Designing for open-ended play

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Doctoral Dissertation by Linda de Valk

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PROEFSCHRIFT

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Table of contents

List of design cases

1

Introduction

Introduction to this thesis

Two girls are playing at their neighborhood playground. They build a shelter from old clothes they brought from home and put over the slide. One of the girls is wearing a pink cape. "I am superwoman!" she says. "I am going to save us from the enemy!" When she steps out of the shelter, the other girl starts to shout: "No! You cannot walk there, there are flames everywhere!" The girl with the pink cape quickly runs back into the shelter. "What shall we do?" she asks the other girl. "I think we have to make some protective shoes," the girl responds. They take two tennis rackets and attach them to the girl's shoes. "Now what?" One of the girls picks up some tennis balls. "You have to bring these precious treasures to the secret chest near the swings," she says. "But you cannot hold them in your hands, you have to bounce them." The girl with the pink cape gives it a try but the ball rolls away. "Now it is my turn!" says the other girl. Quickly they attach the tennis rackets to her shoes. Suddenly the boy from next door is running towards them. He has a large stick in his hand. "I am a knight!" he shouts. "And I am going to rescue the princess." The girl with the pink cape sighs: "Oh boy, you get it all wrong!" and quickly sends him away.

The scenario above describes an everyday play situation. Play is a beneficial activity for all ages and especially children learn greatly through play. Play is an important aspect of their development and supports them in developing and strengthening a wide variety of skills. The scenario illustrates several characteristics of children's play. For example, the girls are involved in constructive play when building a shelter, and in fantasy play when pretending to be a superwoman. In their play, the girls are physically active and cooperate with each other. They negotiate about goals and rules and take turns. Together, they create a magical world that exists outside of ordinary life. When the boy joins them, he tries to enter the girls' magical world, but he gets dismissed as he does not play by their rules.

In this thesis, we explore how to design for children's play, supporting a variety of routines as mentioned in the scenario above. More specifically, the research presented in this thesis focuses on designing playful designs with interactive technology that children can play with in an open-ended manner, supporting children to play in diverse ways while

inventing rules and setting goals themselves. Interactive technology connects physical input from the children measured with sensors to some kind of output delivered by the design, for instance lights, sounds or movement. Children react on these outputs and give physical inputs again, creating a cycle of interaction. Besides that, the interaction can also start from the design side, when the outputs actively invite children to start interacting. If we return to the three children (boy and girls) playing in the scenario above, this is how they could continue their play with interactive, open-ended objects.

The boy walks back to the two girls. He is holding a collection of blocks in his hands. "Look what I've found!" he says. One block drops on the ground and makes a sound. The girls look out of their shelter and approach him. The boy throws all blocks on the ground and the blocks make a lot of sounds. One of the girls picks up a block. "Everyone has to pick up one," she shouts, "and then we run around, but you're out when your block makes a sound." The three of them play this game for a little while. When the block of the boy makes a sound, both girls point at him and say: "You're out!" The boy shakes his head: "No, I was having a break." One of the girl stops and picks up some more blocks. She drops the blocks and cheers when they make sounds: "This sound is the best!" "Wait, let me," says the boy. Now it is his turn. He picks up the blocks again and drops them in a circle. The other girl kicks against the blocks to make even more sounds.

Over the years technology has become more present in everyday life, including children's lives. There are opportunities and challenges in designing playful environments for children that incorporate interactive technologies. Technology offers new possibilities such as personalization, dynamic content that can be refreshed and that can grow in line with the development of a child (Shwe & Francetic, 1999). But technology can also be directive and restrictive, leaving little room for the imagination and creativity of children. There is a need for digital toys that support and encourage children's creativity in an open-ended manner instead of directing and controlling children's play by predefined interactions (Shwe & Francetic, 1999; D'Hooge et al., 2000; Cassell & Ryokai, 2001). In line with this, the work presented in this thesis concentrates on designing for open-ended play. In open-ended play, games and rules are not predefined but children are free to create their own meanings with the interaction opportunities of the design. In this way, play is a result of the dialogue between players (children) and the design. Open-endedness as a design quality was already used by Friedrich Froebel, who developed open-ended toys that children could play with freely in many different configurations (Zuckerman, 2010). Open-endedness is also an important aspect of the well-known Reggio Emilia educational approach (Edwards et al., 2010; Gandini, 2011). In that approach, open-ended materials are used to support creativity and imagination (Gandini, 2011) and children are considered active participants who have a lot of freedom to create their own learning activities (Edwards et al., 2011).

In open-ended play, variations in rules and attachment of meaning are essential design aspects that provide children with a sense of control and let them invent their own play,

which can lead to a variety of forms of play with one open-ended design. When playing with traditional toys or carrying out games with rules, children already invent new rules or adapt existing rules and goals, as well as change the meaning of objects. For example, children pretend a stick to be a magical sword or add extra rules to an existing game of hide-and-seek. The design intention of open-ended play is to support different goals, rules, stories, roles and so on to enhance children's imagination and creativity. Previous research has demonstrated that children are capable of playing with interactive, open-ended play objects (Bekker et al., 2010a) and that they can come up with a variety of games (Hopma et al., 2009). In this thesis, we elaborate on this work by investigating designing for interactive, open-ended play in more depth. Our challenge is to examine how we can support designing for open-ended play through diverse design research activities resulting in relevant design knowledge and guidelines. We see opportunities in further exploring aspects such as social interaction and creativity in play. Open-ended play is valuable in stimulating social play among children in which children develop skills such as negotiation and respecting another child's point of view. Moreover, open-ended play offers opportunities for children to be engaged in creative processes and meaning making leading to diversity in play.

In this first chapter, we describe related work concerning children's play and the role of technology in this. Next, we discuss the context in which the research presented in this thesis took place. We continue with a discussion of the objectives and approach of the research. Finally, the structure of the thesis is presented.

Related work on play

Designing for open-ended play brings together a number of disciplines. Theories of play are interwoven with literature on child development and design research on human-computer interaction and user experience. In this section we discuss related work, which served as a background for our research. We list related theories on play and discuss the role of play in children's development. Next, we focus on technology and play and discuss previous work exploring interactive technology in play. We end this paragraph with a discussion of creativity and play.

CHILDREN'S PLAY

There is not one definition of play that includes all the views and experiences connected with it. As the work in this thesis focuses on designing playful designs for children, we will now give a non-exhaustive overview of theories on play that relate to children.

Play is a spontaneous and intrinsically motivated activity that enables players to create a temporary perfect world with its own boundaries and rules (Huizinga, 1955). Play is situated outside of everyday life and can totally absorb the players. It is a voluntary act with no direct benefit or goal. Players intentionally choose to be involved in play, mostly

for the experience of playing; a lusory attitude, as described by Suits (1990). Play differs from exploration (Hutt, 1976); while exploration focuses on how objects or persons function ("What can it/they do?"), play deals with what the player can do ("What can I do with this object or person?"). Play also differs from games with rules, as it is free from externally imposed rules (Rubin et al., 1983).

Children consider play to be, among other things, fun, active, spontaneous and unconstrained. For children, playing is also a way of practicing skills and exploring imaginary worlds (Acuff & Reiher, 1997). Play is essential in children's development and contributes to the cognitive, physical, social and emotional well-being of children (Goldstein, 2012). Different forms of play focus on one or more of these skills. For instance, physical play stimulates children's motor skills development. Examples of physical play include climbing, running and sliding, and games such as soccer or tag. Social play involves children playing together, in parallel or solitary. By playing together, children develop skills such as sharing, cooperating, expressing emotions and respecting each other's opinions. Cognitive play supports children in exploring and understanding relationships with the environment. Examples of cognitive play are problem solving, constructing and role playing.

Through play, children develop new skills and further strengthen and develop existing skills. For example, children practice their imaginative skills, their strength, their speed and their capacities to compete or to cooperate. When playing, children try out most recently learned skills and competencies (Bruce, 2001). They can express their imagination and be spontaneous and active, alone or together with other children or adults. Generally, children are intrinsically motivated to play; they explicitly 'choose' to play (Bruce, 2001). Through play, children also get to learn about themselves and the environment around them. Children enact real scenarios to help them process previous situations and emotions. Moreover, children rehearse future scenarios and adult skills in their play.

Children can play everywhere and with almost everything. Play spaces include homes, schools and neighborhood playgrounds. Research on play shows that children prefer playgrounds that include high degrees of challenge, novelty and complexity (Fjørtoft & Sageie, 2000). Children look for a variety of elements in school playgrounds (Titman, 1994): a place for doing (e.g. being physically active, finding challenges), for thinking (e.g. exploring, discovering), for feeling (e.g. belonging, ownership) and for being (e.g. personalization, privacy). Adults often favor neat and tidy playgrounds with shiny equipment, but children may not benefit from these kind of play spaces at all. Children prefer to manipulate their environment using loose materials and enjoy having the freedom to make their own constructions and making the environment 'their own', even if only for a short period of time (Malone & Tranter, 2003).

Children often play with tangible toys. For children, anything can serve as a toy: a stick

in the woods, a stone found on the path or elastic rubber bands. Toys can be defined as tangible items used for play (Kudrowitz & Wallace, 2010). Some of the earliest designed toys were developed by Froebel and Montessori (see: Zuckerman, 2010). More recent examples include miniature cars, dolls and building blocks. Toys may suggest in which ways children should play with them, but there are no rules or limitations bounding their use (Magerkurth et al., 2005). Toys do not have a concrete aim which means that playing with a toy is not focused on a particular outcome but rather on the activity itself (Gielen, 2010). In this sense, toys differ from games which have a clear goal that players aim to achieve and toys do not share the competitiveness of games (Polaine, 2010). The pleasure of playing with toys is in the playing itself.

Concerning theories on play, play has been examined in different ways. Earliest theories on play focus on the reason for play to exist. For example, the surplus energy theory (Spencer, 1873) discusses the main reason for children to play as a means to eliminate surplus (excess) energy. Although a lot of researchers and developmental experts reject this theory, many playgrounds have been designed supporting this view. A contrary theory is the relaxation theory (Patrick, 1916) which claims that children actually recharge energy in play.

Modern perspectives on play attempt to explain the content of play focusing on children's development. Two well-known theories are developed by Jean Piaget and Lev Vygotsky.

Piaget (1962) believed that children learn and develop through active engagement with the environment, with play having a strong influence on this development. Children construct knowledge by experiencing and interacting with the environment. In this way, learning is a continuous process of adaptation to the environment, with children taking new knowledge from this environment and adapting this knowledge to fit with previously developed understanding. Piaget furthermore describes children's development in a series of stages that all children go through in the same order (ages by approximation): the sensorimotor stage (0 to 2-year olds), the preoperational stage (2 to 7-year olds), the concrete operational stage (7 to 11-year olds) and the formal operational stage (11+ year olds). Other scholars have criticized Piaget's work for being more theoretical than empirical and for not taking social context into account (e.g. Berk, 2002). In contrast, Vygotsky (1976; 1978) focused on the social context in which children's learning occurs. He observed that social support from adults and peers helps children in completing tasks before they can complete them on their own. When children can complete a task with such social support (or scaffolding), they are in the zone of proximal development. Play can create such a zone as: "*In play a child behaves beyond his average age, above his daily behavior; in play it is as though he were a head taller than himself*" (Vygotsky, 1978, p. 102). Although these theories illuminate different perspectives, both clarify that play is beneficial for children and that through play activities children move forward in their development.

The main body of research presented in this thesis concentrates on children in the age range of 6-8 years old, though we also present design cases targeting a younger or older age groups. Therefore, we decided to make three personas (fictional characters) that represent children from various age groups (see next page).

The personas show diversity for the different age groups concerning play and their likes and dislikes. At around the age of six or seven, children's play changes in several ways, causing the age group of 6-8 years old to be an interesting and challenging group to design for. Children become more involved in social play and move from fantasy-oriented play towards more realistic and competition-minded play (Acuff & Reiher, 1997; Kompan, n.d.). Older children (6+) are still involved in fantasy play, but with more structure, realism and details (e.g. richer texts, more contoured scripts, more organized plots) than younger children (Johnson, 2006). Younger children (4-6 years old) are mostly self-centered and impulsive, enjoy running and moving around, and are mainly involved in parallel play (Acuff & Reiher, 1997; Kompan, n.d.). Children from the age group 6-8 actively push away from childish concepts associated with the earlier period (Acuff & Reiher, 1997). They become more interested in complex and challenging forms of play. Children aged 4-7 years old start to play games with rules. By 4 years of age, many children can play games with a set of simple rules. Games with rules become especially important for children in the ages 7-11 years old (Piaget, 1962). 6 and 7-year old children still enjoy playing simple games, but around the age of 8 children have developed their strategy skills and want to apply them in games with rules (Johnson, 2006). Older children enjoy structured competitive play in larger groups. From the age of 6 or 7, children move from being largely self-centered to peer-oriented and start to become more interested in playing together with other children (Parten, 1932; Acuff & Reiher, 1997). Competition becomes stronger, as children want to figure out what they are good at and how this compares to others (Acuff & Reiher, 1997). Play environments for this age group should thus be appropriate for large groups, be dynamic and persuade children to be active (Kompan, n.d.).

To summarize, research shows that play is beneficial for children as play allows them to develop various valuable skills. While children develop, play changes. In this thesis, we focus on children of 6-8 years old. These children enjoy physical and social play and start to play games with rules. We will examine these characteristics of play in the next chapters.

TECHNOLOGY AND PLAY

Today's children are growing up with technology all around them. The last decade, Child Computer Interaction has become an important area within Human Computer Interaction (Markopoulos & Bekker, 2003; Read & Bekker, 2011). Read & Bekker (2011) propose the following definition of Child Computer interaction: "*a study of the Activities, Behaviours, Concerns and Abilities of Children as they interact with computer technologies, often with the intervention of others (mainly adults) in situations that they partially (but*

TOMMY

Tommy is a 4 year old boy. He likes rough-and-tumble play such as running, jumping and romping around with his father. Tommy looks up to his older brother, who is already learning to read and write and who always beats him in a game of basketball. Tommy is impulsive and changes rapidly from one play activity to another. In the back garden, Tommy often plays near the little shed where there is a large apple tree. He pretends this is a magical place where wizards fight with scary monsters. When he plays with the boys from his street, they usually go the neighborhood playground where they play with the swings or construct castles in the sandpit.

LOUISE

Louise is a 7 year old girl. Her favorite toy is her hula-hoop. Louise spends a lot of time with her two closest friends. They sing songs together and imagine they are super stars. They also gossip a lot about the boys from their class. Louise has a crush on Adam, but all he wants to do is to play soccer with his friends. Louise is a sporty girl; she plays volleyball and often goes to the swimming pool with her parents and sister. When she has a volleyball game, she gives everything in order to win. On Sundays, Louise enjoys baking cakes or cookies together with her mom.

JOEY

Joey is an 11 year old boy. He does not 'play' anymore, but rather hangs around with his friends. Most of the time they play video games inside. Joey likes playing the game Minecraft the best. They sometimes go outside to play soccer and debate about the rules for a long time. They divide themselves into two teams and as Joey is not so good in soccer, he often gets the role of goalkeeper. Joey considers girls to be stupid, especially his younger sister Gracie. She often challenges him and then starts to cry, so that his parents blame Joey as he should be wiser as the older brother.

generally do not fully) control and regulate". Hourcade (2008) summarizes important design principles concerning interaction design and children and identifies several research trends within this field such as supporting creativity and problem solving and supporting children with special needs.

Technology is also becoming more present in children's play. Children enjoy playing with tablet applications, video games and smart toys such as augmented toy environments and electronic pets. These new designs, as from now on referred to as 'digital toys', combine the best of both worlds: the strengths and attractiveness of traditional toys and the possibilities computers and electronics have to offer (D'Hooge et al., 2000). With interactive technologies, children are offered additional features in their play such as feedback and control (Kafai, 2006). Interactive technologies can respond to children's interactions and allow children to be in control of the flow of their gameplay through their own interventions (Kafai, 2006). Play objects that exhibit behaviors do not kill children's imagination, but capture it in novel ways (Ackermann, 2005).

For designers, designing digital toys is an even greater challenge than designing traditional toys (D'Hooge et al., 2000; Hinske et al., 2008). Digital toys consist of aspects from traditional toys as well as novel interactive aspects. Designers thus have to take into account many factors such as form and affordances, game and interface, hardware and software. Rather than adding interactive technology to existing toys (e.g. adding sounds to a cuddly toy), designers should create new forms of play enabled by technology that deliver enhanced play value to children (Shwe & Francetic, 1999; D'Hooge et al., 2000). And even more, rather than controlling and directing children's play and leaving less to the child's imagination, digital toys should support and encourage children's creativity in open-ended ways by creating designs for open-ended play only limited by the child's imagination (Shwe & Francetic, 1999; D'Hooge et al., 2000; Cassell & Ryokai, 2001).

Previous work has explored designing for technology and play in a variety of ways including toys, playgrounds and games. For example, Hinske et al. (2008) provide some initial guidelines on integrating technology into toys: provide added value through technology; technology should stay in the background; design for implicit interactions; and strive for robustness in the presence of failures. Sturm et al. (2008) lists key issues for designing interactive playgrounds that stimulate children to move and play together: social interaction, simplicity, challenge, goals and feedback. In their work on Head Up Games (HUGs), which are active outdoor pervasive games that do not require focus on a screen, Soute et al. (2010) defined four characteristics that set HUGs apart from other pervasive games, namely: social interaction, physical activity, flexible and adaptable rules, and fun. Deen (2015) examines the motivational elements in educational games, focusing on the support of autonomy. This results in the Applied Game Design Model in which the learning content is integrated with the game mechanics, approaching both learning and gaming as a restructuring practice.

Overall, playing with these new kind of toys does not replace older, traditional forms of play but rather digital toys add to the range of play options available to children (Goldstein, 2011; 2012), creating whole new worlds for play (Scarlett et al., 2005). In this view, we are interested how we can design interactive play designs to enable children to play with digital toys in a creative, social and open-ended manner. Therefore, the research in this thesis aims at developing interactive prototypes and evaluating them with children to explore how children play with open-ended play designs.

CREATIVITY AND PLAY

In our research, we are interested to engage children to play with interactive technology in a creative manner. Creativity is commonly viewed as a valuable skill for children, which supports them in exploring the world and preparing for adulthood. Especially for children growing up in this 21st century, creativity is an essential to succeed and be satisfied in the future. As the world around us is changing more rapidly than ever before, children must learn to deal with constant new issues and challenges. They have to be able to think and act with a creative mindset to manage unexpected problems. In the last years, creativity is gaining more attention in the field of interaction design and children (e.g. Bevans et al., 2011; Hsi & Eisenberg, 2012; Decortis et al., 2013; Chu & Quek, 2013). Creative thinking is as an iterative process of coming up with own ideas, experimenting with them and generating new ideas from this (Resnick, 2007). These ideas are often related to making new things in the world and improving ideas in your head, which inspires to make new things. Making things does not only involve physically constructing things such as building a robot, but also involves baking a cake, writing a short story, or inventing a new game.

Play offers an opportunity for children to develop their creative abilities. Creativity is in many ways present in children's play, for instance in inventing their own rules during a game of hide-and-seek or creating stories with their dolls. Different forms of play can include aspects of creativity, for instance construction play and fantasy play.

Construction play is considered a purposeful activity that teaches children how to cope with the physical world (Zuckerman, 2010). Several toys have been specifically developed for construction play, supporting activities as (re)building, disassembling, decision making and structure planning. An important figure in the history of construction toys is German educationalist Friedrich Froebel (1782-1852) who was the founder of the Kindergarten (1837). He was also a designer of construction toys (wooden blocks) and his building kits played a central role in the Kindergarten system. Modern designs are inspired by Froebel's design principles, for instance LEGO and Cricket devices (Resnick, 2007). Cricket devices are tools that children can use to create their own interactive projects. These small devices are programmable which allows children to stimulate their imagination and make a wide range of devices that move, play sounds or light up. Fantasy play supports the creation of stories and enables children to enact situations from the real world. An example of an interactive design for storytelling is the StoryMat (Cassell &

Ryokai, 2001). This design is a soft playing mat that children can sit on and use to tell their own stories together with their stuffed animals. The mat records their stories and recalls previous ones using sound and animations. In this way, a child playing on the StoryMat can become inspired by stories from other children and expand his or her imagination.

We are interested in strategies for designing interactive play objects that encourage and support creativity. Our research focuses on exploring interactive technology that helps children to develop as creative thinkers by allowing them to 'make new things' while involved in play, such as inventing games and rules, moving objects around and constructing things, and interact with peers in different ways. In this way, children re-invent their play and make it their own while trying out the possibilities the design offers them. We plan to take along these qualities of creative play in our empirical user studies.

Research context

The work presented in this thesis is conducted within the I-PE project (Intelligent Play Environments). This project is funded within the Creative Industry Scientific Programme (CRISP), which is supported by the Dutch Ministry of Education, Culture and Science. The project involves two universities (TU Eindhoven and TU Delft) where research is carried out in collaboration with a number of creative and/or industry partners: Kompan, Almende, Innosportlab Sport en Beweeg!, Driessens & Verstappen, Sports & Technology and the Patching Zone.

The aim of the CRISP program is to generate knowledge, tools and methods that can support designers in developing intelligent and user-centered Product Service Systems (PSS). PSS is described by the CRISP program as "*a systematic combination of tangible products and intangible services*" (see also www.crispplatform.nl). PSS design and development is a complex process as partners from different fields have to collaborate to achieve a product-service combination which provides a highly satisfying user experience. The CRISP program consists of eight projects that are categorized as either foundational projects or inspirational testbeds. Together these projects result in fundamental knowledge as well as initial validation of results in application oriented contexts. The I-PE project is one of the inspirational testbed projects and aims to investigate how to design PSSs for interactive play environments.

