programming interface (API) is built. These are the libraries, which the designer building the software for their games typically would use. They are typically game related, in contrast to the component libraries which are technology related, and they offer task-specific functionalities. According to Engeberson and Wiedenbeck (2002) using these kinds of libraries makes it easier to code software for novice programmers. These libraries have been made from observing designs of Head Up Games and noting what kind of interactions designers want to achieve. For instance it was noted that designers want the devices to be able to send messages to devices nearby. Therefore the API offers the function sendMessageToClosestDevice(). Linguistically this is a function name that describes the action that the designer most likely wants to achieve when programming his game. The API finds out which device is closest and sends the message to it.
Furthermore, some of the API libraries are also designed for the ease of use for the designer. One example of this is the Head Up Games library assignTeam(). This library dynamically, at run time, assigns devices to a team using RFID tags. The designer only needs to specify which RFID tag is related to what team and the Head Up Games module handles the rest. This function is of course a functionality that the designers could build by themselves, but since it is a recurring function it is convenient to have it predesigned.

### 2.8.4 Physical Shape and Form

The prototypes have a dedicated case that is designed to perfectly fit the hardware. In the design of the case extra attention has been paid on the durability and robustness of the prototypes. The prototypes used in this research have a 3D printed case. The material for the casing is not dedicated and therefore designers can choose to apply the material they prefer around the hardware.

### 2.9 Related work

Well-known games that use technology outdoors are *Can You See Me Now* (S. Benford et al., 2003; Steve Benford et al., 2006) and *Catchbob!* (Nova et al., 2006). *Can You See Me Now* is an urban catch game where players in a city, with the help of handheld computers, GPS and walkie-talkies, chase online players who move their avatars in a virtual model of the same city. In *Catchbob!* players in teams of three try to find virtual objects and surround them with a triangle. Like most games of this type also these games are played with devices using GPS and/or Wi-Fi and use devices with small displays e.g. PDA or smartphone. These kinds of games have brought novel and past time experience to gaming by targeting adult players in outdoor environments. For children again, outdoor play is a natural and traditional occupation.
3 First Evaluation

3.1 Study Setup

The study was executed by two researchers, who designed, implemented and evaluated all the games. One researcher is a PhD candidate in a HCI-related program of a Dutch university. She has previously developed the RaPIDO platform and is knowledgeable on game design and involving children in the design process, the other researcher is a final year master student, with limited experience in designing with and for children. The study took five weeks in total, Figure 7.

To satisfy our goal of using high-fi prototypes in a design process and exploring interactions as well, we decided to create three separate games. This way we could explore games that are quite different from each other and deploy a wider range of interaction styles without using everything in just one game, which might affect the usability and simplicity of the game. We also decided that each game only should have 2-3 rules, since we wanted to keep the games very simple at this stage. We believed that it would be more important to try out a game that works and which we can develop further than starting out with a complicated game that might not work or which would take too long to implement.

At the start of the project, we chose three game concepts that we thought suitable for implementation. The first game was a game concept created during an earlier brainstorm workshop that had not been implemented at that time. For the second game concept we took inspiration based on a game played as a child. Finally, as the third game we selected to re-implement a game from a previous project, called
Save the Safe. All games were implemented on the RaPIDO platform and took about two weeks to go from concepts to playable prototypes.

![Figure 7. Timetable for first evaluation](image)

We organized three evaluations sessions, with children of a Scouting organization in the Netherlands, Figure 7. The sessions were planned during the regular scout meetings on Friday evenings at 18:30h. As the sessions took place in November and December this meant that the games were played outside in the dark. The area that we play-tested the games in was at the scout-home in the woods. There was a grass area available, lighted by three huge lampposts; furthermore, the (unlit) woods surrounding the area were also available for play. It is important to note here that the children, as they were scouts, were used to playing outside in any weather conditions. The children were aged 7 to 10 years old, mostly boys, and in total 16 children were part of the scout group - though the scout leaders informed us beforehand that not every child attended every meeting.

Before starting the sessions we informed the parents of the children of our plans and we obtained consent for their children participating in the sessions, and also for gathering video and photo material.

Each session was planned to take two hours - which was equal to the duration of the regular Scouting meeting. We planned to first let the children play the games, while we both observed directly as well as gathered video material for later reviewing. Furthermore, we planned to apply GroupSorter (Soute et. al., 2013) to gather feedback from the children; this entails that after playing all the games, we first ask the children individually to rank the games from most fun to least fun. Subsequently, we form small groups (4-5 children) and repeat the ranking, though now as a group effort. By recording the ensuing discussion we hope to gather qualitative insight in what elements of the games were experienced as fun (or not), and also identify areas for improvement. Furthermore, to elicit new ideas and inspiration for the further development of the games, we planned to let the children create collages of their favorite games. We expected that this would be a fun activity for the children, while it allowed us to pose some questions without putting the children in a real interview setting.
In short, the data we expected to gather was our own direct observation and experience of the game play; video data; ranking data and audio data from the group interviews. Because of the conditions of how and where the games were tested we did not expect to get high quality video footage, but we decided to capture it all the same as a backup in case we needed to review it later.

Below are the accounts for each evaluation session. For each session we explain the games we designed and elaborate on our expectations of the game play before the session. Next we describe specific details for the session and we report the results of the evaluation, both in terms of the process as well as how and why we decided to change the games for the next iteration.

3.2 First Iteration

For the first session we created three games, which took about two weeks to design and develop. These games were implemented and were piloted with adults before evaluating them with children. Note that for each game we defined a basic set of rules, and that a limited set of these rules was implemented on the devices. There are two reasons for doing this; first, we see the technology as a supportive element of the game, and, like in traditional games, many game rules are implicitly defined, which we argue do not need to be explicitly enforced by technology. To give an example: in a game of tag, players might beforehand explicitly agree on the play area, but there is never a debate on how the actual tagging operation is defined; players implicitly know, from previous games of tag, or from other similar games. Second, from a design point of view, by defining only a basic set of rules we expect that there will be situations that are not properly covered by the rule set. When this happens, our strategy is to ask the children how they would prefer to change or add the game rules. Their response gives us valuable insight in how the game can be improved.

3.2.1 Games

Below follows an account of the three games that were developed. First, the basics of each game are laid out, next we describe what part and how it was implemented using technology.

**Follow the Light.** At the start of *Follow the Light* all players line up on one side of the game field. The goal of the game is to be the first to reach the opposite side of the field. At the start of each turn a color, an animal and a numeric value are announced. If the particular color is present in the player's clothes, he/she is allowed to take a number of steps forward, the number of steps corresponds to the value that was announced. The size of the steps must be proportionate to the animal that was announced; e.g. if the animal is a mouse, only small steps can be
taken. When the appropriate number and size of steps are taken, a turn is done and a next turn starts.

The devices announce the color, animal and step count: the LEDs indicate the color; the number of steps to be taken is indicated by the number of LEDs that switch on and the animal is represented by a sound. One of the researchers is at the end of the playfield, also holding a device. She starts each turn by holding a tag to a device, which then broadcasts the color and step count information to the player devices. Subsequently, players must turn the rotation wheel, and based on the final orientation of the wheel, the device calculates which animal is selected and the audio starts playing. The player that first reaches the researcher wins the game.

**F.A.R.M. (Finding Animals while Running and Mooing)** is an individual chasing and collecting game. At the start of the game, each player receives an assignment to collect a set of animals, e.g. a cow and two horses. The player that first completes his/her assignment wins the game. Players take turns in being the 'farmer'. At the start of a turn the farmer gets assigned an animal, which can be won by other players if they tag the farmer within 10 seconds. Players are allowed to trade animals to better match their assignment.

Players decide amongst themselves who starts the game as farmer and in which order the next players take up the role. The farmer grabs a token from a bag and holds it near his/her device for identification. Once the token is identified, the device starts making an animal sound and continues to do this for the duration of the tagging phase. When the sound stops and the farmer has not been tagged, he/she can keep the animal him/herself.

**Save the Safe.** In *Save the Safe* players are randomly divided into two teams: a team of robbers and a team of cops. At the start of the game, one of the cops receives a key and the goal of the cops is to safeguard the key from the robbers. The goal of the robbers is to steal the key and with it open the safe. If the robbers do this within three minutes, they win the game. If not, the cops win the game.

In this game each player is given a device. At the start of the game, the device indicates with a color which team the player belongs to: blue for cops, red for robbers. The key is represented virtually: if a player has the key, his/her device starts to vibrate. Thus, only the player that has the key notices this. The key is automatically transferred between two players if they are in each other's close proximity. The safe is a real object, tagged with an RFID tag. The robbers can win the game, by stealing the key from the cops and next, holding the device that contains the key near the safe. Audio notifications indicate the start and end of a game.
3.2.2 Expectations

Before we ran the first evaluation we had certain expectations regarding the gameplay, and also regarding the process.

First, we expected that the children would be able to understand the rules of every game. We also expected that there could be some minor technical problems and that situations would occur that would lead to discussion.

In F.A.R.M. we expected debate about the starting distance between the farmer and the rest of the players. Further, we expected the players to form a strategy to win the game, i.e. in choosing to run or not to catch an animal.

In Follow the Light we expected debate concerning the sizes of the steps with regard to the animals.

In Save the Safe we expected that, since the key is invisible, there would be confusion about who has the key and that players would actually pretend to have it to lure opponents away from the actual player with the key.

Regarding the process, based on our earlier experience with working with children at schools and after-school settings, we expected that when making the collages the children would have an idea of what their favorite games are, they would discuss the games and different elements in them, they would also discuss why they like a certain game. We expected the children to have fun while creating the collages and that it would give us insights into why children like certain (features of) games.

3.2.3 Procedure

Fourteen children were present at the scout meeting. As we only had eight working devices, we had to split up the group to ensure each child got to play every game. The group was split in two subgroups: the first group played F.A.R.M. and Save the Safe, while the other group were kept busy by the scout leaders. After playing the groups switched places (see Figures 8 and 9 for an impression of the game play). Next, because we were running out of time, the groups were merged and all together Follow the Light was played in teams of 2-3 children, sharing one device per team. After all games were played, we went inside where children individually filled in a ranking form, ranking all games from most fun to least fun. The children were divided in three groups and each group was asked to create a collage of their favorite game; we left it up to the children whether to reflect on the games we played or to create a collage of other games. Each group was led by a researcher or a scout leader who prompted the children while they were creating the collage to explain why a game, or a game feature was fun. We captured the process of making
the collages on video. After the children went home we discussed the games with the scout leaders.

3.2.4 Results

From our observations we gathered that in general children enjoyed F.A.R.M., though we also observed some issues. As we expected, immediately at the start of the game discussion started at what was an appropriate distance between the farmer and the rest of the players. The children easily agreed on what was a proper distance - they mentioned other games where this was done as well, so it was quite easy for them to discuss this. However, what we had not foreseen is that, though the children had an agreement on the distance, they would still very much try to cheat, which led to much argument. Furthermore, the sound indicating which
animal was identified, only played on the device of the farmer. Sometimes the other children had difficulty hearing the sound. We did not observe any trading or other form of strategy making in the game. Players mostly tried to catch all the animals, including the ones that they did not need to collect. Finally, an animal could only be won by running very fast, and it was soon clear which of the children had an advantage over the others by being faster runners. A few of the slower children decided not to even bother running.

The children did not really seem to be enthusiastic about *Follow the Light*, some children even mentioned out loud that the game was boring. As expected, there was quite a lot of discussion on how big steps they were supposed to take. Because of lack of time the whole group had to play the game at the same time, which led to the game being played in teams of two to three players. Since the amount of players in a team got bigger, each team also had a larger variety of colored clothes on them; almost all the teams were allowed to take steps on every turn. The pace of the game was slow and there was hardly any excitement.

*Save the Safe* seemed to be appreciated most, though there were some complaints about it being difficult to transfer the key to another player. Indeed, as expected, we observed players pretending to have the key. Players within the same team were trying to give the key to each other as to confuse the other team, although this did not work very well since the key did not transfer very easily. Right after the last game finished, the devices collectively crashed.

Based on the individual ranking data we calculated an overall ranking: (1) *Save the Safe*, (2) *F.A.R.M* and (3) *Follow the Light*. We also calculated Kendal’s *W*, a measure for the agreement between rankers. There was a high level of agreement between the rankings: *W* = 0.75. This preference was also supported by our own observations.

Doing the collages did not work with this group. The children had a hard time sitting down and concentrating on doing the collages. In the end they seemed to think that it was more fun to make a mess and playing around than discussing the games. The audio captured during the creation of the collages was unfortunately unusable (poor acoustics and several children speaking at once in a closed location).

Finally, we discussed with the scout leaders about what they usually do during the scout meetings, what kind of games they play. We learned that they usually play games invented by the scout leaders. The ideas for these games come from traditional outdoor games and strategic board games. The children are also used to playing out in the woods in the dark.
3.2.5 Implications for the Design Process

After the evaluation session we briefly reviewed the video and audio data and we discussed our main observations. Based on that we decided what features of the games should be improved or replaced, taking into account whether that is achievable in the short develop time available.

Based on the feedback of the children, our own observations and the rankings we decided to drop *Follow the Light* all together; we saw little possibilities to improve the game play. For *F.A.R.M.* we decided to rework the game for the next session. For *Save the Safe* we decided to only tweak some parameters to make the transferal of the key easier and fix the bug that caused the devices to crash. As we had decided to drop *Follow the Light*, we wanted to create a new game instead. Based on the remarks of the scout leaders about playing in the woods, we decided to create a game that could be played there.

With regard to the evaluation process, we decided to not again ask the children to create a collage. We discussed what happened with the scout leaders, and in retrospect, they thought it was not really surprising: the children go to the scout meetings in their free time on Friday evening and this is their venue to let go of all of the pent up energy of a whole week of sitting inside a classroom. Thus, it was hard for them to sit and behave and take part in a creative exercise. In contrast: for children at school it is a welcome change from the regular school routine.

3.3 Second Iteration

3.3.1 Games

First we describe for each game what changes were made to either game play and/or technology:

**Invade the Castle.** This game was developed to replace *Follow the Light*. The idea for invade the castle came partly from discussions with the scout leaders (playing out in the woods in the dark, searching for and collecting things), some game features were inspired by Camelot (Soute et al., 2009), and the idea of how to search came from the idea of using avalanche searching techniques (player gets to know when he/she gets closer to the target). Since both *F.A.R.M.* and *Save the Safe* were games where children have to run quite a lot we also decided to design a game where less running was needed and the children had to concentrate more on problem solving.

In *Invade the Castle* the players are divided into teams of 2-3 players. The narrative of the game is based on invading a castle, and to do this teams have to collect three
types of weapons (a catapult, an arrow and a shield) that are hidden in the woods. The first team to collect all three weapons wins the game.

The weapons are virtual entities: three scout leaders each get a device that represents a weapon, by repeatedly broadcasting a ‘signature’ signal. The scout leaders hide themselves in the woods before the game starts, and remain at their locations for the duration of the game. Next, each team gets a device, and at the base station where one researcher is keeping track of the score, they select which weapon they are going to search for, by holding the corresponding tag to their device. Now, the device knows for which weapon to look. As children enter the woods, the device shows nothing, but once they come into range (approx. 30 meters) of the area where their selected weapon is located, the device turns red. As the team gets closer to the scout leader, the device gradually turns from red, through orange and yellow, to green. Once they are close enough (2 meters), they “acquire” the weapon by staying in range for 15 seconds, after which the device turns blue to confirm the acquisition. Next the team returns to the base station and they can select a new weapon to start searching for. Once a team has collected all weapons, the game ends.

**F.A.R.M.** Though we acknowledge that a bit of cheating is often a part of a game, and can even add to a positive game experience, we observed in the previous session that children cheated many times with respect to the distance that should be observed at the start of each turn; and children were getting annoyed because of this. Therefore we decided to program the devices that they would enforce a minimal distance between the players, before starting a turn: as long as the other players were too close to the farmer, all devices displayed a red color. Once the distance was right, the devices turned green and the game could advance. Furthermore, as we had observed that not all players heard the animal sound, we changed the game such that once an animal was selected, the corresponding sound was played on all devices.