Each project within the CRISP program has strong connections with the creative industry, which enables discussions between scientific and creative partners as well as joint development of innovative designs and immediate dissemination of knowledge, tools and methods to design practitioners. For example, in the I-PE project we collaborate with a number of creative and/or industry partners, such as Kompan, a manufacturer of playground equipment, and the Patching Zone, a media lab for professionals and students focusing on creative social innovation.

The I-PE project aims at developing fundamental knowledge, insights and guidelines for the design of intelligent play environments. These environments are designed to stimulate social and physical play among children. The project examines how such an environment should be designed to present appealing play opportunities. The interaction opportunities are designed in an open-ended manner to encourage players to interpret the possibilities in their own manner and improvise during play. We are interested in understanding how to design for emergent play, i.e. play that emerges from interaction between the design and the users. Also, a decentralized approach has been taken to examine whether we can design a play environment that adjusts to changes in the play context, such as the number of players or the configuration of play objects. The research in the project is carried out in three sub-projects. The first sub-project explores how user experience can be measured through the use of an interactive experience assessment tool. The second sub-project focuses on the development of a decentralized platform that supports the emergence of a rich variety of play activities. The third sub-project, which corresponds with the research presented in this thesis, aims at developing design knowledge on how to design interactive, open-ended play environments for children. The three sub-projects are connected to each other which results in collaborative outcomes such as prototypes and studies (with separate focus angles) and the development of an overarching framework and design tool. For example, we developed the design prototypes of FlowSteps and GlowSteps (two different versions) together with the researchers of the second sub-project. In team meetings we brainstormed about ideas and concepts and discussed possible interaction behaviors. The two PhD researchers on the sub-projects further developed and programmed these interaction behaviors and made the physical prototypes including the electronics. The PhD researcher working on the second sub-project had a leading role in this. In this thesis, we discuss the outcomes from the perspective of designing for open-ended play (the third sub-project).

The research discussed in this thesis is carried out within the education and research theme of 'Playful Interactions' at the Department of Industrial Design, Eindhoven University of Technology. Within this theme, design professionals and scientific staff work together in educating students towards becoming the designers of the future. Carrying out research in this theme entails being involved in student projects and other theme activities such as expert meetings and feedback sessions with students as well as discussions and strategy meetings with fellow staff members.

Research objectives and approach

In this thesis, we aim at exploring how to design for open-ended play with interactive objects. In order to deal with this challenge, we are motivated to study how children interact with designs for open-ended play and to translate these findings into design knowledge applicable for designers. Please note that in the scope of this thesis with the term 'open-ended play' we mean open-ended play with interactive objects, unless

clearly stated otherwise. Our research addresses several objectives. On a high level, the research presented focuses on two main research questions:

1. What happens when children are involved in open-ended play with interactive objects?

2. How to design interactive, open-ended play designs for children that stimulate creativity and social interaction?

The first question is concerned with the concept of open-ended play and how children behave in open-ended play environments. We aim to explore open-ended play in detail to gain a better understanding of open-ended play and how it relates to creativity and social interaction. We believe open-ended play offers children the possibilities to behave creatively by inventing their own rules and games and provides opportunities for social interactions such as negotiation, competition and cooperation. The second question concentrates on the activity of designing for open-ended play and attempts to generalize how designers can be supported in creating meaningful and engaging open-ended play designs, focusing on specific aspects such as rules, social interaction and prolonged play.

Related to the chapters of this thesis, we formulated a number of sub questions touching upon the main research questions:

- *How to define and position open-ended play?*
- *How can designers consider open-endedness during the design process?*
- *What types of rules occur in open-ended play and how to design for them?*
- *How to support designing for open-ended play with a design tool focusing on the dynamics of interaction?*
- *How do children play on the long-term with an open-ended play design and how to design for that?*

In our work, we focus on open-ended play that emerges from interactions between players (children) and interactive objects. Within the research project of which the work described in this thesis is part of (see previous paragraph on Research context), we have developed a framework that visualizes the different relations in open-ended, interactive play environments (see also Rijnbout et al. (2013)). This framework (see Appendix A) has two levels with various elements. The lower level consists of the players, the designed objects and their interaction opportunities. The higher level consists of the dynamic behavior and emergent properties of the system, the stages of play and development of meaning, and the user experience. This framework provides an overview of important elements and their relations and combines the areas of play, interactions and emergence. The framework aims to explore the relationships between design decisions on the lower level and the effects they have on the elements of the higher level. The research presented in this thesis is mostly concerned with the relations between the design decisions in the lower level and the stages of play and development of meaning that occur in the higher level.

This thesis follows a design research process in answering these questions using both theory and empirical studies (see Figure 1.1). This process has similarities to the iterative research process consisting of a theory cycle and a use situation cycle as proposed by Stolterman & Wiberg (2010). In their approach, interaction design research has two goals with the primary being to support theoretical development (theory cycle) and the secondary to support the context of use (use situation cycle). Our design research process results in a variety of outcomes such as scientific papers, interactive prototypes and design knowledge and tools. These outcomes can be divided into theoretical and practical contributions. On a theoretical level, this research provides improved knowledge on open-ended play and relates it to aspects such as designing for children, creativity, social interaction and rule creation. On a practical level, this research illustrates how this theoretical knowledge can be translated to interactive, open-ended design prototypes. Furthermore, we present design knowledge in the shape of models and guidelines that support designers in the process of developing open-ended play designs.

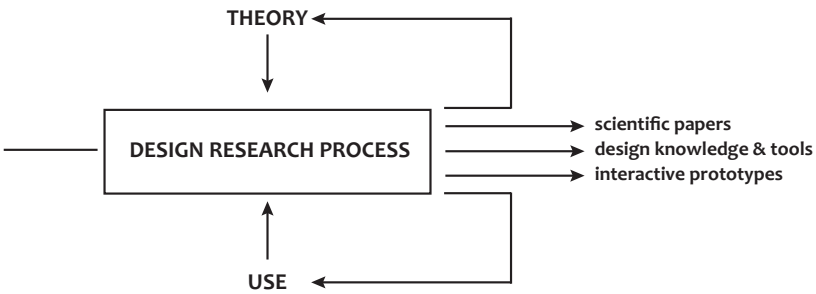


Figure 1.1 Design research process and outcomes of this thesis.

In order to come to these contributions, we applied a particular design research approach. Overall, the work in this thesis is carried out in an iterative manner, following a research through design approach (Zimmerman et al., 2007) in which we aim to generate scientific knowledge on how to design for open-ended play by creating and evaluating prototypes in various iterations. In our research, we designed and evaluated design prototypes of interactive play environments to explore the concept of open-ended play with children in real-life settings. These design prototypes are not finished commercial products, but developed to answer our research questions on designing for open-ended play. Research questions and directions were based on progressive insights derived from findings of earlier iterations, as is common in research through design. Qualitative methods were used to analyze the different results. In this way, we were able to explore how different design decisions concerning open-ended play worked out in context. This kind of evaluation in the real context of use is typical for research through design (Fallman, 2007). We believe the research through design approach is suitable for our research on open-ended play, because both the context and the users who interact with an open-ended design influence how it is used, as the interaction opportunities are

intentionally left open to interpretation by the users who are interacting with the design in context. Open-ended play starts to happen with particular users in a particular context and needs to be evaluated in this setting in order to understand it and to translate findings to design knowledge. We combined these research through design iterations with a number of additional design research activities such as literature studies, design reflections and post-hoc analyses of design cases. This enabled us to focus on a specific part of the play experience and to gain more insights into the design process.

In particular, in this thesis the following methods and studies were used:

- Literature study on positioning open-ended play in relation to existing literature on play and games (Chapter 2).
- Design analysis of existing open-ended play designs developed by design researchers around the world (Chapter 2).
- Interview study with students from our department reflecting on their design process (Chapter 2).
- Post-hoc analyses of design cases featuring our designs as well as designs developed by students of our department (Chapter 3, Chapter 4 & Chapter 5).
- User evaluations of innovative interactive prototypes, developed as part of our design research, with children (Chapter 5 & Chapter 6).

Structure of the thesis

This thesis is divided in three main parts, each containing one or two chapters. See Figure 1.2 for a visual overview of the structure of this thesis.

In the **first part** of the thesis we work towards a design approach for open-ended play. This part aims at defining, positioning and demonstrating open-ended play to develop an improved understanding of the concept of open-ended play in the context of interactive play environments. The first part consists of two chapters:

In Chapter 2 we introduce open-ended play by positioning it to existing literature on play and games. Open-ended play relates to a number of classifications by scholars from different backgrounds, including game design, interactive art and sociology. We continue with providing a definition of open-ended play. Next, we give a selective overview of interactive designs for open-ended play and analyze various design parameters in order to explore relevant design decisions for open-ended play. Lastly, we concentrate on the process of designing for open-ended play. Through interviews with students who experienced designing for open-ended play, we identify three essential actions in the design process: defining the design space, choosing what to design and what not, and early and frequent user confrontations. We present these actions and their position in the time frame of an iterative design process.

Chapter 3 discusses the relevance of rules in open-ended play. When designing interactive play designs, designers need to be aware of the role rules have in play. We present a division into two different types of rules for open-ended play: interaction behavior rules (behavior that a designer programs into a play object) and created game rules (rules players invent in the context of play). Open-ended play designs offer simple interaction behavior rules that players interpret and improvise with to develop game rules and meanings during play. We illustrate these different types of rules in two design cases and discuss related implications for design.

In the **second part** of the thesis we present the Stages of Play model, a design tool developed to support the process of designing for open-ended play. This model divides the experience of interaction into three stages: invitation, exploration and immersion. In the invitation stage, potential users are attracted to the design. In the exploration stage, they are supported in trying out different actions and building up their understanding of the design. In the immersion stage, the design aims at keeping the users engaged in the actual play experience. The content of the two chapters that belong to this part is as follows:

Chapter 4 describes the Stages of Play model, including our motivations for development and the relation to other models that describe interaction dynamics. Furthermore, this chapter discusses various applications of the Stages of Play model by designers, emphasizing the variety of uses and values the model can have. We carry out a post-hoc analysis of four design cases in which Industrial Design students applied the model in their design process. This analysis leads to a better understanding of different ways in which the model can be used, including for design, reflection and analysis.

In Chapter 5, we further explore the Stages of Play model by focusing on one particular aspect: social interaction. Open-ended play often occurs in social contexts in which children play together and negotiate about rules and meanings. By analyzing two design cases, we examine how social interaction develops through the three Stages of Play and how this knowledge can support designers in developing open-ended play designs for a social context.

The **third part** discusses how children play with an open-ended play design over a longer period of time and presents implications for design for prolonged open-ended play. This part consists of one chapter:

Chapter 6 describes a user evaluation on prolonged use of an open-ended play design. In this study, children are invited to play with the open-ended design GlowSteps for a period of ten weeks. Analysis of observational data focuses on three perspectives: interpretation and improvisation, Stages of Play and types of social play. Overall, observations show that children continue to play enthusiastically with GlowSteps over time and integrate various created rules and meanings, which demonstrates that open-

ended play remains pleasurable and interesting over time. We translate these insights to implications for design that support designers in creating open-ended play designs for prolonged use.

Finally, Chapter 7 presents the conclusions of our research, summarizing the main contributions, discussing the important insights and proposing directions for future work.

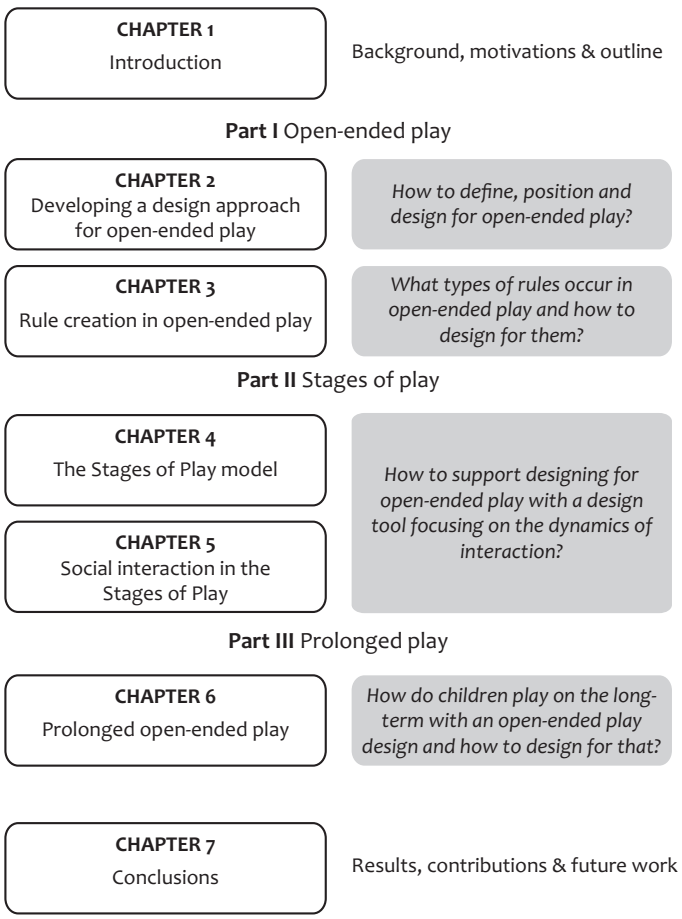


Figure 1.2 Thesis outline.

PART I:
OPEN-ENDED PLAY

2

Developing a design approach for open-ended play

ABSTRACT So far, designing for interactive, open-ended play has been mainly investigated in small-scale studies, which resulted in some first steps in understanding aspects of open-ended play. In order to fully ground this concept and its important aspects, this chapter discusses open-ended play in more depth, working towards a design approach for open-ended play. First, we position open-ended play in relation to other literature on play and games and present a definition of open-ended play. Then, we discuss and compare a number of existing interactive designs for open-ended play in order to understand relevant design parameters and accompanying design decisions. Lastly, we discuss the design process of open-ended play. In order to explore how designers consider designing for open-ended play during their design process, we performed an interview study with six students of our department of Industrial Design who recently worked on projects on designing for open-ended play. By reflecting on their experiences we are able to identify three essential steps in the design process of open-ended play, namely: defining the design space, choosing what to design and what not, and early and frequent user evaluations. We present these steps and their position in the time frame of an iterative design process.

This chapter is based on:

Valk, L. de, Bekker, T., Eggen, B. (2013). Leaving room for improvisation: Towards a design approach for open-ended play. In Proceedings of International Conference on Interaction Design and Children (IDC 2013), ACM Press, 92-101.

Introduction to this chapter

The concept of open-ended play combines the qualities of free play with the integration of interactive technology. Free play is an important form of children's play that is described as play that is not initiated by somebody else (e.g. adults) but that provides children with the freedom to choose themselves what to do and how to do this, when to stop and to try something new (Santer et al., 2007). Children are creators of their own play, using whatever toys or (natural) props they prefer. Free play is considered an important learning experience for children. Through free play, children develop various skills and increase their understanding of the world around them (Santer et al., 2007). Children engage mostly in outdoor free play in the yard at home, at their own street and at local parks or playgrounds (Veitch et al., 2010).

In open-ended play, we are interested in developing designs that provide children with interaction opportunities that they can attach their own meaning to and create challenges and goals with. Designs for open-ended play can be toys, props or large-scale playgrounds. In this thesis, we focus on tangible play objects that include digital technology in the shape of sensors and actuators programmed with simple interaction behavior to determine how a design invites, acts, responds, continues, etcetera. With this interactivity, players invent their own game rules, situated in context.

This deliberate freedom in interpretation for players makes designing for open-ended play a difficult design goal. The structure of the play activity develops during interaction in context, which means that designs for open-ended play should have simple interaction behavior rules supporting players in constructing their own game play *while* they are actually playing instead of providing *predefined* goals and rules. This relates to the theory of situated action (Suchman, 1987): people do not structure their activity beforehand but attach meaning in situated interaction.

For a couple of years now, several international researchers have been working on designing for open-ended play. For instance, open-ended play has been discussed as a design value for designing playful interactions (Bekker et al., 2010a) and the influence of multi-modal output on open-ended play has been evaluated (Hopma et al., 2009). Moreover, several designs for open-ended play were developed and studied, including handheld designs (Iguchi & Inakage, 2006), body attributes (Rosales et al., 2011), musical designs (Creighton, 2010) and interactive playgrounds (Sturm et al., 2008).

In discussions with other researchers, we have realized that it is a challenge to design for play that is less predefined and to communicate how to deal with this process to others. Also from experiences of designing for open-ended play ourselves and coaching students in this, we have found that the open-ended qualities of interaction can actually hinder the design process as designers experience difficulty in making design decisions on how to provide opportunities for users to invent their own play.

To improve our knowledge of open-ended play and how to design for it, the next step is to develop a more clearly defined design approach for open-ended play. With this design approach we aim to generate design relevant knowledge consisting of an enhanced definition of open-ended play and guidelines for the design process. Therefore, we performed a number of complementary activities that we will discuss in this chapter. Firstly, we ground the concept of open-ended play in literature on play and games aiming at a better positioning and understanding of the concept of open-ended play. Secondly, we discuss eight existing open-ended play designs, developed by several research groups around the world, to examine important design parameters of open-ended play objects. Thirdly, we explore the process of designing for open-ended play by interviewing students and letting them reflect on their design process. Together these activities result in a model illustrating our design approach for open-ended play.

Positioning open-ended play

This section examines how we can position open-ended play relative to existing literature on play and games. Several scholars have discussed classifications of play and games, often based on a component of freedom and flexibility. These scholars represent a variety of backgrounds including game design, interactive art, improvisational music and sociology. They look at play using different lenses; some discuss their work in relation to interactive designs, while others focus on play in general. This is illustrated by the definitions and characteristics of play that they offer. Below, we will discuss a selection of these works, using the well-known play classification of ludus and paidia (Caillois, 1961) as starting point.

In his work on play and games, philosopher and sociologist Caillois (1961) made a distinction between two opposite forms of play: ludus and paidia. Ludus is structured, rule-bound and goal-directed play while paidia is unstructured and spontaneous improvisational play. Ludus refers to solving a particular problem for personal satisfaction and concerns games such as chess, hide-and-seek, sports games and bets (e.g. holding your breath or trying to stare longest without blinking). In ludus, rules are very important; they should always be obeyed, no matter if they are invented or part of the official game. Normally ludus leads to the development of a special skill, fulfilling a certain achievement or acquiring a feeling of satisfaction. Paidia does not have such a clear outcome. Examples of paidia are spinning around to get dizzy, making somersaults, scribbling, or a child laughing at its rattle. Paidia is related to the need for disturbance or tumult, expressing itself in activities as holding up a queue, disturbing the work and play of others and endlessly cutting up paper with a scissor. In his blog on philosophy and digital game theory, game designer Bateman (2005) describes paidia as an amusing, creative and chaotic activity, but also short-lived as it soon becomes a game (and thus ludus). As an example of a paidia game he mentions ‘sink’; a natural play activity played close to a large body of water. The activity consists of throwing something that floats

into the water and trying to sink the object by throwing another thing at it. Bateman (2005) considers play as a journey from paidia to ludus and vice versa. For instance, when temporarily escaping from the rules of ludus, one can move back to paidia. To support paidia, no complex learning needs to be involved and players have to be encouraged to experiment.

This distinction between games (ludus) and free play (paidia) as proposed by Caillois (1961) helps to frame play more specifically. From this distinction, the balance between structure and spontaneity comes forward as an important element that determines if play is either ludus or paidia. More recent literature proceeds to investigate structure and spontaneity in play. In their book on game design, Salen & Zimmerman (2003) describe play as "*free movement within a more rigid structure*". Play takes advantages of the possibilities provided by a system's structure. Play elements create 'rules' that make free movement in play possible. Costello & Edmonds (2009) continue on this definition by making a distinction between directed and emergent play. They reflect on these two forms of play in the context of interactive art works and state that play designs should create a balance between directing play (rigid structure) and offering opportunities for play to emerge through the activities of the player (free movement).

Games are considered rule-based artifacts in which players aim to achieve a certain goal (Dormans, 2012). Juul (2005) gives the following definition of games: "*A game is a rule-based formal system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels attached to the outcome, and the consequences of the activity are optional and negotiable.*" In games, the rules set-up possible interactions and developers can control the sequence of actions by levels (Dormans, 2012). Juul (2002) prefers an emergence structure in games as this provides a balance between freedom of the player and control of the designer. The designer does not specify everything beforehand, though they can make the occurrence of certain actions very likely. Furthermore, in games with an emergent structure relatively simple rules can lead to a wide variety of game dynamics (Dormans, 2012). This underlines the relations between the basic components of a game (mechanics), gameplay (dynamics) and user experience (aesthetics) (Hunicke et al., 2004).

While games thus clearly require structure, rules and goals, free play appears to be less-defined. Nachmanovitch (1990) mentions free play as an activity of spontaneous free improvisation. Being a musician and improvisational violinist himself, he writes and teaches about improvisation and creativity. In his work he identifies two types of free play, namely Lila and Bricoleur. Lila means divine play and is a state in which players enjoy the simplest of things. Bricoleur (or Bricolage) is a state in which players spontaneously improvise with what the environment offers them. In their work on free play in open-ended interactive art environments, Morrison et al. (2011) define free play as "*non-narrative, non-competitive, and without logical ending point*". Play is kept alive as the

ending point continually evolves. This relates to Carse's (1987) work on finite and infinite games. The aim of a finite game is winning the game, while an infinite game is played only for the purpose of continuing the play. Morrison et al. (2011) mention the following two aspects of free play. First, it is constantly rejuvenated as it is co-constructed and co-authored by its participants. They are in control of discovering what the design has to offer them. Second, it is free from any predetermined order of meaning. People construct their own meaning and invent their own interpretations while interacting with the design.