**Save the Safe.** We fixed the bug that caused the devices to crash.

### 3.3.2 Expectations

For this session we were expecting that the changes we made to the games would make them easier to play for the players. In *F.A.R.M.* we expected that the children would not try to cheat as much. We also expected that finding the right distance between the farmer and the chasing players would be easy for the children. In *Save the Safe* we expected that the game flow would be like last time, since no changes were made. For *invade the castle* we were not sure if the players would understand how to find their targets, if they would have some problems while doing that or if they would find them at all.
3.3.3 Procedure

This time ten children were attending the scout meeting. The weather conditions were different than in the previous session: it had snowed and the temperature was around the freezing point (see Figure 10). Again we split up the group in two: the first group played F.A.R.M. and Save the Safe, while the second group was keeping themselves busy in a snowball fight. After the first group finished playing the games, the groups were switched. After both groups had played the two games, we went inside for a short break to warm up. After a hot chocolate with cookies we went outside again and played Invade the Castle with the entire group.

F.A.R.M. and Save the Safe both were played in an open playing field and we were able to videotape the sessions as well as observe directly ourselves. Invade the Castle was played in the woods, which made it nearly impossible to capture on video (see Figure 11 for an impression of the researcher's view from the base station). One of the researchers remained at the base station to track the progress of the game; the other researcher went into the woods with the children and walked around observing as much of the game play as possible.

When Invade the Castle was finished, we asked the children to rank the games from most fun to least fun. Again the group was split up in two and a researcher shortly interviewed each group. Afterward, the children went home and we reviewed the games with the scout leaders.

Figure 10. Playtesting F.A.R.M. in the snow
3.3.4 Results

In *F.A.R.M.* the players had difficulties using the tags and in some cases they needed our help. We realized that the RFID reader is placed exactly below the spot where a child's thumb is located when holding the device, which makes it difficult for a child to place the tag in the right place. Because of the cold weather children were wearing gloves, which made it even harder to handle the tags. The game flow was interrupted every time a player struggled to get the RFID tag identified. Finding the right distance between the farmer and the rest of the players was easier this time.

Though we fixed the bug that caused the devices to crash, we inadvertently did not change the parameters for the transferal of the key. Still, the players seemed to enjoy playing *Save the Safe*.

Some teams had a hard time finding the weapons in *Invade the Castle*, though at the end of the game each team managed to obtain at least one weapon. What we observed was that the children would walk in range of the weapon, and that their device started slowly blinking red; what happened was that they were really on the edge of the range, and the devices were quite sensitively programmed for this, immediately switching off the LEDs once they were out of range. This confused some of the children who did not understand which way to walk and thought their device was not working properly. Once we demonstrated how to handle the situation, the children had less trouble finding the weapons. Furthermore, the lights of the devices of the scout leaders were showing, resulting in children only partly relying on their own devices to hunt for the weapons, but as soon as they spotted the lights of the leader's devices they would go in a straight line towards the scout leader.

With regards to the ranking of the games in this session, the children were much less in agreement. The combined rank resulted in (1) *Invade the Castle*, (2) *Save the Safe* and (3) *F.A.R.M.*. However, there was little agreement (Kendal’s *W* was 0.31). On closer inspection of the data we conclude that *F.A.R.M.* was by most children ranked lowest, but there was nearly a tie for *Save the Safe* and *Invade the Castle* for first place.

In the interviews children told us that all of the games were fun; only by comparison *F.A.R.M.* was the least fun. Further, the children appeared to have some trouble to reflect on their experiences and to discuss why one game was more fun than the other: "I simply liked that game. Just because.". Though one child could express his preference for *Save the Safe* with regard to the game play: "In *F.A.R.M.* it was just a lot of chasing. And in Save the Safe it was chasing too, but at the same time you also had to search too (for the key)".
3.3.5 Implications for the Design Process

Because handling the tags in our opinion interrupted the game's pace in *F.A.R.M.* we decided to redesign that part.

As we made the mistake for not tweaking the parameters of *Save the Safe*, this remained our goal for the next session.

As we were programming the devices for *Invade the Castle* for this session, we had not expected that the LEDs being on would have such an effect on the game play, probably because we did our own development and testing during the day, and of course in the dark a light is much more visible than during daylight. Thus we decided to switch it off. Furthermore, we decided to improve the interaction mechanism for providing feedback when entering the range of the weapons.

Interviewing the children informally at the spot worked fine for us, though the question remains how valuable the information retrieved from the interviews is. Mostly, the interview data supported our own observations of the game play, there were only very few cases where new insights were obtained. Still, from a research point it is preferable to have data that supports our observations, and so we decided to interview the children in the next session too.

3.4 Third Iteration

3.4.1 Games

*F.A.R.M.* was adapted so that tags were not needed to start a turn. Instead, when the players were properly aligned, the device would automatically select an animal.

*Save the Safe* was changed for easier transfer of the key.

*Invade the Castle*. The devices of the scout leaders no longer showed a light once the game has started. The range for which the tracking devices pick up a signal was extended, and the interaction for showing the range was made more robust.

3.4.2 Expectations

In *F.A.R.M.* we expected that the game pace would be higher since they would now be able to play the game without our help.

In *Save the Safe* we expected that the flow of the game would change since the key transferred better now.
In *Invade the Castle* we expected that there would be less confusion for the players during tracking down the weapons.

### 3.4.3 Procedure

14 children attended this scout meeting. Again, we split the group up, though this time into three subgroups. Each group played *Save the Safe* and *F.A.R.M.*, while the other groups remained indoors with the scout leaders. We did not randomly divide the groups, but made a split based on age, to see if this would affect the game play in *F.A.R.M.*. This time it was raining quite heavily, though for the scouts the weather did not seem to be a problem; they normally also play outside when it rains. After all groups had played both games, we went indoor for a short break. After the break we played *Invade the Castle* with all children. Like in the previous session one of us was in the forest with the children observing the game flow, while the other remained at the base station. In contrast to the previous session, when the researcher at the base station could see some of the children playing, this time the woods were pitch dark and from the base station the game play could not be observed (see Figure 11).

After the game play we asked the children to rate the three games from most fun to least fun. Because of time running out we managed to interview ten out of 14 children. Then we thanked the children for the participation in our evaluations and awarded them with a 'diploma' as game designers. Finally, we again discussed the games with the scout leaders after the children went home.

![Figure 11. A challenge when observing “in the wild”: limited visibility](image)
3.4.4 Results

As in the previous session children who enjoyed running and chasing liked playing *F.A.R.M.*; it was less popular for the other children, though the difference seemed less than in the previous session, probably because younger children were not asked to compete with the older children. With the removal of the RFID tags the game play went a lot smoother and the children were able to play the game without needing our help.

*Save the Safe* remained popular, though now the settings for transferring the key seemed now a bit too easy.

*Invade the Castle* was again popular. This time it was very dark in the woods, and now the lights of the scout leaders’ devices were switched off, the children really needed to navigate using their own device to collect the weapons. As the devices now responded more reliably, the children were able to do this. One of the scout leaders mentioned that he was hidden underneath a bush, and he heard the children walk in circles around him, before identifying his exact location. We also observed that two groups found their targets rather easily, whereas the other two had some problems. Again, after briefly demonstrating the workings of the devices they understood it better and they could find their target.

The ranking data resulted in the following combined ranking: (1) *Invade the Castle*, (2) *Save the Safe* and (3) *F.A.R.M.*. This is identical to the ranking of the previous session, though this time the children were more in agreement: Kendal’s $W = 0,53$.

3.4.5 Implications for the Design Process

Though this was the last evaluation we reflect here on how we would improve the games based on the evaluation.

*F.A.R.M.* seems to have reached its limits. In its current form it is a game that appeals most to children that enjoy intense physical activity, but there is no challenge for the children who do not. In the first session, when the game was new, these children were more inclined to play along, but once it became clear that the faster children had a distinct advantage, their participation decreased. One interesting opportunity we see for this game, is to implement some sort of *skill balancing*, i.e. making it harder to win for the faster children and at the same time making it easier to win for the slower children. That way the challenge is balanced more equally which might make the game appealing for a broader range of children.

Though the settings for transferal of the key still need to be further optimized, we think that the game is well balanced. Similar to *F.A.R.M.* this game requires physical
activity too, but now as a group effort so there is less need for an individual player to run all the time. Also, the invisible key adds to the experience of the game.

The main feature of *Invade the Castle*, searching using the devices, clearly appealed to the children. We can think of many ways to enhance the game, e.g. with the game rules that let players win bonus weapons, or that let players block their opponents.

3.5 Discussion

The experience of creating and evaluating these games have generated insights on different levels, namely (1) on the rapid, iterative, design process (2) on evaluating with children in this particular setup and (3) on what interaction mechanisms and technology are appropriate for interactive, outdoor games for children.

3.5.1 Design Process

Most design changes that we implemented based on our direct observations of the game play and comments of the children, concerned directly the play and interaction functionality. Seemingly small details, like the duration of some interactions, influenced heavily the emerging game experience, showing the inadequacy of evaluating a mock-up of the game interactions e.g. when play testing functionality with Wizard of Oz interventions. For example, the virtual key in *Save the Safe* could have been prototyped using a piece of paper or other small physical objects. However, it is easy to see that this would alter the game: the piece of paper is clearly visible to the other players, especially when passing it around between players, so the element of guessing which player actually possesses the key (as is present when the key is virtually represented) is taken out of the game completely. And particularly that feature of the game turned out to be the most fun part. Thus, we argue that instead of play testing with paper prototypes, it is best to immediately focus on the actual, working, interactions.

With regard to the time it normally costs to develop a working prototype, we conclude that with the RaPIDO platform we were able to bring this time drastically down. Over the course of six weeks we were able to develop, evaluate and improve four games. Furthermore, because it was relatively fast and easy to create working prototypes, the platform allowed us to "tinker" with the technology, and thus freely explore the design space.

Because of the high pace of iterations - we took 1 to 2 weeks to develop new iterations of the games - we did not have much time to run an in depth analyses of the results of the evaluations (e.g. run a structured observation, or content analysis of the interviews). Though we beforehand thought we would have time to analyze the interview data, after the first session it was immediately clear that we would not. Further, the interviews did not yield as much information for improving the
games as we had beforehand expected; directly observing the game play was much more effective. Nonetheless, the little information that was gleaned from the interviews was useful for triangulating our findings from the direct observations.

Another benefit of rapidly iterating over small changes is that it becomes easier to observe the impact of a small feature change. We argue that this way the design process becomes a "self-steering" process: if based on an observation a wrong conclusion was drawn and subsequently a wrong decision regarding the game mechanics is implemented, the next session will immediately show the (negative) effect and the design decision can be undone quickly.

Testing early and often in the design process makes sure that as a designer you do not "fall in love" with your own (features of the) games. After only one week of implementing a game, it is much easier to toss a feature in favor of an improved version or abandon a game altogether. In contrast, if one has taken months to implement a game, it is much more difficult to part from it, if at an eventual user test it turns out that certain features do not work out as expected.

### 3.5.2 Iterative Testing with Children

We experienced that repeated evaluations with the same group of children has a few distinct advantages: first, in the first study we got to know the children, which made it easier to interpret observations. For example, a child that behaves in a certain way may or may not do that as a consequence of playing the game and it is relatively hard to tell the difference from a single observation only. However, when observing the same children over time, as a (game) designer it becomes easier to tell which behaviors can be attributed to a child and which might be the result of playing a certain game.

The second advantage is that the children got to know us in the first study and because of that gained confidence and were at ease in their interactions with us. An often argued side effect of the children getting acquainted to researchers is that the power imbalance, that might exist between a child and an adult (Hendrix et.al., 2008, Markopoulos et.al., 2008), is lessened. In fact, we even experienced this to the extreme; the power imbalance was reversed in a sense that we had to try hard to assert ourselves on the participants, simply to get and hold their attention. We attribute this to two causes: first, as we indicated, the children became familiar with us; and second, because the groups that we handle are bigger than what is most common in HCI research (we typically test with 10-15 children at a time) children did not feel at all intimidated by the two researchers (in contrast to evaluations where only one or two children are present). In the field of interaction design and children it is commonly advised to take measures to redress the power balance between adult researchers/designers and children. In our case, we eventually had to claim a leading role in order to quiet the group down, and make sure they were all paying attention. This did not seem to have a negative impact, possibly because the children equated us to their scout leaders and they too
addressed the children in this manner. Regarding the scout leaders testing the games with the children and interviewing them, we could clearly see that the children were comfortable with the scout leaders and therefore there was no need to consider power balance affecting the study. This could be seen from the natural way the children were responding to the scout leaders interview questions and the way they were open about telling their own ideas regarding the games and the game play.

This brings us to another observation: when observing "in the wild" it is important to adjust to the context of an evaluation (Rogers, 2011). With respect to how, we add that as an evaluator, one should interact within that context. In the first study this meant that we positioned ourselves in the roles of scout leaders. Related to our observation above is the notion that one evaluation method cannot simply be transplanted from one context to another. Certain patterns of behavior have been established between the children and the scout leaders and as a researcher we argue that you should be aware of this and plan your evaluation accordingly. An example of this is the observation that using collages to elicit information from children as a method did not work well in this particular context, simply because the children were not used to sedentary activities within this context. In contrast: we have applied the same method earlier in a school context where it worked well.

The age of the children ranged from 7 to 10 years old. This is something we had not anticipated, but in the end had to adjust to: for some games it might occur that the challenge for a seven year old to compete with a ten year old becomes too high, resulting in a negative game experience for the seven year old, and maybe even for the 10 year old, as the competition is too low for him. We observed this during the play test of one of the games, and later adapted for this by not randomly mixing the children but instead sorting them by age group. Then the chances for winning the game became more equal for all players, resulting in a better game experience.

Finally, by iteratively testing the games we could also easily get out usability issues from the games and try out new rules for the games. By doing this we could see how the game play changed by changing small things in the game, an example of this is how the game flow in Save the Safe changed when changing the parameters for the key transfer.

### 3.5.3 Interaction in Outdoor Games

In total we designed, implemented and evaluated four different games that we implemented. In these games we used a variety of interaction styles and technologies, but the one technology most commonly used was the radio communication. We used it for two purposes: for communicating game events between devices, so they could appropriately respond to what was happening in the game with respect to other players. Further, we used the radio technology for getting a rough estimation for distances between devices (and thus players). Both
features contributed significantly to the novelty of game play, as it allowed us to introduce features in games that have no similarity to features in traditional outdoor games. An example of this is; the virtual key in *Save the Safe*, which was transferred between players based on proximity.

Furthermore, for feedback to the players we often used audio, visual and tactile cues. We found all modalities appropriate for supporting outdoor games, though that does not automatically mean that every style of using it is appropriate in the context of outdoor gaming. To give an example: in *Follow the Light* we needed to convey to the players how many steps they could take in a turn. At first we implemented it by letting the LEDs blink, each blink accounted for one step. However, this enforced the players to be paying attention to their device at a specific frame of time within the game. Also, the information is volatile, once it is shown it is gone. So, a moment of distraction, for example when talking to a team player (which we want our games also to encourage!) would result in the loss of game information. Therefore, we redesigned that part of the game to have each LED correspond to one step, which was a more robust way of showing the same information.

Another technology we made heavy use of was RFID technology. Each device is equipped with an RFID reader, which allowed us to program the devices to detect objects tagged with an RFID tag. Though we used it moderately in the games themselves, we employed the RFID tags mostly for setting up the games.

In contrast to other research prototypes, that often have a limited lifespan and/or are quite sensitive with respect to their environment, we were quite satisfied with how the devices performed: they were quite reliable, even in harsh conditions (snow, rain, low temperature, and rough handling).
4 Second Evaluation

The aim of the second evaluation was to enable adults with no programming experience to create games i.e. engage in end-user programming of the games. In this study we wanted to find out what requirements there are for an integrated game development environment, IGDE, and what level of complexity such an environment should offer for people with no programming skills. For instance should it be coding or just adjusting parameters in the game. Actually creating such an environment is outside the scope of this study; in this study we will focus on eliciting the user-requirements for such an environment.