In sum, the works discussed above represent various disciplines, resulting in a range of definitions and descriptions. As a first step to come to a general interpretation, we use the two forms of play proposed by Caillois (1961), games (ludus) and free play (paidia), as categories and added our own sub-categories to describe their different characteristics: process, outcomes, rule definition, rule creation, and experiences (see Figure 2.1). Although this thesis specifically focuses on designing interactive open-ended play designs for children, this figure does not yet make a distinction between different types of designs (e.g. games or interactive art works) or different user groups (e.g. children or adults). Instead, we aim at providing a general understanding of the differences between games and free play, in order to position the concept of open-ended play accordingly.

Games (ludus)	Free play (paidia)
Structure	Chaotic
Finite	Infinite
Fixed rules	Improvisation, spontaneity
Predefined	Own construction of meaning
Challenge, competition	Sensation of play, expression

Figure 2.1 Self-defined characteristics of games (ludus) and free play (paidia).

Concerning the position of open-ended play, Figure 2.1 displays games and free play as two distinct types of play. In fact there is a large grey space in between (see Figure 2.2), including less structured games and less chaotic free play.

Games (ludus)		Free play (paidia)
Structure		Chaotic
Finite	Open-ended play ⟷	Infinite
Fixed rules		Improvisation, spontaneity
Predefined		Own construction of meaning
Challenge, competition		Sensation of play, expression

Figure 2.2 Open-ended play in the grey continuum between games and free play.

Open-ended play can be positioned somewhere in this grey space between games and free play. At the start, open-ended play mostly resembles free play and its characteristics because little is predefined. But open-ended play can move either way: players can continue to play for the sensation of it (paidia) or they can move in the direction of games as rules and goals are developed (ludus). This is also true for free play in itself. Players are encouraged to use their own initiative to play spontaneously without, or with little, structure. This kind of play can eventually lead to a game with rules (ludus).

To summarize, open-ended play has less degrees of freedom than free play, but is still far removed from highly-structured games. Please note that in the field of digital as well as board games there can be large differences in offered degrees of freedom. For example, in some digital games (among others The Sims, Grand Theft Auto, Minecraft) players can freely wander around and decide themselves what they want to do while playing the game, displaying creativity and inventiveness (see also Dormans, 2012). In interactive open-ended play objects, the integrated technology (sensors and actuators) already provides some structure. Certain calibration values and action-reaction behaviors need to be set beforehand. Playing with these objects is not as open as non-interactive free play objects, but a lot less strict than games with fixed predefined rules. Based on the results of positioning open-ended play as well as our own previous experiences in designing for open-ended play, the following definition of open-ended play was formed:

> ***Open-ended play is play without predefined (game) rules in which players can attach meaning to the design properties and the interactions while playing. Its goal is to trigger a player's creativity and stimulate a variety of playful experiences by leaving room for interpretation so that players can play in diverse ways with an open-ended play design.***

This definition explains how open-ended play differs from games (there are no predefined rules) and what players are supposed to do (attach meaning) to what aspects of the design (design properties and interactions) so that the designer knows which design decisions have to be made in order for players to be able to play with the open-ended design. Moreover, the definition clarifies the overall aim of open-ended play (encouraging creativity and stimulating diverse playful experiences) and how this can be achieved (leaving room for interpretation). To further position open-ended play, we now zoom in on the characteristics in Figure 2.1 and 2.2 in more detail.

PROCESS (STRUCTURE - CHAOTIC)

Games often have a fixed structure that the designers defined beforehand. Players have to behave and move within the boundaries of this structure. Free play on the other hand emphasizes the freedom that players have when they want to play with anything at any time and location. In free play, changes within play are also encouraged, making free play a rather chaotic and dynamic process.

When involved in open-ended play, players experience a process that is less structured than games, but also less unpredictable than free play. Open-ended play purposively does not embrace the complete structure as offered in games, but also does not fully support the chaotic state of free play. Open-ended play somewhat restricts players in their play as it offers play objects in which designers enclosed certain design intentions. These intentions give some structure to the play process, but also leave room for unstructured play. The challenge for open-ended play is to develop designs that are specific and easy to understand but also general enough to encourage imagination and creativity in how to use them.

OUTCOMES (FINITE - INFINITE)

In general, games with rules aim at certain end goals that imply that there is a winner of the game. This is also part of the structure of the game, as described above. While playing a game, players expect a conclusion or a final act (Carse, 1987). They obey the rules to come to this achievement. When a game has ended, players cannot resume a game; they can only start a new (occasion of the) game. Free play on the other hand mostly resemble infinite 'games', in which the ending point continually changes in order to carry on with the play. This relates to the chaotic nature of free play in which play constantly changes and adapts. Players bend the rules while playing and their play is not bounded by time.

In itself, open-ended play is infinite as it does not contain a logical ending point. Players can fluidly begin interacting and playing with an open-ended design while constantly adapting their actions and related experiences. While involved in open-ended play, players can invent finite games including goals. Finite games can exist within an infinite game when players perceive these finite games as moments in their continuing infinite play (Carse, 1987).

RULE DEFINITION (FIXED RULES - IMPROVISATION)

Games include fixed or official rules that players have to follow to play the game. Defining these rules is not done by the player but is a task of the game designers, although players are free to add their own rules to a game, influenced by for instance the social context or the mood they are in. In contrast, free play supports improvisation and lets players spontaneously create their own play, unrestricted by any fixed rules. In free play, defining the rules is a responsibility of the players. They can decide not only on the content of the rules, but also on how many rules are applied and when they are used. In this process, players are influenced by their everyday experiences; they might have seen a television show with characters they want to act out, just as musicians are inspired by a tune they heard that day.

In our view, open-ended can be seen as a form of improvisation in which players create their own play spontaneously and with little preparation. Open-ended play designs actively encourage players' imagination by reducing structure and supporting different

rules and goals as well as different procedures or narratives. Related to the mechanics and dynamics discussed before (Hunicke et al., 2004), open-ended play aims at offering a small set of mechanics resulting in a large variety of dynamics, in which players enjoy a large freedom of interpretation. While involved in improvisational play, players are encouraged to share and agree on their mental models in order to feel like "*being on the same page*" and to achieve meaningful results (Fuller & Magerko, 2011).

RULE CREATION (PREDEFINED - CONSTRUCTION OF MEANING)

Supporting players in making up their own rules as they play is important as it gives players a feeling of control (Bruce, 2001). In games, players often combine invented rules with predefined rules developed by the game designers. Free play emphasizes on construction of meaning by the players. This means that little is predefined and players are encouraged to make meaning as one pleases. This relates to the act of improvisation as discussed in the previous section.

In open-ended play, construction of meaning is essential. Design decisions are made to offer diverse opportunities to which players can attach meaning. This meaning can result in rules and goals of play. As open-ended play designs are often used in a social context, it is important that the players' invented meanings correspond with each other. Amongst players, rules of play are mental concepts of which the understanding must be shared (Gray, 2009). When players are playing by the same constructed rules, this can lead to engaging play experiences.

EXPERIENCES (CHALLENGE & COMPETITION - SENSATION & EXPRESSION)

Games often embrace some element of challenge that provokes players and makes it more difficult for them to reach the end goal. This is sometimes made even harder by adding an element of competition. In this way, games aim at evoking playful experiences such as challenge and competition (Korhonen et al., 2009). In free play the emphasis is much more on the sensation of play and the ability for players to express themselves. Free play aims at stimulating playful experiences such as sensation and expression (Korhonen et al., 2009). In relation to this, Karoff (2013) mentions four play moods, which are different ways of being in play and concern how players engage with the world and other players and people around them. The four play moods are devotion, intensity, tension and euphoria. In devotion, players experience a feeling of being in a flow and continuously being in the moment. They are concentrated and focused in their play. An example of devotion is children who are playing with a set of LEGO blocks. Intensity relates to experiences of "*your bodily being as ready and excited for more*" (Karoff, 2013). This is especially the case in physical play situations on a slide or a swing. In tension, players are ready to show and express themselves and are aware of others doing the same. For example, when a group of girls is dancing together they share this mood and all are aware of the moves and style they express. Euphoria, lastly, is the most open-minded play mood. In euphoria, players experience an intensive expectation of silliness. Examples include water fights and teasing each other.

If we relate these experiences and moods to open-ended play, two aspects are important to mention here. Firstly, open-ended play aims at supporting a variety of play experiences and moods so that each player can decide which experience or mood they prefer, whether this relates to games or to free play. Secondly, open-ended play encourages players to shift from one experience or mood to another whenever desirable in order to create a natural flow in play with repeating and exceeding play situations.

Analyzing examples of interactive designs for open-ended play

In the previous section, the design space of open-ended play has been positioned in relation to games and free play. To further explore this design space, we use this knowledge from literature to take a closer look at a number of interactive designs for open-ended play and to examine relevant design parameters, resulting in design advice that guides designers in making design decisions.

In the last decade, several interactive designs for open-ended play have been developed by researchers around the world. In this section, we will give a selective overview of these designs. We have chosen a selection of eight interactive designs. These designs illustrate how open-ended play has been interpreted by various design researchers so far. The selection was made based on a literature search on interactive open-ended play designs. All designs were developed with a focus on children, which fits the focus of this thesis, but they differ in design intentions and contexts and show a wide range of applied interactive technologies. See Table 2.1 on the next page.

The eight designs are: Statue (Rosales et al., 2011b), FeetUp (Rosales et al., 2011a), Morel (Iguchi & Inakage, 2006), jogo (Creighton, 2010), Interactive Pathway (Seitinger et al., 2006), LEDtube (Bekker et al., 2010a), ColorFlare (Bekker et al., 2010a) and FlowSteps (Valk et al., 2012). The last three designs were developed in our department; the first five designs are from other research groups. Below, we will first briefly describe all the designs and then analyze them in comparison to each other.

DESIGNS FOR OPEN-ENDED PLAY

The following eight designs were part of our analysis.

Statue (Rosales et al., 2011b) is a fanny pack (hip bag) that reacts on children's movements by audio-visual feedback. The system only reacts on vigorous movements in the Y- and Z-axis. The fanny pack encourages children to play: "*Statue stimulates children to play games related with being a statue or moving without being noticed, which are commonly played by children, according to our ethnographical observations.*"

FeetUp (Rosales et al., 2011a) lets children play with gravity. The design consists of

Table 2.1 Overview of the interactive designs and their age group, design intention, technology and context.

Design	Age group	Design intention	Technology	Context
Statue	Children (ages 6-9 years old)	Encourage social & physical free play	Input: movement sensors Output: sound & blinking lights	Free play (parks, playgrounds, homes)
FeetUp	Children (ages 6-9 years old)	Encourage free play and practice social interaction skills	Input: pressure sensors Output: sound & blinking lights	Free play (parks, playgrounds, homes)
Morel	Players in general, with a special focus on children	Facilitate new forms of physical outdoor play	Input: pressure sensors in 'sender' Morel Output: sound & movement (launch) mechanism in 'receiver' Morel	Outdoor physical play
jogo	Children (ages 3-15 years old)	Encourage children to play and socially interact in a physically embodied sense	Input: sensors detecting position and color of ping-pong balls Output: sound samples	Public (indoor) play, such as during a play exhibition
Interactive Pathway	Children (ages 3-5 years old)	Enhancing the most basic playground activity: walking and running	Input: pressure-sensitive mats Output: spinning motors	Outdoor playgrounds
LEDtube	Children (ages 7-11 years old)	Stimulating social, physical and creative play	Input: rolling/shaking sensors Output: color of light	Public (indoor) play, such as in day-care centers
ColorFlare	Children (ages 7-11 years old)	Stimulating social, physical and creative play	Input: rolling, shaking and pointing sensors Output: color of light, flashing light, transmitting light	Public (indoor) play, such as in after-school care centers
FlowSteps	Children (ages 6-8 years old)	Stimulating social, physical and creative play	Input: pressure sensor Output: light 'behaviors'(red and blue)	Public (indoor) play, such as in schools

pressure sensors and lights and sound speakers embedded in children's shoes. As soon as the shoes are not in contact with the floor or any other surface (i.e. children are jumping) lights on the shoes start to blink and a sound sample is played. "*The system incorporates a simple rules system so that children have the opportunity to create their own system of rules, challenges and goals based on the basic, but consistent information they receive.*"

Morel (Iguchi & Inakage, 2006) is a soft, cylindrical object that can be kicked and thrown like a ball. When two Morels are in each other's vicinity, this is communicated by sound feedback. While other Morels are nearby, players can 'charge them up' by holding and squeezing their Morel. The other Morels will now respond with sound feedback, communicating that they are being charged up. When the charging comes to a maximum, the charger can squeeze once more to launch up the other Morels. "*Morel encourages the improvising of new games and behavior by not defining game rules on its own, but by providing players the ability to know the existence of other Morels in the vicinity, and to remotely make other Morels launch up in the air.*"

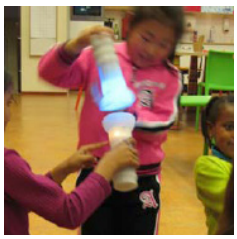
Jogo (Creighton, 2010) is a music generator consisting of a round tabletop and colored ping-pong balls. The play surface consists of four circles of sixteen holes dividing the surface into sixteen steps, each one representing one sixteenth note in a measure of music. The balls have five different colors which each represent another sample. These balls can be placed in the holes on the surface. Their position and color are detected and the corresponding sounds are played. "*Simplicity and ambiguity in the design aims to inspire and motivate free play.*"

Interactive Pathway (Seitinger et al., 2006) consists of two wooden beams with pressure-sensitive mats attached to the wood, creating a path for children to walk over. The mats control motors next to the mats. When children step on a mat, the corresponding motor starts to spin. In this way, the children are accompanied by the motors spinning one by one while they walk on the pathway. "*The diverse play patterns observed resulted from a simple design which enabled open-ended play patterns instead of predetermining any one or two activities.*"

The following three designs come as a series; insights of the first design LEDtube led to the development of the second design ColorFlare, whilst the lessons learned from both these designs led to the third design FlowSteps.

LEDtube (Bekker et al., 2010a) is a cylindrical shape emitting light at each end. It reacts to children's behavior by changing the color of its light (red, green or blue). Two versions were created: one changes color when it is rolled and the other when it is shaken. "[LEDtube,] *which had fairly limited interaction possibilities, was designed to explore whether players enjoy interacting with open-ended play objects.*"

ColorFlare (Bekker et al., 2010a) is based on the LEDtube, but with more interaction possibilities and more diverse output. While rolling the ColorFlare, it changes color. When shaken, it will start to flash. In flash mode, the ColorFlare can transmit its color to another ColorFlare in range. "*We increased the number of states to which the children can allocate meaning and thus support more diverse games, which may increase the chance that children enjoy playing with it over time.*"



FlowSteps (Valk et al., 2012) are interactive mats that react with light to children's movements. Two different colors of lights (red and blue) are used with different interaction behavior. Children can step on a light to catch it or move it around by stepping along on other mats. "*Children can decide themselves to play with the red or with the blue light. By giving meaning to the interaction opportunities, they can create their own game rules.*"

ANALYSIS OF DESIGN PARAMETERS

In order to explore the design parameters that play a role in designing for open-ended play, we analyzed the eight designs in reference to these dimensions. For this, we looked at the typical HCI model, which consists of a user (human) and an object (computer) interacting with each other through input and output devices (e.g. Hewett et al., 1996). If we translate this model to open-ended play, there are some important aspects to highlight. In open-ended play, designs can consist of multiple objects that can communicate with each other. Moreover, multiple people can interact with the objects simultaneously and communicate with each other while being involved in social play. Based on an initial comparison of the designs, we argue that the following three parameters describe important differences between the designs: output modalities, communication between objects and ownership of the objects. Moreover, the context of play adds formal game elements to the picture. We selected three formal game elements described by Fullerton et al. (2004): players, procedures and rules. Below, all six parameters will be briefly discussed.

Output modalities are part of the feedback from the design. This feedback can consist of one or multiple modalities. For example, Statue contains two modalities (audio and visual) while jogo has one (audio). When the design exists of multiple objects, there can

be a form of Communication between objects. In this way, objects can also influence each other. Ownership of the designed objects can be personal or shared among players. Players concerns if the design is intended for single-player or multi-player purposes. Players can have different roles and perform different interaction patterns as cooperative play or competition (Fullerton et al., 2004). Procedures describe the required methods of interaction. A design can require a sequence of steps (multiple actions) existing of several rules. For instance, ColorFlare incorporates a sequence: for transmitting a color, players first need to shake it so that it starts flashing before they can point it towards other ColorFlares to transmit their color. Rules are closely related to procedures and explain the allowed actions and how the design responds to that. Rules describe the interaction of the design which can consist of simple, cause-and-effect rules or more complex, multiple interaction rules. For example, FeetUp has one simple rule: if the shoes are not in contact with a surface, the lights on the shoes start to flash. Morel on the other hand has more complex rules, e.g. holding and squeezing a Morel charges it up and lets other Morels respond with sound feedback.

Table 2.2a Design analysis on players (vertical) and ownership (horizontal).

	Personal object	*Shared object*
Single player	-	-
Multi player	Statue, FeetUp, Morel, LEDtube, Colorflare	jogo, Interactive Pathway, FlowSteps

Table 2.2b Design analysis on interaction rules (vertical) and procedures (horizontal).

	No steps	*Sequence*
Simple rules	Statue, FeetUp, Interactive Pathway, LEDtube	-
More complex rules	jogo	Morel, ColorFlare, FlowSteps

Table 2.2c Design analysis on communication between objects (vertical) and modalities (horizontal).

	1 modality	*>1 modality*
No communication	jogo, Interactive Pathway, LEDtube	Statue, FeetUp
Communication	Colorflare, FlowSteps	Morel

As the tables show, the designs are not similar in their design parameters. Table 2.2.a classifies the designs relative to players (single or multi) and ownership (personal or shared objects). All designs are multi-player, i.e. they are designed for social play. This is illustrated by for instance audio-visual feedback that is visible or audible for all players and designs that consist of multiple objects that are distributed among several players. The majority of the designs consist of personal objects that are either attached to the body (Statue, FeetUp) or handheld tangibles (Morel, LEDtube, ColorFlare) that children can keep close to themselves. The shared objects consist of tabletops (jogo) and objects positioned on the floor (Interactive Pathway, FlowSteps) that create a shared play space.

In Table 2.2.b the designs are described in terms of their procedures (no steps or sequence) and rules (simple or more complex). The most 'simple' designs have no steps and only cause-and-effect rules (Statue, FeetUp, Interactive Pathway, LEDtube). These designs simply react on actions of the players, no matter if this is the first time a player performs a certain action or if it is part of a sequence of actions. In between is a more complex design (jogo) with multiple rules related to different aspects of the design (e.g. the holes in the surface and the color of the balls) but with no steps or sequence of rules. On the other end are three designs that consist of more complex rules and require a sequence of steps in their interaction (Morel, ColorFlare, FlowSteps). These designs include qualities such as rules that build on each other (e.g. first shake a ColorFlare to make it open for communication and then transmit its color to another object) and different interaction behaviors (e.g. the different colors of light of FlowSteps behave differently). This asks more from the players if they want to understand all the rules, but this also offers them more opportunities to play around with these rules.

Table 2.2.c lists the parameters of output modalities (one or more) and communication between objects. Most designs include only one modality (sound, light or movement). Most of them have no communication between objects (jogo, Interative Pathway and LEDtube) which means that players can play alongside each other without the objects influencing each other. Others support communication (ColorFlare, FlowSteps) as they include a communication protocol between objects which means that objects can influence each other (e.g. changing the color of another player's ColorFlare) or that output modalities spread over objects (e.g. moving active light of FlowSteps). The designs that have more than one modality are divided into no communication (Statue and FeetUp, which both include sound and light feedback but the separate object do not communicate or influence each other) and communication (Morel, which supports charging and launching other objects when they are in the vicinity). More modalities provide more opportunities for interpretation, i.e. more properties that players can attach meaning to and involve in their game play.

To summarize, these table shows that the design space of open-ended play offers a lot of freedom to move around in this design space. The described parameters show how different design decisions can lead to a variety of open-ended play designs. Statue,

FeetUp, Interactive Pathway and LEDtube are designs with very simple, one dimensional interaction possibilities. ColorFlare and jogo already offer more variety in their interaction possibilities but no or only a simple sequence to go through. Morel and FlowSteps have interaction possibilities that go through several steps, e.g. first action A and then action B in order to get to reaction C. The tables are not meant as an assessment tool, i.e. one design is not better than the other. This depends largely on other factors as the goal of the project, the context of use and the intended user group. Overall, it is important to note that, when designing for open-ended play, different design parameters should be considered, including: players, procedures, rules, modalities, communication and ownership. These parameters influence design decisions that can lead to various open-ended play designs. In this thesis, we present these parameters as relevant design knowledge for design researchers and practitioners. Also, the parameters help to position the open-ended play designs we developed to other existing designs as discussed above and to highlight their unique and novel characteristics.

Interview study

In the previous sections we discussed the concept open-ended play and examined relevant design parameters. As a next step we present an interview study on the design process of open-ended play in this section. The purpose of this study is to gather relevant insights on the design process and translate these insights to valuable design advice.

Many interaction design processes go iteratively through phases of establishing requirements, designing alternatives, prototyping and evaluating (Rogers et al., 2011). In several repetitions, the initial design is improved based on results from previous iterations. Preferably, this process is combined with a user-centered approach: users are involved throughout the design process (Rogers et al., 2011). These kind of iterative design processes are also typical in game design, and often include repeated moments of playtesting (Salen & Zimmerman, 2003; Fullerton et al., 2004). In order to evaluate the play experience of a game, this game must be played with actual players (e.g. children, teens, adults). We expect this to also be true for open-ended play; even more so as the game rules and goals are not set beforehand. Therefore, it is even more difficult to predict what will happen when users start to actually play with the open-ended play design.

In this section we examine the design process for open-ended play. In order to reflect on this design process, interviews were held with six Industrial Design Master students. They worked on recent Master student projects (hereafter called: design cases), all carried out at the Playful Interactions theme within the Department of Industrial Design, Eindhoven University of Technology over a period of two years. At this department, students perform design and design research projects. Most of these projects are based on a design brief provided by the department, most of the time in cooperation with

real-world clients and stakeholders. Students have a lot of freedom to give their own twist to the project. For instance, students can choose a specific target group or form of play to design for. All students have their own style and vision and their interpretation is key in our educational system (see also Bekker et al., 2010b). While the projects ran, the design approach for open-ended play was already growing and developing. Therefore, we provided the students of the projects described in this chapter with some preliminary insights and gave them various stimuli for their process. For example, the differences between games and open-ended play were discussed and literature on play and age groups was distributed. As the knowledge on open-ended play was developing in parallel, the information provided to each student was not identical. Moreover, because of this also the specific content of the design brief provided to the students changed.

Below, we will first discuss the methodology of this study. Then, we will describe the six design cases in more detail.

METHODOLOGY

The design cases were examined as follows. First, the project reports were reviewed, with special attention to the process and design rationale. Then, the students were interviewed individually. In these interviews, the focus was on the students' goals, vision and approach for the start, middle and end of the project. The interviews were semi-structured. Beforehand, we made a list of questions, based on our aim to explore how the students' design processes for open-ended play developed during the project. These questions were phrased in an open manner to stimulate discussion. We were interested to find out how the students started the project and how they determined their aim of the project; what changed during the project and why; what the result of the project was and how satisfied they were with this result; and what they would have done differently if they would do the project again. Moreover, we asked them about their experiences of designing for open-ended play; and how this changed over time in the project; what problems they encountered in this; how they made design decisions on the open-ended aspects; and what possible restricted them in this. Examples of interview questions are: 'What was the design brief at the start of the project?' and 'What went well and what didn't go well in your process concerning open-ended play?' See Appendix B for a full list of the interview questions.

All interviews were audio recorded and transcribed afterwards. Summaries of the interviews served as input for several discussion sessions among the researchers. In these sessions we talked about the results and their implications for the design process.

DESIGN CASES

During a period of approximately two years (2010-2012) several projects on the subject of designing for open-ended play were carried out by students of our department. From these projects we selected six Master student projects as design cases for this study. These cases were performed at different moments of the investigated time period and

therefore represent how students experienced designing for open-ended play while our corresponding knowledge was still under development (as the different design briefs discussed below show). Moreover, in these projects students went through at least one successful design (research) cycle including a user evaluation with children or teens. This provides us with relevant insights on the complete design process of open-ended play.

See Table 2.3 for an overview of the selected six design cases. One case (Bababa) was a short project involving two students. Another case (Wondrous Imagination) was an individual graduation project. These two cases were initiated by the students themselves. The other four cases were all individual projects defined by the department in a design brief. These four projects consisted of one design project (CoCones) and three design research projects (Shuffle, Cooil and Push/pedal car). The design briefs usually described the overall goal of the projects and, if applicable, their connections to previous work and current (research) projects, but it left opportunities for the students to find their own direction of interest. See also Appendix C.

Table 2.3 Overview of the six student projects.

Name	Type of project	Weeks (Year)	Initiative
Shuffle	Design research	10 (2010)	Department
Cooil	Design research	10 (2011)	Department
CoCones	Design	10 (2011)	Department
Push/pedal car	Design research	10 (2011)	Department
Bababa	Design activity	4 (2012)	Students
Wondrous Imagination	Graduation	24 (2012)	Student

The first design brief ('Shaping Play 2009-2010') focused on exploring the concept of affordances as a powerful tool to influence behavior of intended users in the context of an interactive playground. Students were challenged to engage children in physical playful activities. In this brief, open-ended play was not explicitly mentioned. The Shuffle project was carried out with this design brief. Instead of physical play, the student who worked on this design brief decided to focus on stimulating social play. From his recollection, the target group and the context of open-ended play were fixed from the start.

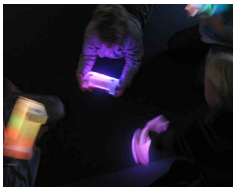
Continuing upon this first brief, the second design brief ('Shaping Play 2010-2011') has some similarities as well as some novel aspects. Similar to the first brief, this second brief focuses on interactive play objects, affordances and physical play. Moreover, the second brief explicitly mentions open-ended play and its aim to explore objects with multimodal input and output. The brief also gives more details with respect to models of analysis, such as framing, play scripts and physical movement analysis. The Cooil project was carried out with this design brief. The student who worked on this project adopted

the focus on open-ended play and multimodal feedback but decided to focus on social play instead of physical play. Furthermore, he chose a specific age group of children (5-8 years old).

The third design brief ('Creating Play 2011') was slightly different than the previous two design briefs. This brief was very open and indicated that the project can be tailored to students' personal development and interests. As a general aim for the project, the brief mentions creating appealing play experiences for specific user groups that elicit social and physical play. Moreover, different aspects and focus areas are discussed including playful experiences, social play, decentralized behavior and open-ended play. This is related to two current research projects, including the I-PE project which covers the research described in this thesis. Both CoCones and Push/pedal car are carried out with this design brief. These students also indicated that the design brief was very open. The student who worked on CoCones decided to work on one of his own ideas, namely encouraging respect in the classroom. The student who worked on Push/pedal cars started with the idea of a decentralized system.

Below, all projects are briefly described in chronological order. Please note that in each project a design was developed and evaluated with target users (children or teens).

Shuffle (2010) was a design research project by Koen Verbruggen. This project focused on stimulating social play among children. The design Shuffle offers children a personal device with which they can exchange colors of light with other players. Children need to negotiate with each other to get the desired color or help another child with achieving this.



Cooil (2011) was a design research project by Stephan Hoes. The goal of this project was to explore how multi-modal feedback can contribute to social play. A design called Cooil was developed that demonstrates different output opportunities depending on whether children play with the design together or whether they play with it alone.

CoCones (2011) was a design project by Patrick Leijte. His goal was to increase the value of respect among high school students. The project's focus was on designing objects to be used during gym class at high school. The design CoCones was developed: cone-shaped objects that react with light feedback on students' actions. The teacher can decide which games to play with the objects. For instance, when students run towards a cone and shake hands, the lights of the cone change to their group's color.

Push/pedal car (2011) was a design research project by Martijn Kors. The goal of the project was to investigate how cooperative play can be supported by adding an interactive system to an existing design. Push/pedal cars were chosen as an existing design and a system with tokens was added that indicated when children should change position or should find a new child to ride around with.

Bababa (2012) was a short project of approximately four weeks by Chris Gruijters and Gijs Houdijk. This was a learning activity initiated by the students themselves. The goal of the project was to make the old-fashioned ball pit more attractive by adding sounds. Interactive balls were developed that reacted on movement with sound feedback. Ten of these balls were put into a ball pit together with a bunch of normal balls. Young children played with the ball pit and tried to retrieve all interactive balls.

Wondrous Imagination (2012) was the graduation project of Gijs Houdijk. This project was initiated by the student himself, building on his previous projects concerning playful interactions. The goal was to create an immersive world that triggers children's fantasy. A carpet with abstract interactive objects was developed offering children the opportunity to direct their play with tools and puppets instead of being an active actor themselves.

Results

In this section we describe the results of the student interviews. We divided these results into two categories, described in the sub-sections below. This categorization emerged from the interviews. The first sub-section discusses relevant challenges and considerations when implementing the definition of open-ended play in design. In the second sub-section we focus on the design process of designing for open-ended play by presenting three important steps in this process.

IMPLEMENTING THE DEFINITION OF OPEN-ENDED PLAY

At the time of the interviews the positioning of open-ended play was carried out in parallel. Therefore, in the interviews with the students, we discussed an initial version of the definition of open-ended play, based on earlier work by Bekker et al. (2010a), which describes open-ended play as a process in which the designer does not defines rules and goals but instead creates interaction possibilities from which different types of play can emerge. We especially discussed the difficulties and challenges the students faced while applying the definition in their design process.

The definition of open-ended play mentions, among other things, that open-ended play does not include any predefined (game) rules. Actually, claiming that there should be no predefined rules, already defines a rule. But from the discussions with students it became clear that not all rules are similar. Students made a distinction between game rules on the one hand and interaction rules on the other hand. Game rules are rules related to the actual game play; for instance, how to reach a goal or how to gain extra points. Interaction rules, on the other hand, are rules for interacting with the design as input-output relations and affordances; for instance, shaking an object emits a certain sound. These interaction rules are similar to the rules described as one of the design parameters. In open-ended play, game rules may be left open, while some interaction rules have to be defined by the designer. For instance, Shuffle is designed to be a personal, individual object that children can hold in their hands. The U-shape of the design encourages children to place their Shuffle against another child's Shuffle, which activates the exchange of colors (interaction rule) that children can interpret as the goal being to collect all different colors (game rule). In the next chapter, we will investigate these different rules in open-ended play in more depth.

Adjusting the aspects of openness (ambiguity) and complexity is a key action in designing for open-ended play. Overall it is important that there is some ambiguity in output so that players can come up with their own goals and follow self-invented steps (rules) to reach these goals. When this level of ambiguity is too high (i.e. the design is too open), the design risks at not being a real design anymore. On the other hand, a design can soon become too complex when many opportunities for interaction are offered. Therefore, open-ended play should focus on finding a balance between ambiguity and complexity by providing structure but also possibilities for spontaneity. A design that is too structured prevents children from being spontaneous, but without any structure children are not able to be spontaneous. Some restrictions need to be set and some aspects need to be defined. Making these decisions can feel rather definitive, but they are necessary to be able to make claims related to the design, especially when performing design research. This refers back to the definition of play as "*free movement within a more rigid structure*" (Salen & Zimmerman, 2003), finding a balance between directing play and emergent play (Costello & Edmonds, 2009).

Context is another important factor that can help in positioning the design but that also limits it. For instance, when play occurs in an indoor room, players cannot throw balls or run as far as they would on an outside playground. CoCones is an example of a project that uses context as part of its structure. CoCones was specifically designed for the gym class and uses a familiar shape of this context in its design, namely cones. Bababa is also very context dependent. If the interactive balls were not part of a ball pit, but solitary objects to play with on for instance the school yard, this would probably lead to different forms of play. Instead of trying to discover the interactive balls in the collection of balls in the ball pit, their interactivity might be used while throwing or rolling the balls to each other. Wondrous Imagination showed that a design can also create its own context. The

play carpet serves as a context upon which fantasy stories can be developed.

Overall, the interviews made clear that when applying the definition of open-ended play in the design process, and most likely also the information in Figures 2.1 and 2.2, a translation of this knowledge to more concrete design knowledge, and eventually design advice, is needed. For example, there seems to be some nuances between having fixed rules (games) and having no rules at all (free play). Illustrative examples and design questions could further explain the subcategories. Moreover, other factors such as ambiguity and context need to be mentioned and thus considered as well.

DESIGN PROCESS

The interviews with the students made clear that designing for open-ended play asks for a somewhat adjusted design process. This required from students to first change their attitude on design and then to try to understand and decide how to design in this novel way. Students indicated that it took longer and was more difficult to make specific design decisions, as aspects of the design are deliberately left open. Therefore, especially the first design iteration lasted longer than in previous projects when design decisions could be made more easily based on theories or standards. Students needed time to learn how to work with ambiguity instead of getting rid of it as fast as possible. In open-ended play, user research methods such as user profiles and initial observations can help to make design decisions. For example, designers can formulate user profiles of children from a certain age group based on related literature, in order to understand a user's daily activities, interests and preferences. Initial observations of children's playground activities can provide a designer with strategies on how to stimulate certain forms of play. Design decisions can also be made based on a designer's vision that can direct the values a design encompasses or influence the choice whether to go for a tangible, a digital or a hybrid play design. In any case, students emphasized that it is extremely important to make these decisions and scope their projects; otherwise the design remains too broad, which can be a particular pitfall for open-ended play. Below, we discuss three steps that support this: defining the design space, choosing what to design and what not, and early and frequent user evaluations.

Defining the design space: For the students, the project usually started with further defining the design space. This included making decisions on context (e.g. outdoor playground), user group (e.g. 10-12 years old boys) and the overall goal of the design (e.g. stimulating physical play or encouraging social interaction). Most students did not have a particular play scenario in mind at the start of the project. Such a scenario usually arose after some initial observations or a first explorative user study. Some of the students worked with a specific higher-level goal, related to their vision as a designer. For instance, one student aimed at stimulating social behavior as he observed that society is becoming less social nowadays (Shuffle). Another student wanted his design to lead towards more respect among high school students (CoCones). Such design values were mainly used as an inspiration; the short duration of the student projects did not support

real validation of these values in the design. The students mentioned the design values also helped them in their thinking process: instead of focusing on details of the design and its interactions, designing for a certain value helped them in constructing the bigger picture in the project.

Designing for open-ended play particularly meant choosing a certain framing and exploring what happens within that frame. At the start of the project, students attempted to fix a number of factors in this frame. Next, they explored in various iterations which possibilities the frame offered and what was most interesting or suitable to work out or research further. The frame helped students to establish an environment for their design in which interactions could take place. For instance, the Bababa project focused on developing an interactive ball pit. The frame was thus a ball pit with a bunch of same-sized balls with different colors that children around the age of four could play with. Then, a designer's role is to decide on adding and removing certain aspects within that frame by tweaking the corresponding parameters such as ownership and output modalities. For example, the amount of balls can influence if a ball is considered to be a personal or a shared object (ownership) and each ball can react with only sounds or also lights or vibrations (output modalities).

What (not) to design: When designing for open-ended play, this must not be considered as 'just designing something' and assuming that children can come up with their own game rules and goals anyway. When designers do not work out certain design aspects, this decision should not be based on the expectation that children will interpret it anyway. Designing for open-ended play implies daring to take a risk, as one of the students put it. As a designer of open-ended play designs one does not know at the start of the project what the eventual outcome will be. A designer usually has some assumptions, but these assumptions can turn out to be wrong. Children can play with the developed design in a novel, unexpected manner. Therefore it is important to make conscious decisions on what is going to be designed and what is going to be left open for the children to interpret while interacting with the design and to evaluate this with potential users as early as possible (see also next sub-section). Several aspects can influence these decisions such as the context of play and the age of the children. The Wondrous Imagination project showed that young children (around the age of four) were not capable of dealing with very abstract play objects yet. Qualities needed to be built into the objects that, together with an introduction story, evoke fantasy play.

Throughout the process, the design is approached both top-down and bottom-up. The design decision making process moves from a high level intention, through the dialogue between the user and the design in the middle level towards the tangible actions in the lowest level. Open-ended play is then triggered at the low level (by sensors, actuators and affordances) and will move up again from there. Students reported making design decisions based on various aspects. Some of them were related to the students' own development (e.g. choosing a specific kind of technology to develop these skills) while

others were more practical decisions (e.g. choosing a technology that is currently available). Making these design decisions occurred at different moments in the design process. For instance, in the Push/pedal car project the decision to use existing pedal cars was made early on in the project. Children are familiar with these cars and know how to use them in different ways such as sitting on them and riding them or pushing other children. After some first observations, the design decision was made to add tokens with different colors to the design, but to leave open whether these tokens were personal or shared objects.

Designers often choose to integrate several functions in order to support various types of play to emerge. But this can make the design too complex. For example, in the Shuffle project the final design offered so many interaction rules that it became too complex for children to understand and use them all. Besides that, the children also came up with a lot of self-invented game rules. Reflecting on this design, the student mentioned that a smaller number of interaction rules would have been sufficient for diverse types of play to occur.

User evaluations: After making the first design decisions, it is crucial to quickly try out the design concept with users from the target group. This can be done best by confronting the users with a first (interactive) prototype. Then, it helps understand what actually happens when users from the target group start interacting with the design. Designers for open-ended play should have certain assumptions but the openness of the design makes it hard to predict what will actually happen during interaction. Children can come up with games and rules that were not expected beforehand. This makes designing for open-ended play unpredictable, but this is also its strength. It is exciting and, as one student mentioned: you do not have to worry about restrictions. When such user evaluations are done early in the design process, the insights can be inspirational for next design iterations. In order to be able to do these kind of evaluations, designers need to quickly make some design decisions. After a first, quick iteration the design can be further developed and refined. When children have been playing with the design, one can determine which properties should be enhanced for the next design iteration. Then it is crucial, as in 'traditional' interaction design processes, to repeat such user evaluations frequently in the remainder of the design process.

To get most out of these evaluations, students indicated that it is important to give children a chance to get used to your design and the play setting. If children do not start to play with the design themselves, a short introduction can help. In the Wondrous Imagination project, several design iterations were performed, each concluded with a user evaluation. The design changed from an abstract white carpet with simple objects to a visually richer carpet showing a top-view of a natural environment with objects that children could interact with in various ways. The final design really evoked fantasy play, which was the aim of project. The user evaluations and the accompanying reflection moments helped in developing a stronger design that fitted this aim.

Discussion

The research described in this chapter was aimed at improving our knowledge on designing for open-ended play. We carried out a number of complementary activities contributing to the creation of a design approach for open-ended play.

This chapter introduces a first investigation of the 'landscape' (design space) of open-ended play. The activities we carried out made clear that designing for open-ended play is still in an explorative state. We had to search for the right terminology and an appropriate method of analysis. So far, we have found initial evidence of relevant design parameters and a number of essential steps for the design process. The results presented in this chapter are considered to be intermediary knowledge that represents our current understanding of designing for open-ended play. Rather than a static 'truth', this knowledge is likely to change and develop further in the near future. For example, we can extend our design analysis of existing open-ended play design with additional parameters such as type of modality or flexibility of objects. Design researchers and practitioners are advised to interpret and use the results in such a way that helps to grasp the concept of open-ended play and to apply it in their design process.

While the design analysis covers designs from several international researchers, the interviews only involved students from own department. There is an undeniable correlation between our research and what we taught our students and how they approached their design challenges. Being aware of this, we acknowledge that we would be able to formulate stronger results if we would have extended our interviews with external designers or design researchers. As open-ended play with interactive objects is still rather novel and explorative, it remains a fairly unknown field of design research, which made it difficult for us to realize this. Moreover, our students might be reluctant to confess any negative issues concerning designing for open-ended play as they were taught about this by their superiors (coaches). At the time of interviewing, all students finished their corresponding projects. They could provide us with their honest feedback without having to be concerned that this would influence their assessment in any way. The researcher who carried out the interviews was also not professionally involved in the projects and expressed genuine interest in both positive and negative experiences during the interviews. For example, we asked the students to reflect on what worked well and what did not work well in their design process.

One of the students we interviewed was actually already experienced in carrying out projects concerning open-ended play. Therefore, his attitude towards designing for open-ended play differed from the other students. He mentioned that from previous experiences he learned that designing for open-ended play involves embracing some uncertainty of the possible outcomes. He was not uncomfortable about this anymore, but there was still enough to learn for him. For example, he found out in the project described in this chapter (Wondrous Imagination) that he still formulated design

assumptions concerning open-ended play that turned out to be incorrect. He could make design decisions more quickly than the other students, but he still needed various iterations in order to come to a successful and meaningful interactive design.

Conclusion

In this chapter we described our improved understanding of open-ended play as a first step in developing a more clearly defined design approach for open-ended play. We have grounded open-ended play in literature and positioned it in between games and free play, with the ability to move either way. This clarified the design space of open-ended play and helped us in formulating a definition of open-ended play. Designers can use this improved understanding of open-ended play as a starting point in their design process. It helps them frame the design space and to consider the exceptional characteristics of open-ended play.

Furthermore, we have discussed eight existing interactive designs for open-ended play and analyzed them on a number of design parameters. These parameters illustrate the choices and decisions designers can make in order to create a playful open-ended design that fits their project goal and context. Designers of open-ended play designs should consider these parameters when creating ideas and concepts and developing prototypes in their design process. Moreover, the discussed design examples can serve as an inspiration and comparison for new ideas. In the next chapter, we will focus further on one of the parameters, namely rules.

The positioning and the design analysis further grounds open-ended play and gives advice to designers aiming at developing open-ended play designs, but remains rather theoretical with a focus on the final design. Therefore, we also investigated designing for open-ended play in practice by examining the design process through interviews we held with students who experienced designing for open-ended play in design projects. These interviews made clear how the students experienced designing for open-ended play. This led to an improved understanding of the strengths, pitfalls and challenges of open-ended play and the identification of a set of essential steps in the design process. This resulted in the following design guidelines:

- Designers can predetermine various interaction rules and let users come up with their own game rules. Moreover, the relation between ambiguity (as important element of open-ended play) and complexity (as a choice in design parameters) should be chosen well. A balance has to be found between structure and spontaneity. Also, context needs to be taken into consideration to support and restrict the design.
- Designers should early on in the project define the design space by shaping a frame with clear boundaries related to user values, age group, context of use and forms of play. This is especially important for open-ended play, as a design with no restrictions

becomes difficult for players to interpret.