From the first evaluation we found that HUGs should be made easier to adapt during the game play. It was for instance very clumsy to choose the game with the tags or by rotating the rotation wheel, to choose which devices were in a game and which devices belonged to which team. It would also have been convenient to be able to change some parameters in the game during the testing of the games instead of changing the whole game in the code, e.g. the distances and time when passing the key in Save the Safe. Therefore in this evaluation we also wanted to observe what kind of user needs there were for making the setup of the games easier.

In this evaluation we decided to do design cycles with the scout leaders. As we have no IGDE available yet, the plan was for them to design the games on paper and we would program them. We would also observe their game design and evaluation process. The scout leaders were chosen as the target group since we thought that they could be an end user for the IGDE, since they regularly conceive, and design outdoor activities for children, but do not have expertise in technology.
and interaction design. They are both seen as experts in designing outdoor games for children and experts on dealing with children. By using them as informants for developing the IGDE, we thought that it would show us the nature of the requirements they express that have to be implemented. Additionally, it would also show us their ability to conceptualize the relation of game related behavior, game elements with what is programmed in the devices and the degree to which we could characterize them to thinking in computational terms. Their design process might look different from ours, they might have an insight in what the children want that differs from our experience and they might design different kinds of games than what we would do, which also affects the needs for the IGDE.

Our expectations in the second evaluation were based on observations made during earlier designs of Head Up Games (Soute, 2013).

4.1 Study Setup

In total we organized four sessions with the scouts. The first two sessions were game design sessions, which were done at the scouting house with only the scout leaders present. The third and fourth sessions were evaluation sessions of approximately 2 hours each, with leaders and children of the same scouting organization as in the first study (chapter 3.1.1.). These two sessions were done in the same setup as described in the first study (chapter 3.1.1.). This study took 5 weeks in total (Figure 12). From the picture we can see that it took two weeks from the first brainstorming session, where the scout leaders designed the games, to the first iteration i.e. for us to program the initial games. After the second session we again took two weeks to implement the changes on the games that the scout leaders asked for. After the third session we took one week to implement changes and the games were tested and evaluated by the scout leaders a last time with the children.

![Figure 12. Timetable of second evaluation](image-url)
Before starting the sessions with the children we informed the parents of the children of our plans and we obtained consent for their children participating in the sessions, and also for gathering video and photo material.

The time frame for both the first and second session was flexible, although we had estimated that the first brainstorming session would take about two hours and the second session between an hour and two hours. The third and fourth session was planned to take two and a half hours - which was equal to the duration of the regular Scouting meeting and gave us half an hour to interview the scout leaders after the children had left.

In the third and fourth session we planned to let the scout leaders let the children play the games, while we both observed directly as well as gathered video material for later reviewing. Furthermore, we planned to, after the evaluation sessions with the children, group interview the scout leaders. This was mainly done to see how they experienced the session and to get insights in what kind of changes they would like us to make to the games. For all four sessions the data we expected to gather was our own direct observation of the game play, the scout leaders design process and interviewing the scout leaders. The sessions were also additionally video recorded as backup to later on be able to check details from the sessions.

Below are the accounts for each evaluation session. For each session we explain the games the scout leaders designed and elaborate on our expectations of the game play and reactions of the scout leaders before the session. Next we describe specific details for the session and we report the results of the evaluation, both in terms of the process as well as how and why we in collaboration with the scout leaders decided to change the games for the next iteration.

4.2 Designing the Games

The goal for the first session was to see what kind of ideas for games the scout leaders would come up with and to have them design one to three games that we could implement for the next design cycle.

4.2.1 Expectations

Before the first session we had certain expectations regarding the scout leaders way of designing games and their use of the technology in their games. Our expectations were based on observations made during earlier designs of Head Up Games (Soute, 2013).

First, we expected that the scout leaders way of designing games would be different and less structured from our way of designing. However it would most likely still include some kind of brainstorming and then testing with the children,
although they might skip this with adults. They would have plenty of ideas for games, since they are used to playing a lot of games, and therefore we expect that coming up with game ideas will not be a difficult task for them.

We also expected that they would not think about the added value of using technology in their games and therefore they would most likely design games that could be played without the devices, since this is what they are used to doing. However, with some leading questions, e.g. could this game be played without technology?, they would still be able to come up with game ideas that need the devices. We also thought that they would probably first design games with too many rules and details.

4.2.2 Procedure

Four scout leaders, 2 women and 2 men, participated in the first game designing session. From these scout leaders 3 out of 4 participated in the first study and were therefore familiar with the devices and the games.

Our first aim of the session was to get the scout leaders in the right set of mind for the creative process of designing games. Therefore we decided to start the session by group interviewing the scout leaders, this was done to find out how the scout leaders normally design games, what kind of games they design and if they take in account the age of the children (in the first test we could see that there were some age differences and that the children of different age perceived the games differently). (Questions in Appendix 1). Next we play a Head Up Game. This was done to get the scout leaders to think about games and to remind them of how the devices work. We chose to play Save the Safe (chapter 3.1.2) since it is a good example of a game with the added value of technology.

After this we started brainstorming about game ideas. First we asked them to individually come up with as many game ideas as possible and write them down. This was done to get the scout leaders to think about as many ideas as possible, without judging the level of the ideas or how they could be used in a game and to not be influenced by the rest of the group. We pointed out to them that there were no bad ideas and that their ideas could be as crazy and as non realistic as they wanted them to be. After this the group told each other about their ideas and grouped them. Finally we asked them to think about the game ideas they just came up with and use them and other game ideas they can come up with to design one to three games that can be played with the devices. We also reminded them that they were designing for their scout group, children of 7 to 10 years old.

To avoid having them fall in the same pitfalls, as we had done in the first evaluation, when designing the games, e.g. designing games with too many rules, sticking to details of the game and forgetting the added value of technology, as we have done earlier, we decided to at the end of the session guide them in the right
direction if we would notice that they were doing the same mistakes as we. This was however only done after they had finalized their own design.

Once the scout leaders felt like they were ready, they presented their game ideas to us.

4.2.3 Results

During the session the scout leaders came up with three different games that could be played with the devices. In two of the games the game concept was designed detailed enough for us to be able to program them. The third game was only on a conceptual level and the scout leaders thought that it was a game that would be difficult to play during the regular scout meetings, therefore they agreed on not having the game programmed.

We noted that when designing the games the scout leaders were thinking about the added value of technology. They tried to focus on games that needed the technology and ruled out some game ideas that would not have needed the technology. In the end one of the games they designed could be played without technology and the other one needed technology to work. They were also reasoning about game experience and thinking about how a game would evolve. One of them wanted to rule out cheating in a game, the others did not think it was very important.

Even though the scout leaders managed to design the game concept in detail, they did not think about the detailed interaction between the device and the player e.g. they did not always think about how the user would get feedback in different situations and how the game would start or end. However they did think about some details in the game e.g. using vibration to show a player that a tag has been read, when not wanting to show it to other players. They also decided to skip some interactions with the devices such as messages, rotation wheel, distance and accelerometer when designing the games. There were also some issues with what could be done with the devices and they had trouble of thinking of alternative ways of doing it, e.g. in Candy Crush they would have liked to have each LED showing a different color at the same time and having a “compass” in the device, to know in which direction it is turned.

To be able to program a working game we had to ask them about the timing of the game e.g. “when do players go to the next level?” and feedback about which level players are on. We also asked them about error preventing, what happens if e.g. a wrong tag is read.

From the interview we found that the scout leaders normally get inspiration to new game ideas from other games, e.g. computer games, board games, TV shows and from other scout groups game websites. They find it difficult to come up with
the blueprint for good games. Sometimes it is also a challenge to play the same
games with the whole group since the older and younger children do not always
like the same kind of games. It is also difficult to predict what kind of games the
children like, sometimes the children liked a game the year before, but this year
they find it boring. Sometimes changing a surface feature relating to the game
narrative, e.g. instead of being soldiers the players are football players, changes the
whole game for the children. About half of the scout meetings are used for playing
games. The children like games where they can collect things, where they have to
go from one place to another without being seen and smuggling things. Sometimes
the scout leaders have to start the meeting with active running games, to allow the
children to release excess energy. They always try to play the same game with the
whole group, to make the teams more equal they divide the groups so that the
teams are an equal mix of younger and older children.