- Designers should make clear decisions on what to design and what to leave open for the player's interpretation, creating a balance between openness and complexity. The design parameters as described in the design analysis can be used as guidance for design decisions, e.g. number of output modalities and whether to provide communication between objects.
- Designers are encouraged to confront users of their target group with their design early and frequently to validate the design and gather valuable insights for further design iterations. For open-ended play, these user evaluations are even more crucial as the creation of meaning is unpredictable and only happens during play. Doing early user testing is necessary in order to find out what happens during use.

These guidelines become important at different moments in the design process. Figure 2.3 illustrates the design approach of open-ended play. As Figure 2.3 shows, designing for open-ended play asks for different steps throughout the design process. At the start designers should frame the design space and its openness. During the process, designers have to explicitly decide what properties to design and what properties to leave open for the interpretations of the players. Furthermore, open-ended play asks for an explorative and iterative design process with an emphasis on early prototyping and frequent user evaluations, even more so than in a traditional interaction design process. These steps, identified during the interview study, are represented in Figure 2.3 by four separate blocks. Figure 2.3 also indicates how the two other activities discussed in this chapter (positioning and design analysis) relate to the design process. The positioning of open-ended play supports framing the design space, as it gives some first direction into designing for open-ended play. It emphasizes certain characteristics of open-ended play and provides a starting point for the remainder of the design process. This positioning stays important in the next block of choosing what to design. The design parameters of the design analysis serve as input for making design decisions in this block. These parameters should be considered when creating ideas and concepts and developing prototypes.

We believe this design approach can support designers and design researchers in setting up and carrying out projects in the area of designing for open-ended play. For us, the approach already has value in explaining how to design for open-ended play to novice designers such as students. By presenting the different steps together with the definition and design parameters, we provide them with clear pointers for their design process.

In the next chapters, we will discuss several design cases in which we implemented the design approach. Through developing these designs we examined particular aspects of designing for open-ended play, such as rules, social interaction and prolonged play, leading to novel insights that complement the approach described above. In the following chapter, we will first focus on the role of rules in open-ended play.

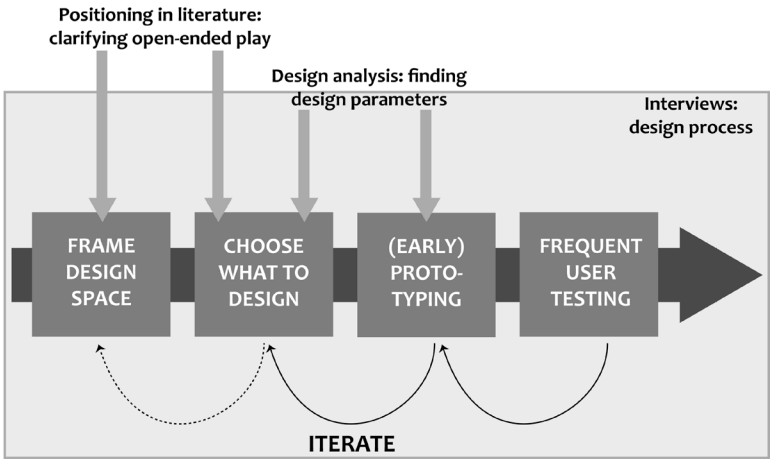


Figure 2.3 Design approach for open-ended play.

3

Rule creation in open-ended play

ABSTRACT From the interview study discussed in Chapter 2, it became clear that rules play an important role in open-ended play with interactive objects, but are difficult to get a grip on. In open-ended play, designers can predetermine various interaction behavior rules and provide players with the freedom to invent their own game rules. When children play traditional games like tag or jump rope, they often combine generally accepted predefined rules with their own invented and negotiated rules. These different rules also occur in play with digital objects involving interactive technology. In this chapter, we focus on the different types of rules that are important in open-ended play: the interaction behavior rules developed by the designer and the created game rules invented by the users (children). We identify two relevant actions in the communication process between designer and users: interpretation and improvisation. This knowledge extends existing communication-based models of design. We present two design cases that illustrate how these steps lead to freedom and diversity in children's interaction with open-ended play objects and we discuss relevant implications for design.

This chapter is based on:

Valk, L. de, Bekker, T., Eggen, B. (2015). Drawing up the rules: Encouraging children's rule creation in interactive open-ended play. Accepted for publication in International Journal of Child-Computer Interaction.

Introduction to this chapter

Anna and Jane are playing with a new interactive play object. When Anna touches the object, it lights up in different colors. "It looks like a rainbow!" she says. "You have to move your hand," says Jane. "Then you can draw a real rainbow." Anna waves her hand over the object and the light follows her movement. Anna starts to draw, making circles and triangles of light. "Now I want everything to be blue!" she says and she moves her hand over the object until it emits mostly blue light. "Can I play with it now?" asks Jane. Anna hands the object over to Jane. Jane start to interact with the objects telling a story: "In a land far away, there was a princess..."

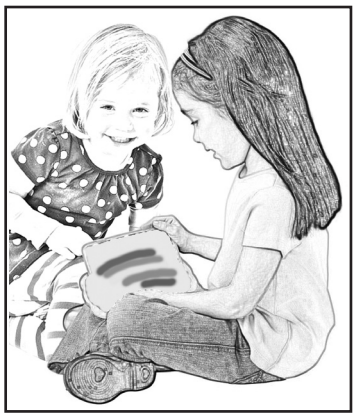


Figure 3.1 Scenario of two girls playing with an interactive, open-ended design.

In the scenario above (see Figure 3.1), two girls are involved in open-ended play with an interactive object. Children can play with an open-ended design in different ways. In the scenario Anna uses the interactive properties of the open-ended design as a drawing tool whilst Jane is involved in dramatic play when she creates a fantasy around the design involving a princess. The design intention of open-ended play is to offer this diversity in play behaviors by designing interactive objects that can be interpreted in various ways. This relates closely to the concept of ambiguity in interaction, which can be considered a property of the interpretative relationship between users and products. Ambiguity asks from users to make decisions on 'meaning making' (Gaver et al., 2003) as it provides products with multiple possible meanings. Usually, designers attempt to eliminate most ambiguity in order to control the user's interpretation of a product (Gaver et al., 2003). But actually, embracing a level of ambiguity in an interactive design opens up some important benefits. Instead of constraining user's responds or imposing solutions, ambiguity allows users to find their own interpretations in interaction with a design and offers them the opportunity to appropriate designs into their daily lives (Gaver et al., 2003).

This chapter investigates different types of rules in open-ended play with interactive objects and translates these insights to implications for design. We explore the relations between the designer's intention when developing an open-ended play design and the intention of the users (children) when interacting with the design. More specifically, we investigate connections between the rules that are part of the design's interaction behavior and the rules children invent while playing. At first sight, it may seem a contradiction that this chapter discusses designing for rules in open-ended play as usually no game rules are predefined in open-ended play. Most traditional open-ended toys, such as blocks and crayons, are tools that do not incorporate a set of rules, such as

games. When interactive technology is added to open-ended play designs, an extra layer is added that creates an interesting field of tension. The interactivity in such open-ended play designs is programmed according to a set of rules as the scenario at the start of this chapter also illustrates (e.g. touching the design makes it light up). On the other hand, children also invent their own goals and rules (e.g. making the design light up in blue) as the game play unfolds. The challenge in designing for open-ended play is to facilitate this dynamic process of rule creation in an engaging way.

According to the Oxford dictionary, rules are defined as "*a set of explicit or understood regulations or principles governing conduct or procedure within a particular area of activity*" (Oxford dictionaries, n.d.). Rules help to determine what is allowed and are for example used to regulate traffic, to control sports matches or to manage social interaction. In playing (sports) games, rules specify the aim of the game and communicate how this goal is supposed to be accomplished (Suits, 1978). One plays a game by following the rules. These rules are considered mental concepts that need to be shared and understood among players (Salen & Zimmerman, 2003; Gray, 2009). Rules can be self-invented or bended or folded in context (DeKoven, 1978). Rules do not precisely define each action but always leave room for players to be creative within certain boundaries (Gray, 2009). From observing children playing with interactive, open-ended play designs (Bekker et al., 2010a; Valk et al., 2012) we have discerned two types of rules. The first type is the interaction behavior rules, which are the rules that a designer integrates in a play design. In play with interactive objects, interactivity is part of the play design and sensors and actuators determine how a design reacts and behaves. With this interactivity, players invent the second type of rules: their own created game rules, situated in context.

In the following chapter we first present related work on rules in play. Next, we translate these insights from play to the domain of design. We present a new communication-based model that exemplifies different rules and corresponding actions. This model is further illustrated by two design cases and translated to implications for design. We end this chapter with a conclusion and discussion about the relevance of this work for designers in the field of open-ended play for children.

Rules in play

Traditional games have formal game rules by which the game is supposed to be played. But every game is played in a particular setting: in a particular context with particular people. Children can still mold the game and add or adapt rules. Several researchers have identified different sorts of rules in their investigations of play and games. We will discuss a relevant selection of previous work from the domains of ethnography and game design below.

Goldstein (1971) observed two types of rules in his ethnographic work on counting

out rhymes (like 'eenie meenie minie moe'). The first type of rules is the ideal rules or official rules that characterize the rhyme. These are the rules by which children 'should play'. But when children play games, their actions cannot be fully described by only the ideal rules of the game. Secondly, there are the 'real' rules, the rules that are actually being played out by the users: an adaptation of the rules influenced by social values and negotiation between players. These are the rules by which children 'do play'. In the case of counting out rhymes, children exposed strategies of extending a rhyme to count out a different child. This was largely accepted by the other children, who considered it to be a legitimate and clever move. In her work on rules in children's play, Hughes continues on this path by defining a model of game rules that "*allows players to mold their games to the demands of social life in particular settings*" (Hughes, 1995). This model incorporates three different rule systems that exist whenever games are played: game rules, social rules and gaming rules. Game rules are the rules of the game; the ideal or official rules (Goldstein, 1971). Social rules are the rules of the social context in which a game is being played. Gaming rules derive from the interaction between the structure of the game and the social context. They do not only include adaptation of rules; instead the same rules can be used in a totally different way by another group of players.

From the field of game design, classifications of rules are based on analysis of (digital) games and interviews with experienced gamers. Sniderman (1999) proposes the existence of unwritten or unrecorded rules next to the official or recorded rules that are usually explicitly spelled out. The unwritten rules on the other hand are "*literally unstatable*" (Sniderman, 1999) but players seem to agree on them nevertheless. Players might not be aware of all the rules that are affecting a game, but this does not mean they cannot play the game. Salen & Zimmerman (2003) suggest that for any (digital) game rules exist on three related levels: operational, constituative and implicit rules. Operational rules are the explicit rules that guide the behavior of players and can be found on the instruction leaflet of a game. These rules describe how players can interpret and manipulate (attributes of) a game. Constituative rules are the formal mathematical and logical structures of a game, existing 'below' the operational rules. While operational rules guide the behaviors of players, the constituative rules are abstract and exist independently from the player. For example, in the game Tic-Tac-Toe, the constituative rules are as follows (Salen & Zimmerman, 2003): Two players choose a selection from a grid array of 3 by 3 units; The first player who select three units in a horizontal, vertical or diagonal row wins the game; If no player can make a selection and there is no winner, the game ends in a draw. Implicit rules are the 'unwritten rules' of how players should behave while playing the game. Implicit rules relate to 'proper game behavior' as good sportsmanship and etiquette. They can change for every game and context. For example, you might allow a friend who has just began playing chess to try out various moves before making his final decision, whilst you would never allow this to a well-experienced opponent in a serious game of chess. Finally, based on an interview study with eleven experienced board gamers, Bergström (2010) divides the rules of a game into two categories: explicit rules and implicit rules. Explicit rules are part of the

game artifact, usually developed by the designer of the game. Implicit 'unwritten' rules are part of the social agreement between players. Implicit rules are "*often ambiguous, need not be shared by all players, can change as the game progresses, need not be binding and are hard to repeat from one game to the next as they can and will change the context*" (Bergström, 2010). Implicit rules can be made explicit when they are formulated verbally and unambiguously. As this does not happen often implicit rules remain practically invisible, until they are involved in a conflict. But knowing these rules leads to a greater understanding of what is actually happening in the game.

Table 3.1 summarizes the classifications of rules discussed above.

Table 3.1 Classification of rules.

Author	Classification of rules	Context of research
Goldstein (1971)	Ideal rules: *official rules by which children 'should play'*	Ethnography (children)
	Real rules: *the rules by which children 'do play'; an adaptation of the rules influenced by social values and negotiation between players*	
Hughes (1995)	Game rules: *the rules of the game*	Ethnography (children)
	Social rules: *the rules of the social context in which a game is being played*	
	Gaming rules: *derived from the interaction between the structure of the game and the social context*	
Sniderman (1999)	Official or Recorded rules: *explicitly spelled out constraints on the players' behavior*	Game design
	Unwritten or Unrecorded rules: *the normally unspoken behaviors that players adopt in order to play*	
Salen & Zimmerman (2003)	Operational rules: *the explicit rules that guide the behavior of players*	Game design
	Constituative rules: *the mathematical and logical structures of a game, existing 'below' the operational rules*	
	Implicit rules: *the 'unwritten rules' of how players should behave while playing the game*	
Bergström (2010)	Explicit rules: *part of the game artifact, usually developed by the designer of the game*	Game design
	Implicit (unwritten) rules: *part of the social agreement between players*	

Summarizing, this table shows a distinction between the official, explicit rules and the unwritten, real rules. Figure 3.2 and Figure 3.3 illustrate these different types of rules. In both figures, three players are playing jump rope. Figure 3.2 lists three official rules. The girl on the left thinks of a rule concerning turn-taking. The boy in the middle expresses the rule of jumping over the rope, so that it passes under his feet. The girl on the right is concerned with the action she is undertaking: turning the rope around. All of these are explicit rules that the players should follow in order to play jump rope. Figure 3.3 on the other hand shows three unwritten rules. The girl on the left is considering asking her friend to join her with jumping when it will be her turn. The boy in the middle wants to try out a new action: jumping two times in a row. The girl on the right is adding a social game rule: because the boy is much younger than the two girls, he can make one mistake before his turn is over. These are just three examples of rules that players make up themselves and that can be negotiated before actually adopted.

Figure 3.2 Three players playing jump rope and thinking about official rules.

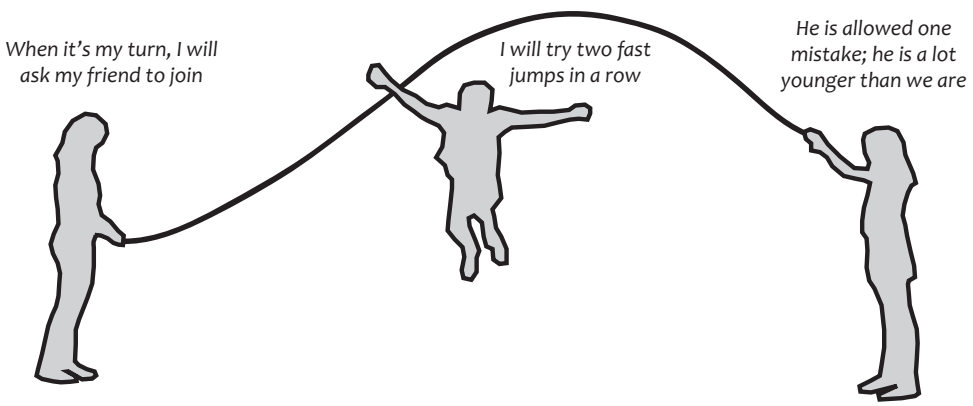


Figure 3.3 Three players playing jump rope and thinking about unwritten rules.

Rules in open-ended play

When designing for open-ended play with interactive play objects, the relations between interaction behavior rules (embedded in object or environment) and created game rules (invented by players) are important. In open-ended play, there are no official game rules, but some direction is given by factors as affordances and interaction opportunities in the objects and the play environment. As we are interested in the combination of open-ended play and interactive technology, the interaction behavior rules are our main focus point. We are aware though that interaction behavior rules are not an independent factor but are clearly influenced by forms and affordances.

A designer usually develops an artefact with a certain intention of how it should be experienced. When a user starts interacting with this artefact, he or she interprets and experiences the artefact in context. In the HCI field, a lot of scholars have investigated this relationship between designers and users of interactive systems. Many relate to design as a form of communication between designers and users and the designed object or system as the medium through which this communication evolves (Rheinfrank & Evenson, 1996; Norman, 2001; Souza, 2005; Crilly et al., 2008). A designer is not in direct control over the process of communication and thus the creation of the user's model: "[The designer] *can only hope to contribute to the way users create meanings and develop mental models commensurate with their needs to use the designers' products*" (Krippendorff & Butter, 1984). In user-centered design, the focus is on aligning the designer's conceptual model (design model) with the user's mental model (user model). Mental models are the models that people have of themselves, others, the environments and objects with which they interact (Norman, 2001). For example, when a user encounters an object, the mental model of this object is based on the interpretation of the object (i.e. product semantics, perceived actions and visible structure (Krippendorff & Butter, 1984; Norman, 2001)) as well as by previous experiences of the users (Norman, 2001). A designer can support the creation of a specific user's mental model by making the operational parts visible and by allowing users to predict the implications and effects of certain actions.

Crilly et al. (2008) have reflected on a large number of existing communication-based models of design (including the models from Krippendorff & Butter, 1984; Norman, 2001; Souza, 2005) and presented an integrated communication model (see Figure 3.4), illustrating how the artefact in the middle relates to the intention of the designer on the left and the interpretation of the consumer (user) on the right. The artefact changes from planned, to realized, to experienced and both the designer and the consumer are influenced by experiences, beliefs, motivations, expectations, capabilities and culture. Therefore, the user's interpretation of the artefact might or might not correspond with the designer's intention. This model summarizes eight key features in communication-based models of design. In this chapter, we focus on two of them in particular: 'Interactive interpretation' and 'Collective consumption'. Interactive interpretation is "*the iterative*

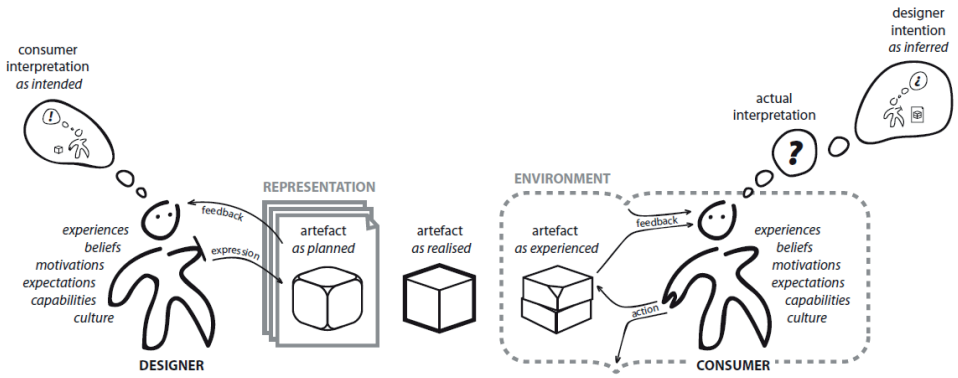


Figure 3.4 Communication-based model showing the relationship between the designer on the left and the consumer on the right, mediated by the artefact in the middle. (Derived from Crilly et al., 2008)

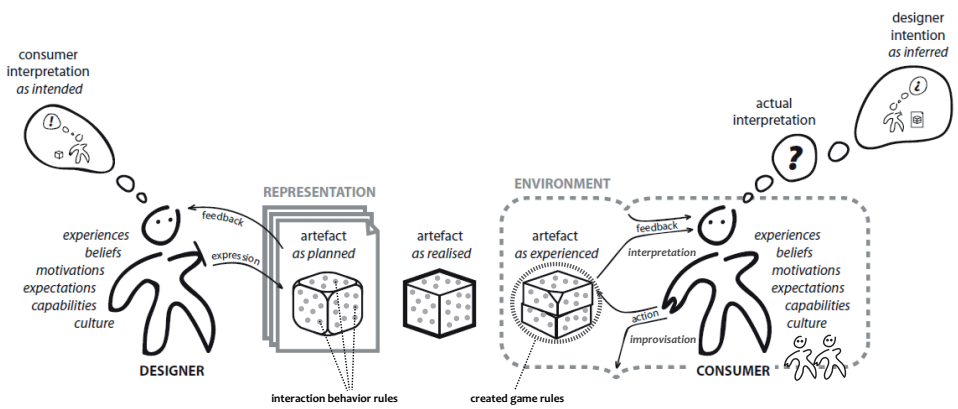


Figure 3.5 Enhanced model for open-ended play: Designers (left) create an open-ended play design (artefact) with interaction behavior rules (grey dots). Players (right) interact with this design in context together with other players. They interpret the interaction behavior rules and improvise and come up with created game rules (grey circle).

process by which interpretations are formed as consumers interact with the artefacts they encounter" (Crilly et al., 2008). Collective consumption depicts the consumer "*as belonging to the broader public, members of which interact thereby influencing each others' interpretation*" (Crilly et al., 2008).

If we put this model in the context of open-ended play with interactive technology (see Figure 3.5), the communication between the design (intent) and the user (experience) remains, but opportunities for interaction are added to the design intentionally left open for the user's interpretation. This means that the users are confronted with a design with a certain level of ambiguity that allows them to 'create meaning' that is personally valuable. The artefact has to communicate this clearly to the user. The interactivity of the design adds additional steps to the model that we try to understand and visualize in this chapter. The form and affordances of the artefact stay important but in this chapter we focus on the interaction behavior rules (blue dots) added to the artefact (the open-ended play design) by the designer on the left. The consumer on the right interprets these interaction behavior rules and improvises with created game rules (orange circle) as an 'extra layer' attached to the artefact. S/he does this in an environment involving multiple players. Although the artefact is currently visualized as one comprehensive object, it can definitely also be a system consisting of a collection of objects with which a multitude of players can interact simultaneously while also socially interacting with each other.

Figure 3.6 on the next page illustrates the different steps that are relevant when designing for open-ended play with interactive objects: the interaction behavior rules embedded in the design, the interpretation of this behavior, the improvisation with the design and the created game rules invented by the users. Open-ended play provides the users with freedom on two levels: interpretation and improvisation. This increases the 'second-order' game design problem as already mentioned by Zimmerman (2003): "*To design a game is to construct a set of rules. But the point of game design is not to have players experience rules -- it is to have players experience play. Game design is therefore a second-order design problem, in which designers craft play, but only indirectly, through the systems of rules that game designers create. Play arises out of the rules as they are inhabited and enacted by players, creating emergent patterns of behavior, sensation, social exchange, and meaning.*" Zimmerman stresses the necessity of an iterative design process to understand the complex yet subtle interactions between rules and play. This is also essential in the design process for open-ended play, as evaluating the interaction behavior rules in context helps understanding how users interpret them and improvise with them.

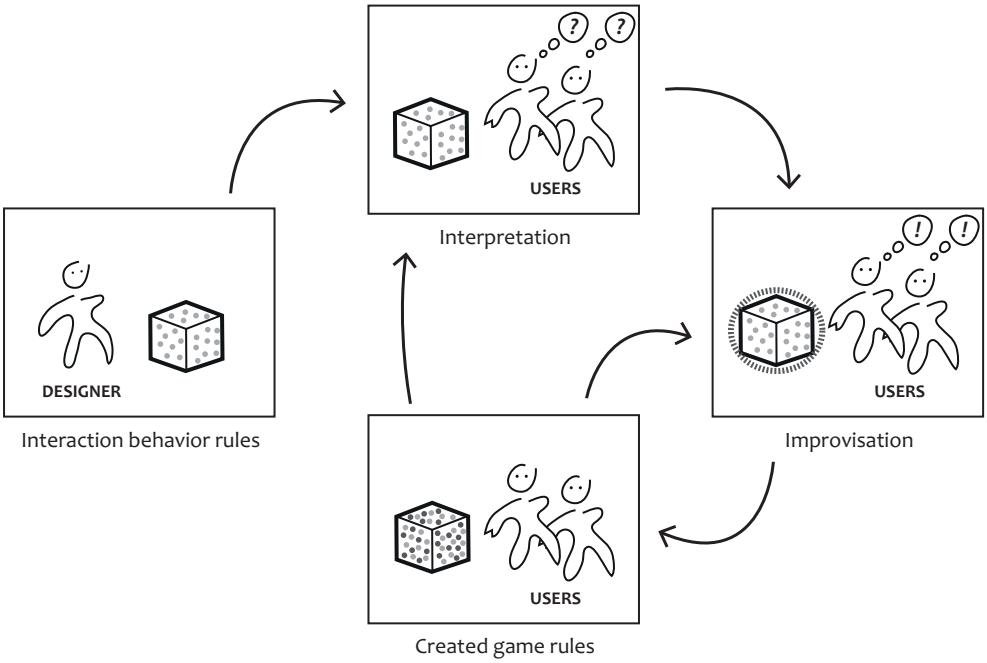


Figure 3.6 Different steps in open-ended play design. The interaction behavior rules (light grey dots) of the design are invented by the designer on the left side. Users interact with these rules through the steps of interpretation and improvisation. Users can interpret an interaction behavior rule in various ways and can then also improvise with it in multiple manners. This leads to a diverse set of created game rules (dark grey dots) when users are interacting with the open-ended play design. During game play users can iteratively interpret and improvise, resulting in a cyclic process.

INTERACTION BEHAVIOR RULES

Interaction behavior rules are behavior regulations created by the designer and incorporate action-reaction patterns programmed into the open-ended play design. These patterns are communicated to users through interaction mechanisms as feedback and feed forward. For instance, imagine a set of interactive handhelds that play a sound when shaken and vibrate to attract attention. Designers usually come up with a certain interaction scenario, i.e. they envision how the interaction behavior rules will be used in a play session. Rather than a verification tool, such a scenario serves as a design tool to specify human-computer interaction (Carroll, 1995): in this case how users possibly interpret and improvise with the interaction behavior rules. Designers must be aware that the interaction behavior rules can always be interpreted in another way than the designer envisioned, as Figure 3.4 and Figure 3.5 also illustrate. The interaction scenario outlines one but not the only possibility.

If we look back at the classifications presented in the previous section, interaction behavior rules can be seen as part of the official rules, as they are made up by the designer to guide the behavior of the players. But the rules are not communicated through an instruction leaflet and the players are not forced to use them in their play. Instead, the interaction behavior rules offer a collection of play opportunities that players are free to improvise with. Therefore, we believe the interaction behavior rules most closely relate to the constituative rules (Salen & Zimmerman, 2003) of a game to provide some logical structure to the play activity. Note that this also relates to the fact that Salen & Zimmerman discuss digital games in their work, while the other researchers based their classifications on traditional (board) games. See also Table 3.2 below.

Table 3.2 How interaction behavior rules and created game rules relate to previous work on rules in play.

	Goldstein (1971)	Hughes (1995)	Sniderman (1999)	Salen & Zimmerman (2003)	Bergström (2010)
Interaction behavior rules				Constituative rules	
Created game rules	Real rules	Social and gaming rules	Unwritten rules	Implicit rules	Implicit (unwritten) rules

INTERPRETATION AND IMPROVISATION

The different rules in open-ended play become connected with each other when players start interacting with the design. As Figure 3.6 shows, the two relevant actions in this process are interpretation and improvisation. Players interpret the interaction behavior rules (left) developed by the designers in different ways and improvise with them in various ways resulting in a number of created game rules (right). In the step of interpretation, players explore and try to understand the designs behavior and build up a frame with certain parameters. Subsequently, when players are using this behavior to create something, they are involved in improvisation. Within the frame that the design offers them, players can give meaning to interaction possibilities and spontaneously shape their play by for instance being competitive or playing in a free and expressive way. In open-ended play, two groups of players can have different interpretations and improvisations and thus play differently with the same design.

In theories of communication, interpretation is regarded as giving meaning to the content of a message. Also in the HCI communication models discussed earlier, interpretation plays an important role. Norman (2001) discusses interpretation as an action in forming one's mental model; by interpreting perceived actions and visible structures, users can shape their mental model of the design system or objects. Users interpret the designs in a circular process while being involved in interaction (Krippendorff & Butter, 1984).

Crilly et al. (2008) make a distinction between intended interpretation (by the designer) and actual interpretation (by the user), influenced by experiences, expectations and motivations. Interpretation occurs independently of the designer's intention (Crilly et al., 2008) which implies that designers can only attempt to encourage certain interpretations, but they can never fully control this. Designers can support interpretation by providing input and output options and ambiguity in interaction. In this way, the design allows users to find their own interpretation in interaction and to integrate them into their everyday lives.

Improvisation is the act of creating and performing spontaneously or without rehearsal (but often well-prepared). Improvisation often occurs in drama or music. In play, improvisation has been discussed in the context of spontaneous and unstructured free play. For example, improvisation can be found in different types of free play such as 'Bricoleur' which is improvisational play in which players use whatever the environment has to offer (Nachmanovitch, 1990); 'Paidia' which is unstructured and spontaneous improvisational play with no clear outcome (Caillois, 1961); or 'Open-ended play' which is, as mentioned earlier, an open form of play without any predefined rules or goals (Valk et al., 2013a). Improvisation can be supported by offering freedom within a certain structure. This structure provides a starting point, while the freedom triggers users to diverge in various directions.

CREATED GAME RULES

As Figure 3.6 shows, the steps of improvisation and interpretation of interaction behavior rules finally result in created game rules: game rules invented by players during their play that often involve setting a goal, regulating when a player wins, defining a challenge, or attaching another meaning to the open-ended play object. These rules do not always have to concern goals or physical actions. For instance, if children are involved in pretend play, their 'rules' can be that they are acting in a fantasy world as a princess or a wizard with magical powers. Created game rules can be expressed verbally (i.e. by words) or physically (i.e. by movements or gestures) and thus shared with other players. On the other hand, created game rules can remain unspoken and thus 'invisible' to other players.

Considering the classifications of rules described before, the created game rules correspond with the real rules (Goldstein, 1971), social and gaming rules (Hughes, 1995) and the implicit 'unwritten' rules (Sniderman, 1999; Salen & Zimmerman, 2003; Bergström, 2010). See also Table 3.2. These are the rules which are developed in context and influenced by social values. In open-ended play, the rules children create themselves are essential; designers aim at supporting children in doing just that. In creating their own rules children often borrow rules from other familiar games and use their tacit knowledge on how to play a game well.

Design cases

To further clarify different types of rules and the actions of interpretation and improvisation as shown in Figure 3.6 in context, we now present two recent design cases. These design cases are examples of interactive play designs for open-ended play. We selected these cases as they differ in physical form and opportunities for interaction and they support different forms of play such as social, physical or fantasy play. Both design cases were developed in an iterative design process in our Department of Industrial Design. Below, we will discuss each design case and explain how interaction behavior rules, created game rules, interpretation and improvisation are supported.

Figure 3.7 Children playing with GlowSteps (left) and Wobble (right).

DESIGN CASE 1: GLOWSTEPS

GlowSteps (Valk et al., 2013b) is an interactive play environment developed to stimulate social and physical play among children. The design invites children to be active together. GlowSteps consists of a set of interactive tiles that responds with light feedback on player's actions (see Figure 3.7). The position of the tiles is flexible and the tiles can be picked up and moved around. Each tile contains a pressure sensor that measures if someone stands on the tile or touches it with their hands. The light reacts depending on the active interaction scenario. In this chapter, we will discuss one of these scenarios named 'Catch'. In this scenario, one tile lights up in a certain color for a short amount of time. In this time, players must step on that tile in order to 'catch' the light. All tiles then flash to show that the light has been caught. If players are not quick enough, the light disappears and appears again at another tile. Players can prevent the light from coming to a tile by stepping on that tile and 'blocking' it. These interaction behavior rules were programmed into the tiles and evaluated with children.

Children played in diverse ways with GlowSteps, using different interaction behavior rules in their gameplay. Table 3.3 illustrates for two of the interaction behavior rules how players interpreted them, how they subsequently improvised with them and to which created game rules this led. For example, when players stand on a tile with a light, all tiles respond by flashing. This can be interpreted as "we just caught the light", which

can lead to improvised actions as keeping score or beating other players and eventually winning the invented game. Overall, the multiple interpretations and improvisations show the diversity, freedom and creativity supported in GlowSteps. Please note that this table does not summarize all possibilities, but gives an impression of the diversity in interaction.

Table 3.3 Examples of interaction behavior rules, interpretation, improvisation and created game rules with GlowSteps.

Interaction behavior rules	*How players interpret*	*How players improvise*	Created game rules
One tile lights up in green for a short amount of time	*I have to react to this green light within a certain time*	*We have to step on the green light*	Let's compete in catching the green light
		The green light is a virus trying to infect us	We have to run away from the green light
	The light represents a living creature	*The Hulk is living in a world underneath the tiles*	We have to jump on the light repeatedly to destroy the Hulk
		A frightened little alien is exploring our world	Let's touch the green light to help the alien feel at home here
If players step on an active light, the light flashes and then disappears at that tile but appears at another tile	*When the light flashes, this means I caught the light*	*We have to count the numbers of lights that are being caught*	Every light that is caught counts as one point
		I am better than you if I catch more lights than you	Whoever gets to ten first, wins the game
	Catching the light means catching the living creature it represents	*The alien is wounded but not dead yet*	We have to catch it twenty more times in order to kill it
		If we move the tiles closer together, it becomes easier to catch the alien	Let's move the tiles closer together now

DESIGN CASE 2: WOBBLE

Wobble (Beukering et al., 2014) is an interactive play environment designed to encourage social and fantasy play. Children can create stories with the interactivity of the design. Wobble consists of multiple interactive light objects (balls on a stem) (see Figure 3.7). The design has been developed by Master's Student Alice van Beukering. Wobble was designed to trigger pretend play by presenting a fantasy world with 'living creatures' (lights) inside the balls. These living creatures can move from one ball to another and change their color of light. Together, the objects form a magical layer in the play environment of children.

The interaction behavior rules of Wobble are as follows. When children are not interacting with Wobble, some of the lights pulsate to show that it is 'alive' and the lights sometimes jump from one ball to another. When children touch a ball with light, the design reacts by moving its light to another ball, as if the lights ('creatures') fly away. Children can move from one object to another, pushing the lights from ball to ball. Children created various games while playing with Wobble. Some of these games were fantasy-oriented: children tried to control the lights by pretending to be wizards and making wizard-like movements or by talking to the balls. Table 3.4 illustrates for two of the interaction behavior rules how players interpreted them, how they subsequently improvised with them and to which created game rules this led. For example, the lights in the balls that pulsate can be interpreted as a representation of something active or alive inside the balls, such as living creatures or a disease. This can result in created game rules that focus on keeping the living creatures alive or stopping the disease that is spread from ball to ball. Again, this table shows that the interaction behavior rules of an open-ended play design such as Wobble can lead to a rich variety of interpretations, improvisations and created game rules.

Table 3.4 Examples of interaction behavior rules, interpretation, improvisation and created game rules with Wobble.

Interaction behavior rules	*How players interpret*	*How players improvise*	Created game rules
Lights in the balls pulsate	*There is something active in the balls*	*There are living creatures in the balls*	We have to keep the creatures alive
		A disease is spreading from ball to ball	We have to stop the disease by catching it
	The pulsations are a signal for something	*The lights are counting down*	We have to be faster than the lights
		The lights are about to change their appearance	Let's see if we can influence this change
If players touch a ball with light, the light moves to another ball	*When a light moves away, this means I caught the light*	*I have special powers*	I am a wizard who can control the lights
		We have to catch as many lights as possible	We get a point for each light we've caught
	The lights represent living creatures	*I can scare the creature away*	Let's try if we can chase the creature away
		These creatures can be seduced to move	We should be silent for a while to allure the balls to come back to us

Implications for design

In this chapter we have investigated different types of rules in interactive, open-ended play and illustrated these rules with two design cases. In this section, we translate our insights into implications for design that are useful and valuable for designers and design researchers working in the field of Child Computer Interaction.

These implications for design elaborate on the guidelines discussed in Chapter 2. To repeat, these guidelines proposed defining the design space, making clear decisions on what to design and what to leave open and carrying out early and frequent user evaluations. The implications for design described below focus mainly on the guideline of making decisions on what and what not to design. We formulated three main implications: Embrace a level of ambiguity, Offer meaningful interaction opportunities and Provide freedom within structure.

EMBRACE A LEVEL OF AMBIGUITY

In designing for open-ended play, the intention is to develop a design that supports multiple interpretations and meanings when users start to interact with the design. To achieve this, designers have to embrace a level of ambiguity. This allows users to find their own interpretations and supports them in appropriating the design into their daily lives as they choose a meaning that fits their personality and environment.

But how does someone design for ambiguity? A first step is to make conscious decisions on what to design and what to leave open to the interpretation of the users, taking into account the skills and abilities of the target group. Then, designers have to shape the parts that are intentionally left open in a certain way. Gaver et al. (2003) list a number of tactics for integrating ambiguity in design, such as using blurred or inconsistent information to emphasize uncertainty and create a space of interpretation. For the context of open-ended play, we think that it is most relevant and promising to focus on ambiguity in interaction and make this appropriate for children. This can be achieved by for instance presenting 'information' that is not immediately clear and that is not communicating an obvious, predefined goal, but that actively stimulates the children's imagination. For example, the pulsating lights of Wobble communicate a sense of living creatures that can trigger the imagination of children, but they do not proclaim any predetermined goal or use. These lights encourage children to start exploring the design and invent purposes themselves. Moreover, the design should not explain why things happen but behave in a particular way with unexpected surprising functionalities every now and then. For example, when children play with GlowSteps they often quickly understand the programmed interaction behavior of the active lights, but they can be intrigued by the other tiles that turn red underneath their feet and attach surprising meanings to that to enrich their play.

OFFER MEANINGFUL INTERACTION OPPORTUNITIES

In open-ended play, the designer creates the interaction opportunities as an invitation to and activation of play. Children attach meaning to these interaction opportunities and in this way create their own game play. Therefore, it is crucial that the interaction opportunities are designed in such a way that they support the actions of interpretation and improvisation, in other words that they are intriguing and meaningful.

Different strategies can lead to meaningful designs. Here, we want to emphasize two of them which we believe to be relevant for open-ended play with children. Firstly, designers should find a match between content and context. Observations of the context of use can help to understand the social and physical environment and decision and creation processes that occur in play. Designers can align their design decisions to this improved understanding. For example, observations prior to the development of GlowSteps demonstrated that children play in variable compositions. Therefore, the decision was made to develop a design consisting of a number of stand-alone interactive objects (tiles) that can easily be added to or removed from the play environment, in order to adapt to the current play situation. Secondly, meaningful interaction opportunities should lead to diverse possibilities for game play. Both Table 3.3 and Table 3.4 illustrate how meaningful interaction behavior rules result in various examples of interpretation and improvisation. For this, it is important to design engaging interaction behavior that attracts and appeals to children, and to offer multiple opportunities so that each child can find an opportunity that fits his or her desired play behavior. This also relates to the level of ambiguity, as explained above; when the design offers ambiguity in interaction, it becomes easier for users to add their own interpretation to the design.

PROVIDE FREEDOM WITHIN STRUCTURE

A pitfall for open-ended play can be to offer too much freedom to children. Then, playing with an open-ended play design can become confusing and overwhelming for children. Especially younger children need some direction and structure in open-ended play. Designers have to find a balance between freedom and structure in order to create a setting in which children can interpret and improvise rules.

We argue that this balance shifts from more structure at the start to more freedom later on in a play session. Designers can develop their open-ended play design with this shifting balance in mind. As a first step, designers should define a starting point. This can be as simple as an object that lights up or that makes a sound. For example, when no-one is playing with GlowSteps yet, randomly one of the tiles already lights up to communicate the interactivity of the design and the intention of catching the light. This invites children to start playing and gives them some structure in what is expected from them. Secondly, freedom remains important and can best be supported by allowing children to diverge in various directions. Design decisions related to ambiguity and meaningful interaction opportunities can enhance this, as discussed before.

Discussion

This chapter investigates rule creation in interactive, open-ended play. Within this focus, we want to emphasize the step of interpreting the interaction behavior rules, which adds an extra dimension to the interaction between design and user compared to non-digital play. Instead of offering fixed 'official' rules, the interaction behavior rules can change over time and result in diverse interpretations. The design cases illustrate this by listing multiple interpretations and improvisations for each interaction behavior rule. Currently, we only describe one direction of communication: from the designer's intention to the user's creation of rules. We acknowledge that attention should be given to other directions as well. For example, designers can learn from the rules users create and develop interactive designs that actively react on that. Concerning the design process, we have not yet investigated when designers apply which knowledge on rules in their design process. We expect that the outcomes presented in this chapter are mostly relevant in the early design phase, for instance during brainstorms or while further developing initial concepts. Designers can come up with possible play scenarios involving interpretation and improvisation, such as in Tables 3.3 and 3.4. Combined with informal user tests, this can clarify the design space as designers can identify and analyze intended and interpreted behavior and rules, and use this knowledge to their advantage to develop engaging play designs that evoke potential use but also leave room for improvisation.

Conclusion

Designing for open-ended play is a challenging task, especially when it comes to formulating interactions and supporting rule creation. Open-ended play designers do not want to invent all game rules and goals beforehand, but decide to leave room for rule creation by the users as the design goal is to support diverse ways of interpretation and improvisation. To support designers in this process, this chapter presents a clear overview of the rules in open-ended play focusing on the design intention formulated by the designer and the user intention a designer attempts to elicit. More specifically, we identified interpretation and improvisation as two steps that designers should be aware of and consider when designing for open-ended play. Especially interpretation is crucial in open-ended play as this is the step in which users interact with the open-ended qualities of the design. Furthermore, this chapter discusses two design cases that show how players interpret integrated interaction behavior rules in various ways and improvise with them to create their own rules. These cases demonstrate the diversity and freedom of open-ended play while supporting the connection between interaction behavior rules and created game rules. We formulated implications for design for designers and researchers working in the field of Child Computer Interaction. These implications focus on embracing a level of ambiguity, offering meaningful interaction opportunities and providing freedom within structure.

Figures 3.5 and 3.6 present the results in a visual manner. Figure 3.5 clarifies how the relations between designers and user mediated by an open-ended play artefact differ from non-open-ended artefacts. Figure 3.6 zooms in on this process, presenting the steps from interaction behavior rules created by the designers beforehand through actions of interpretation and improvisation to the created game rules invented by the users during play. This figure shows that open-ended play provides the users with freedom on two levels: interpretation and improvisation. The combination of these figures is useful for designers to understand and apply designing for rule creation in open-ended play and serves together with the implications for design as a comprehensive design advice.