4.2.4 Implications for the Design Process

During the game design session the scout leaders came up with 3 games. Two of
the games were detailed enough for us to be able to program them, the third game
was just on concept level.

**Candy Crush.** In *Candy Crush* players are given assignments to collect colors in a
given order. The aim of the game is to have fulfilled most assignments by the end of
the game. Players are given a color card (Figure 13) with an order of colors e.g.
red-green-yellow, they are then supposed to, in the right order, find these colors,
which are represented by people who are roaming the forest. In this case, the
players would first need to find the red person, then the green and finally the
yellow. Once they have found all the right people they can go back to the base and
get a point and a new color card. In the game there is also a demon roaming the
woods. When encountering the demon the player loses all colors that he/she has
collected so far.

![Candy Crush Assignment Card](image-url)
**Mole.** In *Mole* the players have to find active tags that are hung up on trees. At the start of the game several trees are tagged with an RFID tag. In different levels of the game, different RFID tags are active and it is the players’ goal to find such an active tag, to proceed to the next level. The player that finds the active tag in the third, and final, level wins the game. If a player finds an active tag his/her device will start vibrating and other players cannot anymore tag that tag. The players who have found an active tag will after a certain time limit proceed to the next level. The amount of active tags reduces for each level until the last level that only has one active tag.

### 4.3 First Iteration

For the second design session with the scout leaders the goal of the session was to try out the games that they had designed and we had programmed on the devices. This time only 2 of the scout leaders could join the session, one man and one woman.

#### 4.3.1 Expectations

For this session we expected that the scout leaders would change small details in the game and work on the interaction between the device and the player e.g. add sound when a tag is read. We also thought that they would come up with new rules for the games and make more details in the games e.g. how many right color combinations have to be collected before winning the game.

In *Mole* we expected that after trying out the games the scout leaders would think about: how to proceed from one level to the next, the length of the game, feedback about which level a player is in, feedback when tag is detected (both active and none active tag) and feedback at the start of the game.

In *Candy Crush* we expected the following changes: audio feedback when tag is read and added technology value, e.g. searching for the color like in Invade the Castle or warn for the ghost that can take all colors.

#### 4.3.2 Procedure

Since the aim of this session was to test the games, we decided to test the games one at a time. We started by testing out a round of *Mole*. Since there were only two scout leaders one of the researchers and the cameraman joined in the mole game. After playing the game we sat down to discuss the game. First we let the scout leaders talk freely about their game experience. Once they were finished with telling us about their own thoughts we asked them the following questions that we had expected to get an answer to: What they think about the game? Do they want
to change something? Think about the start and end of the game; How do players
know when to start or end the game? Is this the game they were thinking about? Is
there an added value from using the technology or would the game be the same
without technology? Once the scout leaders had told us how they wanted the
games to be changed, we played the second game *Candy Crush*. Also when playing
this game one researcher and the cameraman joined the game. After playing the
game we did the same procedure as after playing the first game. Once the scout
leaders thought they had told us about all the changes they wanted to make, we
discussed our ideas of changes of the games with them and asked what they think
about them. At the end the scout leaders decided which changes they wanted us to
make to the games.

### 4.3.3 Results

From the session we found that the scout leaders know how to come up with good
game ideas, however they have a problem with designing the interactions between
the players and the devices. Though they did notice that the games did not run
smoothly, they did not know what part of the game to change to improve it. They
were also thinking about the length of the game being related to how many players
and the size of the play: they want to be able to change this easily. They were
surprised that a game can be selected from one device. From the first evaluation
they had seen that we had to choose the games separately from each device and
therefore they had not thought about this possibility.

When asking about the added value of technology they thought that *Mole* had
added value from using technology, and they also came to think about it on their
own when discussing *Candy Crush*. They thought that even if *Candy Crush* can be
played without the devices, the light and sound makes the game more interesting
for the children.

For *Mole* they thought that the tags should only be active only for first player who
finds it and that the tags that are active should be randomized. This way the game
could be played several times without players learning which tags are active. The
length of the game should depend on amount of players and size of the game field.
For now it is ok to have a fixed 2 minutes, but later on it would be nice to be able to
easily change it or to do it once all active tags are tagged. With more levels it would
be nice to know which level the players are on. With 3 levels it is however not
necessary. Going to the next level could be presented by e.g. sound “voice” “level 1”,
“level 2”.

In *Candy Crush* they thought that there should be audio feedback when a tag is
detected. They would like to choose the amount of colors to collect and have more
colors to choose from e.g. search for 4 colors, out of 6-7 colors.
When later on discussing our ideas with them, they also thought that it would be a good idea to in Mole with the help of the LEDs show the players which level they are on, 1 to 4 LEDs being on showing level 1 to 4. An inactive tag should also make a sound, to show the players that the tag was read but that it is not active. In Candy Crush they thought that the devices could show which colors to look for. They could also show how many points other teams have for a competing effect. Colors could also be searched for like in *Invade the Castle*.

### 4.3.4 Implications for the Design Process

From the first testing of the games the scout leaders decided that they want us to make the following changes to *Mole*: the tag is active only for the first player who finds it. Show which levels players are on with the LEDs on the device. Length of the game should be 2 minutes per level. To *Candy Crush* they wanted to do the following changes: search for 4 colors out of 7. Make a sound when the tag is read.

### 4.4 Second Iteration

The goal for the third session was to try out the games with the children. This time 5 scout leaders, 3 men and 2 women, attended the meeting. From them one had not attended in the previous sessions, but he had attended in the first study. 9 children, 8 boys and 1 girl, attended the scout meeting. From these children 5 had attended the first study. For the session we had with us 6 working devices.

### 4.4.1 Expectations

For the third session we expected that the games would be playable, but they will have a few usability issues. The scout leaders will find it natural to explain the games to the children, however they will probably have some confusions because they also have to explain the interaction with the technology. They might have some trouble with setting up the games e.g. how to turn on the devices, choose a game and read tags. We also expected that they will come up with ways of fixing some of the usability issues in the games and they will make more details in the game, e.g. how many right color combinations have to be collected before winning the game.

Since this session was the first where children were involved and the scout leaders had to handle the game play by themselves, we thought that they would give us an idea of what kind of requirements they have for a platform such as change parameters (e.g. how many colors to look for in Candy Crush), add tags with different consequences (e.g. the ghost in Candy Crush) and easily control the games and devices: choose game, devices, teams, decide who is it and check status of devices.
For Mole our expectations concerned mostly the timing of the levels. In other words we thought they might want to think more about when to go to the next level, e.g. after a fixed number of minutes or when all active tags had been found. For Candy Crush again we expected the following changes: add technology value, such as: when searching for the colors do it like in Invade the Castle or warn for the ghost that can take all colors, and taking away the papers and instead only use the devices to count scores and get new color codes.

4.4.2 Procedure

Before this session we had told the scout leaders that this time it was their task to play the games with the children, we would only act as observers and in case of problems help them with the devices. We decided that it would be a good idea to give the scout leaders instructions on how to handle the devices and a recap of how the games work, before the children arrived, therefore we met up with one of them half an hour before the start of the meeting.

The scout leaders decided to start the session by playing an active running game on the grass field. This was done to get rid of the extra energy in the children, so that they would be patient enough to listen to the instructions for the games. While the children were playing, a few of the scout leaders went in to the forest to set up the tags on the trees for Mole. After the energy exertion game, one of the scout leaders explained to the children what they were going to do today at the meeting and then he explained in detail how the first game, Mole, would be played. Once he had done this they all went into the forest, next to the area where the game was going to be played, and he told them about the different interactions of the game and showed them the area where the tags were hidden. After this the scout leaders decided which 6 first players would start playing the game and then started up the game. The game was played 3 times with 6 players in each game, so in total everyone got to play the game 2 times.