PART II:
STAGES OF PLAY

4

The Stages of Play model

ABSTRACT The previous chapters have outlined several important aspects that make designing for open-ended play a challenging task. Based on these insights, we decided to develop a model that gives guidance to designers in the process of developing open-ended play designs. The aim of the model is to get grip on the dynamic process of playing with an interactive design, which involves many changes over time such as variations in rules, goals and meaning. In this chapter, we first discuss our motivations for developing the model and describe related models of interaction over time. Then we present the model we developed, the Stages of Play model, in more detail. This model describes interaction with an open-ended play design as a process that goes through three stages: invitation, exploration and immersion. Thirdly, we focus on the application of the model by designers. We describe a post-hoc analysis of four design cases in order to explore the different values and uses of the model in the design process. The cases consist of four design projects in which students applied the model. Results show that the model was used in various ways, such as for design, reflection and analysis, which illustrates the different values of the model in the design process.

This chapter is based on:

Valk, L. de, Rijnbout, P., Bekker, T., Eggen, B., Graaf, M. de, Schouten, B. (2012). Designing for playful experiences in open-ended intelligent play environments. In Proceedings of IADIS International Conference Game and Entertainment Technologies (IADIS GET 2012), 3-10.

Valk, L. de, Bekker, T., Eggen, B. (2015). Designing for social interaction in open-ended play environments. International Journal of Design, 9(1), 107-120.

Introduction to this chapter

In open-ended play, play varies and develops over time. Children explore different interaction opportunities, come up with new rules and goals or invite other children to join them. Interactive play environments are able to deal with these changes in play using a combination of sensing and actuating technologies that allows them to respond to players' actions and actively invite them to certain interactions. For designers this means that their task is expanding with inventing and creating the interaction behavior of such play environments, keeping in mind that interaction is a dynamic property that develops and changes over time.

In the previous chapters we have pointed out a number of important aspects when designing for open-ended play. In Chapter 2 we discussed our design approach for open-ended play, which, in short, emphasizes on finding a balance between ambiguity and complexity. Designs for open-ended play should be interpretable in multiple ways, but should not overdo this by offering too many possibilities which makes them too complex. In other words, designs for open-ended play should provide some structure but also leave room for spontaneity. This balance correlates with different steps in the design process. Designers are advised to define and frame their design space early on in the design process and make clear decisions on what to design and what to leave open to the users' interpretation. Designers for open-ended play should follow an iterative design process which involves building interactive prototypes and frequently evaluating these prototypes with potential end-users. Furthermore, Chapter 3 elaborates on one specific aspect of open-ended play, namely different types of rules. In that chapter, four steps were proposed that are relevant when designing for open-ended play with interactive objects: interaction behavior rules, interpretation, improvisation and created game rules. The steps of interpretation and improvisation connect the two different types of rules with each other; players interpret the interaction behavior rules and improvise with them resulting in created game rules. These steps demonstrate that there is a process in the interaction that players have with an open-ended play design. Designers for open-ended play should be aware of the steps of this process and take them into consideration when making design decisions on aspects such as ambiguity, meaningfulness and freedom in interaction.

As summarized above, both Chapter 2 and Chapter 3 discussed important insights and design advice for supporting the design process of interactive open-ended play designs. From practice we have seen that designers experience difficulties in making design decisions in this process as they are not sure which interaction opportunities to choose. Because of our insight that there is a process in interacting with an open-ended play design involving the steps of interpretation and improvisation, we are interested to explore if we can translate this process to a useful design tool. In this chapter, we present a model that we developed to help designers in the process of designing for open-ended play. This model, called the Stages of Play model, provides guidance

to designers by describing interaction with an open-ended play design as a dynamic process that changes over time. When designing novel interactive products, designers often envision possible use scenarios illustrating the interactions between the users and the designed products in a certain context. The Stages of Play model supports designers in developing an interaction behavior scenario for an open-ended play environment. The model takes into account how people are persuaded to start interacting with an open-ended play design and to stay engaged by dividing user-product interaction into three stages: invitation, exploration and immersion.

In the following chapter we discuss our motivations for developing the Stages of Play model and describe a selection of related models of interaction over time. Then, we present the Stages of Play model in more detail and discuss the usefulness and value of the model in four different design cases.

Motivations for developing the Stages of Play model

Play is a dynamic process with a high level of unpredictability. Therefore, play cannot easily be captured in predetermined scenarios. This especially holds true for open-ended play, in which goals and rules are not predefined and can change constantly as they are developed during play in a particular context. Designs for open-ended play aim to enhance these changeable characteristics and support the play dynamics of their users. Play dynamics relate to how one type of play evolves into another, influenced by changes in the social rules or the game rules, the number of players or the objects involved in play.

In this chapter, we are interested to explore how we can support designers in developing open-ended play designs that fit these play dynamics. We focus on the interactions between the user or users and the design. The initiative for these interactions can come from either the users or the design. This influences how the interactive behavior of the design should be shaped: active or reactive, guiding or responding. In order to encourage and support the play dynamics, we believe an open-ended play design should facilitate a dialogue with its users including both active and reactive behaviors. The design should be able to shift from one behavior to another, for instance by providing multiple options for interaction that are either active or reactive. In this way, the design can trigger new interactions as well as support ongoing ones. Users are encouraged to start playing and continue playing, explore new options and be involved in social interaction. In this chapter, we aim to set out how this dialogue with shift in initiatives can be best supported in the dynamic process of play over time.

In related fields such as game design and interactive art, several researchers have investigated changing dynamics in play and interaction. For example, Salen & Zimmerman (2003) argue that players experience play by inhabiting, exploring and manipulating the formal structure of the game. Furthermore, they discuss the concept of the magic circle

in play; a temporary world in which game play takes place with its own rules separated from ordinary life. Salen & Zimmerman (2003) emphasize that game designers should not only design for engagement in the magic circle, in this way seducing players to maintain in the circle to continue their play, but designers should also seduce potential players to enter the magic circle in the first place. Polaine (2010) elaborates on this by presenting four principles for interaction in play. In his view, play starts with the invitation to play, continues with exploring the playing field and the rules, results in the creation of flow, and concludes with delivering the initial promise set in the invitation to play. We will discuss his work in more detail in the next section.

In line with this, we developed the Stages of Play model that describes interaction with an open-ended play design in three stages. The model concentrates on the two steps of seduction as mentioned by Salen & Zimmerman (2003): entering and staying in the magic circle. The model presents the total experience of interaction over time in three stages: invitation, exploration and immersion. In the invitation stage, users are seduced to enter the magic circle and start their interaction with the design. The exploration stage focuses on trying out and attempting to understand the interaction possibilities. In the immersion stage, users are encouraged to remain in the magic circle and to play with and manipulate the design. In the stages, the behavior of the design shifts from taking initiative in the invitation stage, towards merely responding on actions of the users in the exploration stage and mixing reactive and active behavior in the immersion stage.

In the next sections, we will first discuss related models of interaction over time. Then, we will present the Stages of Play model in more detail, focusing on the three different stages, the behaviors that occur in these stages and how design decisions can be made for these stages.

Related models of interaction over time

Three related models of interaction have inspired the Stages of Play model: the language of interactivity (Polaine, 2010), the model of creative engagement (Edmonds et al., 2006) and the curiosity process (Tieben et al., 2011). These three models focus on interactive systems and bring forward interesting insights related to interaction between systems and users, although they do not focus on children. The models consider interaction over time, which makes them more relevant than other HCI models, for instance Norman's (2001) conceptual model.

The language of interactivity (Polaine, 2010) uses play as a lens to examine the interactive experience with interactive artworks or user interface elements. For analyzing and designing these interactive experiences, four principles of interactivity are defined. Firstly, the *Invitation to Play* encompasses being enticed and seduced into interaction. To do this, a design should communicate that it is active and awaiting participation. After a

successful invitation to play, the *Playing Field & the Rules* are important to further engage the interactors. The interactors start to explore the boundaries, rules and affordances of the design. Once the interactors have explored and understood the playing field and its rules, the aspects of *Challenge, Boredom and Anxiety* become important. These aspects relate to the notion of flow (Csikszentmihalyi, 1975), which aims at finding a balance between boredom (not enough challenge or too greater skill level) and anxiety (too great a challenge or not enough skill). The fourth and last principle of *Triviality, Open-endedness, Promises* focuses on delivering the initial promise made in the Invitation to Play.

The model of creative engagement proposed by Edmonds et al. (2006) describes the relations between an (active) audience and an interactive art system through three attributes. The first attribute is attractors which are: "*things that encourage the audience to take note of the system in the first place*" (p. 315). The system should have a feature, which stands out in the context and draws the attention of the audience passing by. The second attribute is sustainers, which are: "*attributes that keep the audience engaged during an initial encounter*" (p. 315). Features of the system should keep the audience interested in the system for a period of time. The third attribute is relaters, which are: "*aspects that help a continuing relationship to grow so that the audience returns to the work on future occasions*" (p. 316). The system should engage the audience to seduce them to repeatedly visit the interactive system.

In their work on curiosity and interaction, Tieben et al. (2011) present the sense of curiosity involved in the process of encountering a novel interactive system from the user's perspective. The authors aim at supporting the development of interaction scenarios in the design process of interactive systems. Based on various theories of curiosity, different principles for evoking curiosity and their role in the explorative process were visualized by the authors. The process of curiosity consists of four steps: encounter, explore, discover and adjust. In the step of encountering, potential users notice the interactive system. While exploring, users try to find out what the system is. In the step of discovering, users interpret how the system works. Based on the previous steps, users adjust their understanding of the system and can move back to the step of encountering.

Figure 4.1 on the next page shows an integrated picture of interaction over time, combining the related models discussed above in one visual.

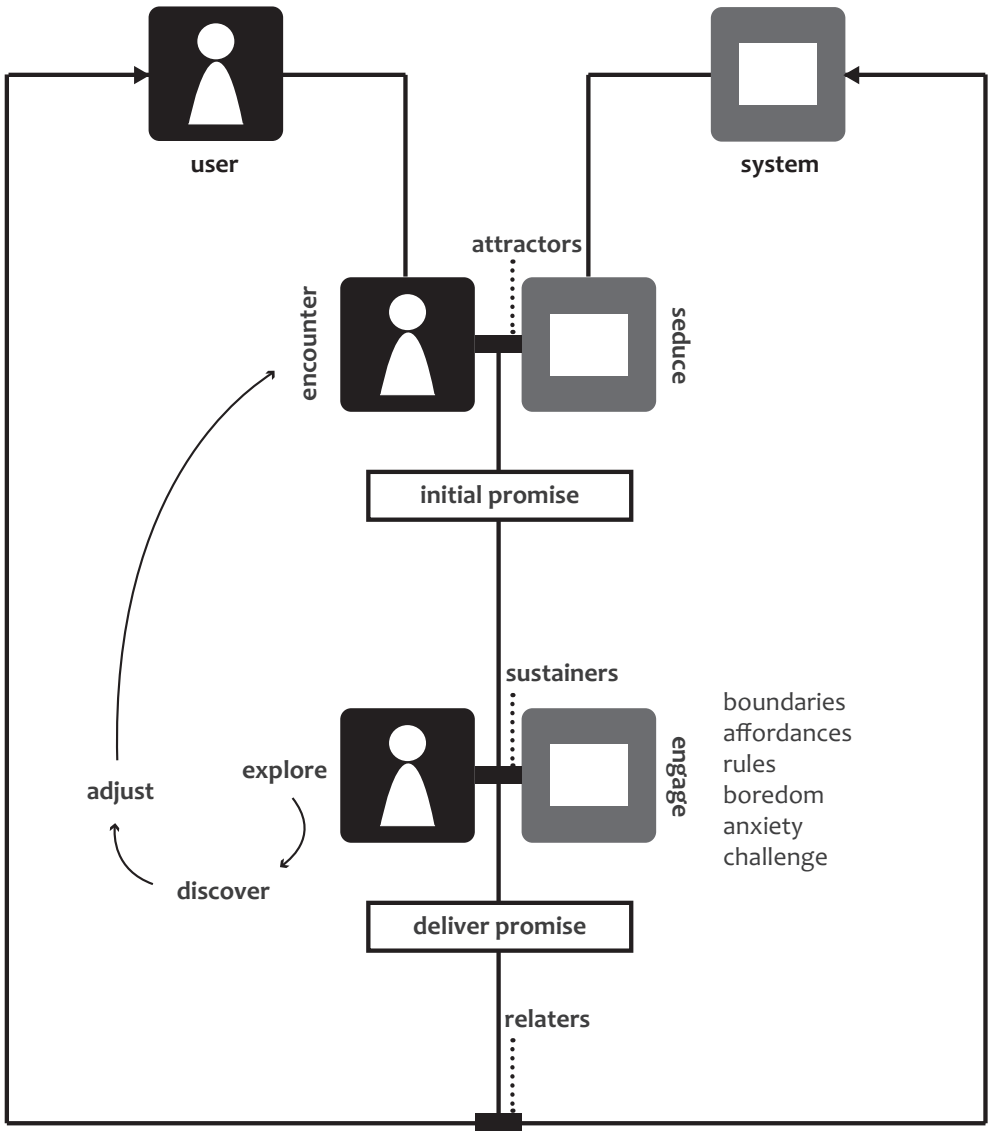


Figure 4.1 This schema combines the language of interactivity (Polaine, 2010), the model of engagement (Edmonds et al., 2006) and the curiosity process (Tieben et al., 2011).

Stages of Play

The Stages of Play model describes interaction with an open-ended play design in three stages: invitation stage, exploration stage and immersion stage (see Figure 4.2). The model helps designers to focus on these core aspects of interaction by bringing together multiple theories on play and interaction and further strengthening them by focusing on nuances and details over time. Designers who apply the model in their design process should take two different perspectives, as is common in interaction design practice. First of all, designers should analyze interaction from the user's perspective, considering how the user will go through the three stages. User actions include noticing the design, trying out different actions and playing with the design and with other players. They come up with goals and rules, define challenges and attach meaning to the design, and become fully immersed in their play activity. Secondly, interaction should be considered from the perspective of the design, focusing on how the design supports the three stages. Design actions include attracting potential users, supporting exploration by offering a variety of interaction opportunities and keeping users engaged. Below, we will discuss the three stages in more detail.

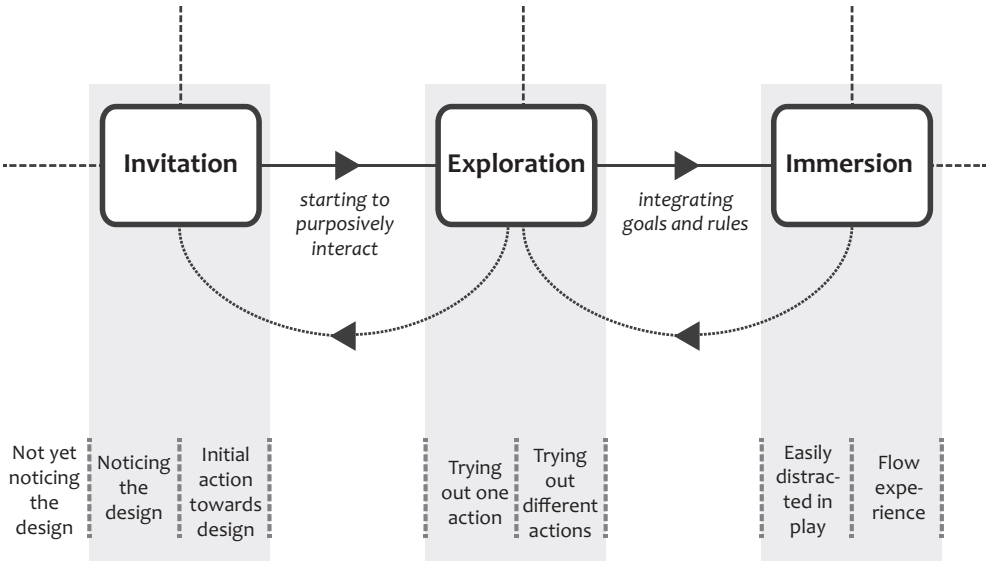


Figure 4.2 Stages of Play model describing actions in the invitation, exploration and immersion stage.

In the *invitation stage*, potential players are attracted towards the interactive objects that form the design and the possibilities for usage they evoke. The designed objects intrigue their audience and make them curious. Perceived affordances (Norman, 2001), expectation feedback (Eggen et al., 1996) or feedforward (Vermeulen et al., 2013) can communicate the opportunities and purposes for interaction. For example, imagine an interactive screen that is placed on a public city square. When someone walks by, the

screen starts to blink. This is an example of an attractor (Edmonds et al., 2006): design properties (such as light, sound, movement) that can be noticed from a distance and that show the interactivity of the design and in this way seduce potential users to come closer and move towards initial action. For instance, the person on the square notices the blinking screen and builds up an expectation that (s)he can interact with the screen. This is a first step of entering into the magic circle of play (Huizinga, 1955; Salen & Zimmerman, 2003), a temporary world with special rules in which game play takes place separated from ordinary life.

When people start to purposively interact with the design, they enter the next stage: the *exploration stage*. For example, the person who encountered the interactive screen starts to move in different directions in front of the screen to investigate how the screen acts and responds. Now, (s)he sees that the screen does not only blink, but also records the silhouettes of people moving in front of the screen. In this stage, the user goes through two steps. First they explore: What does the design do? How does it react, what happens when? Then they move towards: What can I do with it? How can I use it in my play? (Hutt, 1976). Users are involved in exploratory play, not yet bound by rules but investigating the design through play. Exploring variations can already be engaging and fascinating. The design should support the exploratory actions of the user by for instance offering a variety of interaction opportunities so that users are tempted to try out different possibilities.

From the exploration stage, players move towards the *immersion stage*. In this stage users are seduced to remain inside the magic circle and become engaged in interacting with the design. Sustainers (Edmonds et al., 2006) should be incorporated into the design to keep users attracted to the design. They begin to improvise with the design and come up with goals and rules, define challenges and attach meaning to the design. For example, the person on the square can ask other passers-by to join in making an artwork of the silhouettes shown on the interactive screen. Rules are being developed and games are then played following these rules. Eventually, this stage can lead to a flow experience (Csikszentmihalyi, 1975) in which players are totally absorbed in playing and forget about time and place.

Overall, these three stages do not always occur as linear as presented here. From the immersion stage, players can move back to the exploration stage to explore other interaction possibilities or to the invitation stage if a different aspect of the design attracts their attention. After initial use, the invitation stage usually becomes less important although people may still need to be attracted again on a follow-up occasion.

The Stages of Play model is developed to support designers in the process of developing open-ended play designs. The aim of the Stages of Play model is to provide designers with a useful tool that they can apply in their design process to make concrete design decisions. The next section discusses the application of the model in more detail.

Application of the model: four design cases

In this section we illustrate the utilization of the Stages of Play model with four recent design cases performed by Master students of our department of Industrial Design. The results and design processes of the cases provide insights on the applicability of our model.

Models for the design process are often developed to support design activities such as brainstorming about ideas and concepts or redesigning existing designs. Such models aim at making knowledge available for designers and helping designers to incorporate this knowledge in the design process. Examples of design models include sets of cards such as PLEX cards (Lucero & Arrasvuori, 2010) and IDEO Method Cards (2002), toolkits like the Design with Intent toolkit (n.d.) and guidelines such as heuristics for user interface design (Nielsen, 1994).

Models as well as frameworks can be developed for different purposes, such as abstracting, designing and building (Mazalek & Hoven, 2009). The Stages of Play model was developed for designing, and serves as a tool "*in the conceptualizing and design stages by posing questions or challenges, highlighting design considerations, or outlining problem spaces*" (Mazalek & Hoven, 2009). We expect the model to be used as a prescriptive tool in different phases of a design project. It does not give concrete steps on how to design for open-ended play, but it supports understanding which different design decisions should be made. Designers have the freedom to apply the model strategically in the design process. They can use the model in various ways during their design process, e.g. as inspiration for developing an initial concept further or for guidance while creating an interaction scenario. In the earlier part of a design process, the model can be used as an abstract guide to generate design concepts. Later on in the design process, the model supports the development of detailed design decisions and nuances of a design to gain more depth in interaction and specify the concept. The post-hoc analysis of the design cases discussed in this chapter may provide further possible uses of the model. This analysis explores the different roles the model played in the design process. In the course of one year, the model was presented to ten Bachelor and Master Students of which six students applied the model during their design process. For our analysis, we have selected four projects in which the model played an important role in the design process. These projects, from now one called 'design cases', differ on a number of parameters and demonstrate a wide variety of playful designs that support different forms of play such as fantasy, physical and social play.

The design cases result from individual student projects. The first case and fourth case were Master graduation projects, lasting for two semesters (24 weeks). In such a project, the students decide themselves what the focus and objectives of the project will be. The second case and the third case were Master projects that lasted for one semester (10 weeks). The third case was followed-up by a design research activity lasting for an extra

two weeks. These projects were initiated by the department and therefore clearly relate to the research activities described in this chapter. In our department, a lot of emphasis is put on self-directed learning and guiding students to develop their own identity and vision as a designer (see also Bekker et al., 2010b). As a consequence, students still have a lot of freedom to personalize their project, e.g. by choosing a specific context or target group, even though the main objective of the project is predefined.

Information about the model was provided in several ways. In the first case, the student received information on the model in the final (fourth) design iteration of the project, in parallel to the model being formulated at that time. In the second case and third case, the students were introduced to the model in the first weeks of their project. This introduction consisted of a presentation by one of the researchers, background information in the shape of papers and personal contact with the researchers. The student of the fourth case already knew about the model from a previous project, in which she was provided with the same information as the second and third case. See also Table 4.1.

Table 4.1 Overview of the four design cases that were part of the post-hoc analysis.