Once the children finished playing 3 rounds of Mole, the group went again to the grass field and played an energetic tagging game. While they were doing this 4 of the scout leaders went in to the forest with the color tags for Candy Crush. 3 of them had 2 colors and 1 of them only had one color. This was done since they wanted the children to search for 7 different colors. The scout leader who was left with the children then told a story about the colors being lost in the forest and that the children should find them, he also explained the rules and interactions of the game and then they went to the forest to play the game. The scout leader who had explained the rules worked as the ghost in the game and one of the researchers worked as the score counter and gave out new color tags.

After playing both of the games one of the scout leaders sat down with the kids and discussed the meeting and the games with the children. He asked the children what they thought about the games, which one was their favorite and why they liked or
didn’t like the games. Once the children left we interviewed the scout leaders (Interview Questions in Appendix 2).

4.4.3 Results

The scout leaders had some ideas on how to change the games, both regarding the interaction with the game and new game rules. For Mole they came up with the following ideas: randomize the active tags, now some children seemed to learn which tags were active (especially at the end of the game), go straight to next level when all active tags are read, being able to push away players from tags, player has to be at the tag at a specific time e.g. 10 seconds before time is out the player who is at the tag gets the tag and if a player is pushed away from a tag he/she has to find a new tag or not come back in a specific amount of time e.g. 10 seconds. They also thought that it was difficult for the children to find the tags since we had used black duct tape to attach them to the trees, and in this game the aim was not for it to be difficult to find the tags. For Candy Crush they commented that: the colors red & orange and green & mint were too similar on the device and they thought it would be better to only use 5 colors instead of 7 and drop orange and mint, they also wanted to skip the paper cards, and show it on the devices instead. This decision was made since they thought that it was difficult to see the different colors in the dark, they were extra things to carry and not using them would add to the added value of technology. They now also saw the added value of technology in this game since it could be played in the dark and the children also used the devices as flashlights.

Other observations that we made were that it was easy for them to handle the devices, however explaining the games was more difficult than normally because they had to explain interaction with devices and the game flow. The devices also made the scout leaders a bit confused, one of them explained the games first at the grass field then in the forest, later on he said that usually he explains the game rules where the game is played. He was a bit confused about why he had done this and could not explain the reason for doing it like this. The scout leaders carefully thought about if the games can and should be played alone or in teams. In the end they decided that Mole should be played alone since it was light outside and the game was fast pace and Candy Crush in teams since the forest was dark and it was a slow pace game. They also decided to do Mole first since it needed more light to find the tags and for Candy Crush it was good that it was dark outside due to the light effects on the devices. For Candy Crush the leaders told a story about the colors being lost in the forest and that they needed to be found so that a color party could be held. According to the scout leaders they try to tell a story about the games to make it more fun for the children and to get their imagination running, however with Mole they thought that there was already so much to explain about the game play, that it was better to not tell them a story about the game.
It surprised us that the scout leaders decided to openly discuss the games and the game play with the children at the end of the scout meeting. The children thought that searching was fun in both games, 5 out of 9 thought that Mole was more fun than Candy Crush (the rest vice-versa), the darkness and lights was fun in Candy Crush, 1 child thought that these games were more fun than the ones they have played during previous meetings, the rest thought that they were as fun. The children were very naturally telling the scout leader about their opinions of the games.

4.4.4 Implications for the Design Process

From the first evaluation with the children the scout leaders decided that for Mole they wanted to do the following changes: make it possible for players to push away each other from an active tag, a player who has been pushed away from a tag has to go and tag another tag before returning to the same tag, the game ends when the first player finds the active tag on the third level and make sure that all devices go to the next level at the same time. For Candy Crush they wanted to: skip the paper cards and instead have the device show the colors that should be collected, although they could not come up with how this should be done, and make the players collect 4 colors out of 5.

4.5 Third Iteration

The goal for this session was for the scout leaders to get a chance to try out the games once again with the children and to see how the changes they made to the games changed the game play. This time 3 scout leaders, 1 man 2 women, attended to the meeting. 6 children, all boys, attended to this meeting, one of them had not attended in the previous session or the first study. We had 7 devices with us to the meeting, Candy Crush could only be played on 4 of them due to broken LEDs which would have affected the game play.

4.5.1 Expectations

This time we expected that the games will be playable and work well, but they will possibly have some minor usability issues. The scout leaders will come up with ideas on how to fix the small usability issues in the games, they will come up with new game ideas and they will most likely also want to change the games a bit. They will also make more details in the game, e.g. how many right color combinations have to be collected before winning the game. It will be easy for them to handle the devices and they will be more comfortable with them this time and they will be able to explain rules of the games to the children and they will probably be a bit more comfortable with it this time. The children will understand games better since they have played them before. For Mole we expected that both the children
and the scout leaders would comment on that there is no way that the first player can protect himself against the second player who is chasing him/her away.

We also expected that *Mole* will be more “clear” since all devices go to the next level at the same time and it will be easier to find tags due to change of duct tape color, the game will be more fast pace. Being able to push away players from the tags will also change the game dynamics and the players will probably have more discussions and disagreements because of this. *Candy Crush* will run smoother since there will not be a confusion of which color is showed on the paper and the device, however some players might find it difficult to match the collected colors to the ones that were supposed to be collected. After playing the game we expected that the scout leaders would want to add more technology when searching for the color like in *Invade the Castle* or warn for the ghost that can take all colors, they might also want to add an end of the game, e.g. first team to get 5 points.

4.5.2 Procedure

The procedure for this session was very similar to the previous time. This time however it was raining and we decided to cover the devices in plastic foil to protect them from getting wet. Since the children were only 6 this time they could all play *Mole* 3 times. Between the games the scout leaders decided it would be a good idea to go inside and play some active games to warm up. *Candy Crush* was played in two parts, the first half we were in the forest and the second part we were in the forest next to the lit grass field where the forest was less dense. This was done since the children had asked if this could be done during the previous session. The game was again played in teams of two. After playing the games one of the scout leaders decided to interview the children again and ask them about the games. After the scout meeting we interviewed the scout leaders.

4.5.3 Results

This time the games were well played and the only usability issue in the games that we bumped into was that the players had a hard time finding some of the tags in *Mole* even though this time we had put a white piece of tape on the tags. The scout leaders thought that the games were well played and they would not really like to change anything in the games. Due to the plastic wrapping on the devices the scout leaders had a hard time turning on the devices (the on/off switch was difficult to find) and we had to help them. As expected it was easier for the scout leaders to explain the games this time and they seemed very comfortable with the devices.

What surprised us was how nicely the players were playing *Mole*. There were no discussions or arguments when another player came and “stole” an active tag. The players just nicely went to search for another tag and in one case a player even ran away from an active tag when he saw that another player was approaching the tag. In *Candy Crush* it surprised us that there was no problem collecting the right colors.
in the right order and the only issues we bumped into was that one of the devices ran out of battery in the middle of the game and thereby one of the teams score was zeroed in the middle of the game. This however did not seem to bother the players very much. The game play was also different in the forest in the back and in the small forest next to the grass field. When playing next to the lit grass field the game was more fast-paced and the children were running more. The ghost also commented that in the forest it was easy to surprise the children in the dark, but next to the grass field he really had to chase them to catch them. In the interview with the children they also thought that it was more fun playing next to the grass field since the game was then more active. The children also had some ideas for the games, but the scout leader found that the ideas were very diffuse and not really anything that could be implemented or directly related to specifically these games.

4.5.4 Implications for the Design Process

This time the scout leaders did not really want to change anything in the games. They found that the games worked as they were.

4.6 Discussion

The experience of observing the scout leaders creating and evaluating Head Up Games have generated insights on two different levels, namely (1) on non interaction designers designing interactive games and (2) on the user needs and requirements for an Integrated Game Development Environment.

4.6.1 Designing HUGs: Interaction Designers versus Game Designers

From comparing the design process in the first study with the second study we found that there were differences between how the games were designed. As we had expected the scout leaders easily came up with new games and game ideas. To our surprise they were reasoning why some things should or should not be done depending on how it would affect the game play. For instance when deciding on changes for Mole after the first iteration with the children they were carefully thinking about how to make the game dynamic but still keeping it as a game which feels fair for the targeted age group of the players. We had also expected them to design games with too many rules and details, but to our surprise they designed quite simple games and they added on the details as the implementation of the game progressed. For example in Candy Crush they wanted to start with the paper cards with the assignments and once that was working they wanted the devices to show the assignments.

Regarding the interaction with the technology we noted that they had some trouble with designing the game interactions on the devices. They had a very good vision of the game flow and what kind of games the children would like, but they
did not always think about the interaction with the device. For example they did not think about how the game would start or end, how to inform the players that a tag has been read or when the game goes to the next level. After trying out the games they often suggested that there were some usability issues, but they had a hard time coming up with a solution to the problem. In some cases they could state that they wanted an interaction, but they were not sure about how to do it with the devices. For instance after the first session with the children in the second study they wanted to get rid of the papers which showed which colors the players should collect, but they could not come up with a way of how to do this with the devices. If an interaction they had thought about was not possible with the devices they had a hard time thinking about another way of doing it with the devices. For example they would have liked the device to show the color assignments in Candy Crush by each LED at the same time having a different color. This is something that is not possible to do with the devices and the scout leaders could not come up with a different solution to do this. What we did not expect was that they had a hard time thinking out of the box when it came to the technology. Most of the time they were using interactions that they had seen being done with the devices before and they were for instance very surprised to see that they could choose a game by just showing the right game tag to one of the devices after which this device would broadcast the information to the other devices. In contrast, in the first evaluation this was done by showing the tag to each of the devices separately.

As we expected the scout leaders needed some prompting to get them to think about the added value of technology. Although, we did see that there was a clear learning curve. For instance, we needed to ask about it at the second design session once they had played the first game; by the second game, they were thinking about it by themselves. We could also see that this was an idea that grew stronger in them during the four sessions and at the third and fourth session they were already actively thinking about it. What also surprised us was that they mentioned that for them the added value of technology was not only the thought if the game could or could not be played without technology, but they also thought that already the sound and lights were added value to a game.

The scout leaders also had some needs for an IGDE, which we had expected. For instance they thought it would be a good idea to be able to change parameters, like the duration of a game and the amount of colors in an assignment in Candy Crush, right before the game depending on e.g. the amount of players that were playing.

### 4.6.2 Reflections on the Method Used

In general we think that the method used in this study worked well with our target group, the scout leaders. The scout leaders created two working games that both they and the children liked to play. The games had added value of technology both according to our standards and the scout leaders standards and we even learned from them that the added value of technology does not always mean that a game
cannot be played without the technology, but that e.g. lights and sound effects already give the game added value. The scout leaders had fun creating the games and it seemed like it was something they would like to do again. We also got some good ideas for the user requirements for an IGDE.

Still, we do think that there would be some room for improvement, especially if the evaluation is done with a target group with less experience of the devices and/or less experience of designing games. As discussed in the previous chapter, even though the scout leaders had seen the games in the first evaluation, they had some trouble with thinking out of the box regarding the technology. They could easily implement the technology they had seen before in the games, but they had a hard time to think about technology they had not seen. From this we believe that it would be important to prompt more what technology exists in the devices. This could for instance be done by showing all the existing technology on a poster or cards or making a short video with all the interactions. We believe that by seeing the technology beforehand might have restricted the scout leaders to think out of the box, since they already partly had an idea of what could be done but at the same time they were not aware of all the interactions. However it probably also gave them a more realistic picture of what could be done with the devices.

Compared to using co-design, where the user “is given the position of ‘expert of his/her experience’ by providing tools for ideation and expression” (Sanders and Stappers, 2013), as a method for this research, we believe that for this specific research the method we used was more effective. If we had co-designed the games with the scout leaders, we could have assumed the role as technology experts. Although our creative thinking might be too restricted by the knowledge of what can be done with the technology and therefore thinking out of the box might become more difficult for us. Now we got requests that we thought might not be that easy to implement on the devices, but we still tried since that was what the scouts wanted. Two examples of this was how they asked us to skip the paper assignments in Candy Crush to instead only use the technology and randomizing the active tags in Mole. In this evaluation we also wanted to get an insight in how the scout leaders would design the games and for them to be able to do it in the future. Therefore with co-design we might not have realized in which areas the scout leaders need some help when designing HUGs. However, co-design is definitely a method that could be used in the future if we would like to design good games that people with programming skills can implement.

4.6.3 Points for Future Work

From the second study we found that there is definitely a need for an IGDE. The exact user requirements for such an IGDE is however something that still needs further research. We believe that there could be two different target groups for such a platform: those people who only want to change a few parameters in a game and people who want to design their own HUGs, but who do not have
programming skills. For the first target group we would suggest to design an application for a tablet in which the user can choose a game and then choose some specific parameters for the game e.g. amount of players in the game, which devices are in the game, the duration of the game and simple game parameters such as how many colors an assignment should consist of in *Candy Crush*. For the second target group we would suggest a platform on a computer in which the user can design new games but some interactions would be predesigned and in which the user could choose from options on e.g. how to start the game, interaction when tag is read and how to tweak games such as add demons and bombs.
In this thesis two studies about designing interactive outdoor games for children, are described. The first study described a design/evaluation process of interactive outdoor games that deviates from the generally applied way of using prototypes in HCI. Instead of gradually increasing the fidelity of the prototypes, we went ahead and immediately created high-fi (with respect to interactivity) prototypes. The second study describes the process of giving non-programmers the task to design/evaluate interactive outdoor games for children.

From the results of both studies we argue that, for games involving physical activity, outdoor play, groups of players and embodied interaction, it is virtually impossible to test the games with paper prototypes as the lack of interactivity distorts the game dynamics intended by the designer and leads to very different play experiences. Moreover, we argue that in the case where children are involved, the lack of interactivity from using low-fi prototypes becomes more apparent, as children might be less able to reflect on the impact of interactivity and the resulting game dynamics without actually experiencing it.

Based on our experiences from both evaluations we conclude that an iterative design process is a very suitable method for designing interactive outdoor games. Especially when designing games in which the emerging game experience is not only a result of interactive technology (but also of the context the game is played in and other existing game rules), these games need to be really experienced and cannot be tested with lower fidelity prototypes.
Finally we argue that when designing Head Up Games there is a need for interaction designers. Scout leaders and other caretakers of children such as teachers and after school activity leaders often have a good insight on what kind of games the children like and may therefore be good at designing the game concepts for these kind of games. However, these people rarely have experience in interaction design or programming, which we believe is needed for being able to design interactive games with a good game flow and which match with the game concept. Therefore we strongly believe that there is a need for an Integrated Game Development Environment, IGDE. The main idea of such an IGDE would be to give non-programmers and people who do not have experience in interaction design a chance to design and/or tweak Head Up Games. In other words, we would like to enable them to design their own games with a tool that supports the design level of complexity that is appropriate for them; this tool would offer flexibility regarding game settings, but would offer pre-programmed interaction styles. Depending on the targeted user group we would suggest two different IGDEs. One is aimed for users who only want to change parameters in existing games and one for users who want to design their own games. In the second one, we would recommend that some interactions would be predesigned alternatives from which the user can choose the alternative that fits best or even gradually teach the user to start thinking about the interactions of the devices in the game.


Engebretson, A., and Wiedenbeck, S. (2002). Novice comprehension of programs using task-specific and non-task-specific constructs (pp. 11-18)


Waterman, Blades, Spencer 2001, Researching Children's Experience: Approaches and Methods Is a jumper angrier than a tree?, The Psychologist, 14, 474-477


Appendices
Appendix 1: Warm Up Questions & Answers

1. How do they usually do when they design new games?
2. How do they come up with ideas for the games?
3. Do they bump into problems, what kind of problems?
4. What kind of feedback do they usually get from the kids?
5. What kind of games do the children like/not like?
6. Do they have different games for different occasions?
7. Which games are popular?
Appendix 2: Interview Questions for the Third Iteration

1. What did they think about the game(s)?
2. What did the kids think about the game(s)?
3. Do they want to change something?
   a. Think about the start and end of the game:
      i. How do players know when to start or end the game?
   b. Is this the game they were thinking about?
   c. What kind of changes would we do?
   d. Are there things they would like to be able to change right before or during the game?
   e. Would they like to change something on the devices?
   f. Do they come up with the same things as us?