Case	Project briefs (weeks, year)	Introduction to model
Case 1: *Wondrous Imagination*	Project brief 1: Graduation project (24 weeks, 2012)	Introduced to the model in the final iteration of the project
Case 2: *ZooMor*	Project brief 2: Design research project (10 weeks, 2013)	Introduced to the model in first weeks of project
Case 3: *Wobble*	Project brief 2: Design project (10 weeks, 2013) & Design research activity (2 weeks, 2013)	Introduced to the model in first weeks of project
Case 4: *Lusio*	Project brief 3: Graduation project (24 weeks, 2014)	Student was previously involved in project 2, therefore knew about the model from the start of project 3

The projects were discussed by the researchers in multiple sessions, using the final reports from the students as well as personal memories. These discussions led to a summary of how the model was applied in each design case, which was communicated back to the students. They critically reflected on the text recalling their personal experiences and gave feedback to improve the interpretation. At this moment, all students already finished their projects so they could give their feedback honestly without being concerned that this would influence their course assessment in any way. For each case we will now briefly describe the design and discuss how the Stages of Play model was applied and which insights resulted from this.

DESIGN CASE 1: WONDROUS IMAGINATION

Design concept: Wondrous Imagination focused on designing an interactive play concept that evoked storytelling, creativity and fantasy play. The play concept consists of a carpet symbolizing an unfamiliar, adventurous world and a set of abstract, interactive tangible objects (see Figure 4.3). While playing with the carpet, children can take along a number of stuffed toys or their own toys. Children can place the interactive objects on specific places on the carpet. The objects then react by lighting up in a certain color. When children place one of the toys on top of an object, the light of that object changes its color. The design aims at triggering children's fantasy and gives them the opportunity to direct their play by controlling the objects and the toys.

Figure 4.3 Wondrous Imagination: carpet, interactive objects (white) and stuffed toys.

Process: The student followed a process of explorative prototyping involving four design iterations. The first three design iterations focused on enhancing the carpet and the interactive objects. Each iteration concluded with a user evaluation, involving children in the age of two to four years old. Although children seemed to enjoy playing with the design and spent a lot of time discovering its opportunities, it appeared to be difficult for them to move towards fantasy play and start creating a story with the design.

As a new stimulus, at this point the student got acquainted with the Stages of Play model. He integrated this model in the final fourth iteration by putting the existing scenario of use next to the model and identifying bottlenecks in the dynamics of inter-action. In this way, the model made clear that for the immersion stage to be reached in interaction with the design (in which the actual fantasy play should take place), the first two stages (invitation and exploration) should be addressed as well. In retrospect, this clarified why in earlier iterations the actual storytelling and creative, fantasy play was not present as much as expected. Especially the invitation stage of getting children drawn into (the mood of) the story was missing.

Besides identifying bottlenecks, the model also guided the student in redesigning the design concept, taking into account all three stages. Based on the model, the student identified a number of design guidelines for the different stages in interactions. He developed a tangible story book to serve as a trigger for children to start interacting

in the invitation stage, including an open end that stimulates children to continue the story on the carpet using their creativity. Evaluations at the day-care center showed that the story supported the invitation stage of the play concept. While reading the story, children got excited about the characters and the storyline. They imitated the sounds of the various animals and were very curious about how the story would develop. When the children moved to the carpet, they explored the possibilities of the different objects together with the toys and continued with the story. The group leaders confirmed that the addition of the storybook and the visual carpet (invitation stage) as well as the interaction and form of the objects (exploration stage) improved the likeability that more elaborate stories would be invented by the children over time.

Summary: In this design case, the Stages of Play model helped to gain more depth in interaction opportunities. The model provided guidance in aligning the scenario of use with the dynamics of interaction. In this way, the student critically reflected upon his design and identified weaknesses in interaction between user and product. By dividing the interaction into smaller parts (the stages), the student could make conscious design decisions improving the overall design.

DESIGN CASE 2: ZOOMOR

Design concept: ZooMor (Paesschen et al., 2013) was designed as a 'sleeping' zoomorphic creature evoking pretend play among children. ZooMor looks like a cuddly animal with a symmetric basic form and a heightened back allowing children to sit on it and crawl underneath it (see Figure 4.4). The design of ZooMor is intentionally open-ended to stimulate children's interpretation and pretend play.

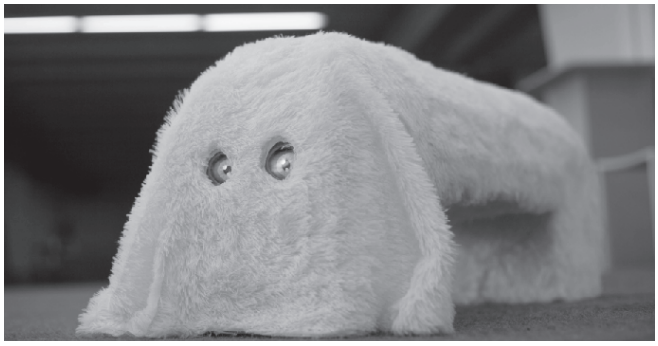


Figure 4.4 ZooMor: third design iteration.

Process: In total, three design iterations were performed, all completed with an exploration at a public play center where children (ages ranging from three to nine years old) are free to drop in and play with the toys that are available. On average, five to ten children played with ZooMor for five up to thirty minutes. Play sessions were observed and children were asked about their experiences afterwards.

This student used the Stages of Play model as a design process framework; putting

emphasis on one of the stages for each of the iterations. The model provided focus in the design process on one aspect of interaction. The first design iteration focused on the invitation stage. The Stages of Play model made clear that ZooMor should evoke curiosity for children to approach it further in the invitation stage. Therefore, the sound of snoring was chosen when ZooMor was inactive (sleeping). Results from evaluating this iteration showed that the snoring did invite children to approach ZooMor and start playing with it.

In the next iteration, the exploration stage was investigated. The model suggested that children should be supported to investigate the possibilities of the design. Therefore, a redesign of ZooMor was carried out adding two eyes that can light up. Also, an additional ZooMor was created with the same functionalities but in a different color. Evaluations showed that these changes led to a stronger zoomorphic perception. Children were talking about the two ZooMors as living creatures frequently. Furthermore, ZooMor stimulated children to explore its behavior, but it did not engage them for a long period of time.

Finally, the third iteration focused on the immersion stage. The model shows that children should be able to attaching meaning, rules or goals to the design in order to reach the immersion stage. Therefore, this iteration aimed at developing richer behavior for ZooMor than only awake or asleep; to eventually elicit more variety in play. ZooMor's eyes were redesigned: they could be open or close and anything in between. In this way, children can attach different meanings to the state of ZooMor such as tired, dreamy or happy. Again, this iteration was evaluated with children. Observations showed richer and longer lasting play, with children attaching meaning to the state of the eyes.

Summary: This design case illustrates how the Stages of Play model can be used as a framework to guide the design process. In this case, the framework was systematically used to structure the process, focusing on one of the stages in each design iteration. Information on the different stages from the model supported design decisions.

DESIGN CASE 3: WOBBLE

Design concept: Wobble (Beukering et al., 2014) is an open-ended play environment designed for children in the ages of four to six years old. The design consists of multiple interactive objects (balls) on a flexible stem so that the balls can move around a bit (see Figure 4.5). Lights inside the balls softly pulsate. When children touch or push the balls, the lights react by changing color or jumping from one ball to another. The design intention is to stimulate fantasy play, as if the lights inside the balls are living creatures that can fly away.

Process: This design case consisted of two parts. The first part was the design project, in which the design concept of Wobble was developed. In this part, the Stages of Play model was used again as a design framework, although not as structured as in Design

Case 2. Design decisions were made based on the stages. For instance, the lights in the balls aim to trigger curiosity and fascination. Children are encouraged to explore and wonder what the lights do and how they can influence them. The intention is to create an imaginary world that stimulates fantasy play in the immersion stage.

Figure 4.5 Children playing with Wobble.

The second part consisted of an extra evaluation study that the student performed as a design research activity. In this part, the Stages of Play model was used as a research tool to code how social play developed over time. The stages were used to classify behavior and accordingly helped in structuring the data. The model also helped in formulating assumptions beforehand by taking the three stages as starting point for classifying behavior. These assumptions were evaluated in an evaluation with 18 children who played in groups of three with Wobble for 15-20 minutes. Results show that social behavior of the children changed from one stage to another; from merely solitary play in the invitation stage, to parallel play in the exploration stage and group play in the immersion stage. As these results show quite distinct changes in social play over the three stages, the model was thus also useful in communicating the outcomes of this study more clearly.

Summary: This design case explains how the Stages of Play can be used as a framework for design as well as a basis for a coding scheme in design research. Concerning the latter, the model was used as a research tool and supported defining assumptions beforehand and analyzing the observations afterwards. Using the model as coding scheme gave direction to the analysis and divided the total play session in smaller digestible parts.

DESIGN CASE 4: LUSIO

Design concept: Lusio (Hooft van Huysduynen, 2014) is a set of C-shaped interactive play objects designed for both indoor and outdoor environments (see Figure 4.6). The objects react with light and sound feedback on actions as shaking, spinning and rolling. For instance, shaking the object changes the color of the light and rolling results in a sound being played. Also, two objects can be merged together creating a ball shape that can be thrown or rolled. The aim of Lusio is to support creative, social and physical play. Objects can communicate with each other to support social interaction. Children can

play with one of the objects in parallel, or involve multiple objects in social group play. Lusio can be used in gym class, or children can play with it freely during breaks at school.

Figure 4.6 Lusio: two objects merged together.

Process: The project in which Lusio was developed consisted of a research part and a design part. The last part was more market-oriented and resulted in Lusio. Lusio was inspired by a design developed in the first (research) part of the project. This earlier design was used as a research prototype in an extensive user evaluation involving 90 children.

This design case integrated the Stages of Play model as a reflection framework; existing knowledge in the mind of the designer that she referred back to at certain points during the design process. The student was already acquainted with the model from a previous project and already internalized knowledge on the model, making it part of her conscience or tacit knowledge as a designer. In this case, the model was used in both parts of the project. In the research part, the model inspired the development of the research prototype. The student did not deliberately design for one stage or used explicit guidelines as a starting point, but the model was merely part of her tacit knowledge on how to design playful interactions. The student checked several times in the design process if the stages were present in the design.

In the analysis of the user evaluation, the model was also used to reflect upon how children played with the design. In the design part, knowledge of the model was present at the concept development phase, but again this was not done very systematically or explicitly.

Summary: In this design case, the Stages of Play model was merely used as a repetitive reflection framework during several moments in the project. The model was not used as part of a formal expert review, but the student used it for frequent more in-formal reflections. The student was already acquainted with the model from a previous project, and almost naturally integrated it in her design process. In this way, it became part of her 'designer's conscience'. The model showed its value during the concept development phase as well as during the user evaluation analysis.

Discussion

This chapter introduces the Stages of Play model, developed to provide guidance to designers in making design decisions in the process of developing interactive open-ended play designs. We discussed our motivations for developing the model and outlined how the model relates to existing models of interaction over time. Moreover, we carried out a post-hoc analysis of four design cases to explore the usefulness and value of the model, which resulted in a number of possible uses for the model by designers.

At first, the Stages of Play model may seem slightly trivial, but designing for open-ended play without any guidance can be very difficult, as described in the previous chapters. Many designers immediately strive for the immersion stage, forgetting about the nuances to get people involved and help them explore before they can get immersed. The Stages of Play model helps in noticing approaching pitfalls and can be used as a tool to communicate and explain the design and its credibility to others. In this way, the model can be useful for designers who have little experience in designing for open-ended play as well as for more experienced designers who might have already internalized the design knowledge represented in the model.

The Stages of Play model is 'just a model', in the sense that it is a representation of what happens in real life. The model does not show all possible lines of interaction. For example, one can imagine that not only the design but also other people in the proximity influence interaction. A more complex visualization might include more of these possibilities, but does not improve the readability of the model. In the next chapters we will focus more on the social context of the model (Chapter 5) and examine prolonged play (Chapter 6).

Another important aspect of the model is the context for which the model is used. There is a difference between people who have no prior experience in interacting with the open-ended play design ('newcomers') and people who have already experienced the design in a previous occasion. For newcomers, interaction always starts at the invitation stage. This stage is thus very important in order to get people to actually start interacting with the design. When people have experienced the design before, they still should be triggered to try it again, although positive previous experiences will also have a large influence in this decision. The newcomers' perspective is extra relevant when designing for a public space (e.g. a city square where a lot of tourists come), whilst the experienced perspective relates more to contexts such as a neighborhood playground or a school environment. In Chapter 6 we focus on the experienced users in a study on prolonged open-ended play.

The post-hoc analysis of the application of the model has demonstrated how the Stages of Play model can guide designers, but there are some limitations to our research that we would like to address here. The four design cases were carried out by students from our own department, which might have affected how and why they used the model

and how they reflected on this. The students were acquainted with the model by us, their superiors, but they had the freedom to choose whether to use the model or not. As we were mainly interested in qualitative (how they used the model) more than quantitative (how many students used the model) data, we did not force the model upon them. When we asked the students to reflect on the summaries we created on how they used the model in their design process, all students already finished their projects and they could give feedback without having to be concerned that this would influence their assessment in any way. Moreover, although (especially Master) design students have developed design knowledge and skills, they are still learning to become design researchers or practitioners. We believe design students can best be compared to 'novice designers', which we think is the most interesting target group for our Stages of Play model. With novice designers we mean recently graduated designers but also more experienced designers who are new to the field of designing for open-ended play.

All design cases presented in this chapter were focused on designing playful designs for children. As this thesis focuses on children, so do a lot of the related student projects in our department. We believe that the Stages of Play model is wider applicable (i.e. for other target groups), but designers should be aware of certain nuances. For example, children tend to be very curious and open to explore new designs. Teens are already more influenced by the social space in which the interaction occurs; what do their peers do? Is it appropriate for them to think this is cool? Adults can be more hesitant and might need a more convincing trigger to start interacting. This also relates to the context for which a design is developed. People might be more open to try out an interactive installation in a museum than on a public square. Designers should keep these nuances in mind and quickly explore and try out various interactive designs in order to validate their assumptions.

Conclusion

In this chapter we have presented the Stages of Play model, which describes interaction over time in three stages: invitation, exploration and immersion. We argued that this model gives guidance to designers of interactive, open-ended play designs. This model helps designers to focus on core aspects of the dynamic process of interaction.

The Stages of Play model brings together the related models of interaction and attempts to map the players' behavior as well as the design properties for each stage. Moreover, the Stages of Play model aims to go one step further from being merely a theoretical model to examining how this model can be applied as a design tool in the design process. To sum up, this reflection on existing related models of interaction and the formulation of our own model has given us some initial insights on relevant steps and constructs such as:

- Having an attractor and setting an initial promise in the invitation stage.
- Letting users explore boundaries, affordances and rules and supporting them to move from exploration to discovery in the exploration stage.
- Engaging players in the immersion stage by implementing sustainers, finding a balance between boredom and anxiety, offering challenge and delivering the promise.
- Think of relaters for recurring encounters.

Furthermore, the post-hoc analysis of the four design cases shows different purposes for applying the model in the design process. Overall, the design cases demonstrate the usefulness of the model in iteratively enhancing ideas and concepts. Usually, students start their first design iteration with developing a global idea focusing on immersion. The model supports them to start thinking about earlier stages of interaction (invitation and exploration) in follow-up iterations and to gain more depth in their ideas on immersion. Moreover, the design cases describe different purposes and ways to use the model including design, reflection and analysis. The model serves as a design framework, guiding the design process and supported making design decisions. Also, students use the model as a reflection framework much like a 'designer's conscience'. Another option is to apply the model as an analysis framework to analyze research data by giving direction or by being implemented in a coding scheme. The model can be used during different moments in the design process: at the start to give some direction, along the way to support design decisions and to give a fresh impulse when being stuck, or throughout the design process to reflect on different steps made. Table 4.2 summarizes the cases, the application of the model and the resulting insights.

Table 4.2 Applications of the model and concluding insights for the four design cases.

Case	Application of model	Insights
1	Gain more depth in interaction	Model helped in viewing concept 'as a whole', identifying design issues and acknowledging the importance of the invitation and exploration stage to reach the immersion stage
2	Design process framework	Model gave direction to the design process and supported making design decisions
3	Coding scheme	Model helped in defining assumptions and guiding the analysis of observations
4	Repetitive reflection framework	Model was useful in reflecting on concept in different phases of design and analysis and became part of the designer's conscience

Before analyzing the design cases, we expected that the Stages of Play model could have value as a design tool that can be used as inspiration in the initial phases of developing design concepts and as guidance for further specifying interaction details in later phases

of a design project. The insights presented above expand this view as the model is not only used in guiding design decisions, but also in analyzing user's interaction behavior and as a reflection tool to critically evaluate the quality of the developed design. These novel insights further strengthen the usefulness of the model for designers of open-ended play designs.

Reflecting on these design cases helped us in gaining a better understanding of the Stages of Play model. Based on how the model was interpreted and applied, we were able to list a number of design questions for the different stages as an addition to the Stages of Play model. Answering these questions helps designers in making the model more practically applicable for their specific design challenge. These design questions are:

- General questions include: *Does the design concept fit all three stages? Does the design emphasize on one of the three stages? How does the design support transitions between the stages? Are there any weaknesses in the interaction flow?*
- More specifically for the invitation stage, questions arise such as: *How does the design communicate its interactivity? How are design properties integrated that attract potential players? Which senses (e.g. sight, hearing) work best for this particular context? What kind of actions should the design stimulate in this stage?*
- Questions concerning the exploration stage include: *How to evoke curiosity to explore the design further? Does the design support diverse exploration? Are there various interaction opportunities to explore? Does the shape of the design offer any flexibility to move around?*
- For the immersion stage, related questions are: *Which design elements keep users involved with the design? How can users attach meaning to the design? How does it support play on the long-term? How to create richness in immersion behavior?*

Overall, this chapter emphasizes how the Stages of Play model provides guidance to designers. We expect that these insights inspire and support other designers in the challenging task of designing open-ended play designs. In order to further develop our knowledge on designing for open-ended play with the Stages of Play model we will investigate the model in more depth in the next chapter by focusing on the social context of use and discuss how social interaction develops in the Stages of Play.

5

Social interaction in the Stages of Play

ABSTRACT As play is often a social experience, understanding the dynamic social context in which such play takes place is an essential step in designing new interactive play environments. In this chapter, we explore the notion of social interaction in the context of open-ended play environments. We describe two design case studies of open-ended, interactive play environments: GlowSteps and Wobble (see also Chapter 3) and discuss how the designs support social interaction. We use the Stages of Play model as presented in the previous chapter to guide our analysis. Results show that social interaction changes over the three stages, starting with solitary play in the invitation stage and moving towards more complex social play in the later stages. These results are translated into implications for design, which guide designers in achieving a better understanding of how to design for the social context of their design proposals.

This chapter is based on:

Valk, L. de, Bekker, T., Eggen, B. (2015). Designing for social interaction in open-ended play environments. International Journal of Design, 9(1), 107-120.

Introduction to this chapter

Open-ended play designs are often used socially; children play together or compete with each other, negotiate about rules and goals and share each other's fantasy worlds. This makes social interaction an important aspect to consider when designing for open-ended play. In Chapter 4 we presented the Stages of Play model which demonstrates three stages in interaction with an open-ended play environment: invitation stage, exploration stage and immersion stage. So far, our investigations with the model focused largely on a player's individual interaction with a design and the influence of the social context in which play often occurs was not yet considered. In this chapter, we will investigate how social interaction develops through the three Stages of Play (invitation, exploration and immersion) and what this implies for designing for open-ended play. Previous research has examined social interaction in open-ended play (Creighton, 2010; Rosales et al., 2011a) but this research did not look specifically at how types of social play might change during a play episode.

Social interaction is a process of reciprocal actions between multiple people. Social skills are the abilities allowing the initiation and continuation of this kind of interaction. Basic social skills can be categorized as emotional or social expressivity, sensitivity and control as well as social manipulation (Riggio, 1986). As they grow older, children develop these skills, such as perspective taking, understanding each other's intentions and emotions as well as conflict situations (Berk, 2006). Applied research on social skills and children largely concentrates on enhancing these skills during play or learning activities. This kind of research provides us with important information on social interaction. For example, in their work on designing for social interaction through physical play, Bekker et al. (2010c) list a number of indicators for social communication such as turn-taking, imitation, shared gaze and joint attention. A large body of research focuses on children with autism spectrum disorder, as these children often experience difficulties in social interaction. Most of this research aims to enhance children's social skills such as collaboration, making eye contact, initiating and terminating interactions, expressing emotions, establishing joint attention, understanding another person's interests and emotions (e.g. Tentori & Hayes, 2010; Hourcade et al., 2011; Escobedo et al., 2012). For this field of research, Gal et al. (2009) developed the Social Interaction Observations (SIO) scale, which assesses social interaction in four categories: play; positive social interactions; negative social interactions; and autistic behaviors. These categories list a number of relevant social behaviors for children in general, such as comforting, helping, sharing, negotiating, smiling (category of positive social interactions) and parallel play, social play and complementary play (category of play).

This chapter aims at gaining a better understanding of the dynamic social use of an open-ended, interactive play environment and to provide insights into how to design for this. We explore how social interaction occurs in the three Stages of Play in an open-ended, interactive play environment through an analysis of two design case studies.

We translate these insights into implications for design, presented in a complementary way using through visuals (models) and text (guidelines) that combine to serve as comprehensive design advice for researchers and practitioners aiming to develop open-ended play designs. In the next section, we first describe related work on social interaction concerning human-computer interaction and child development and play.

Related work

This section describes social interaction from the perspective of Human-Computer interaction (HCI) and Child Development and Play.

HCI

The field of designing interactive technology traditionally focuses on interactions between a user and an artefact (Norman, 2001). Recently, more attention has been given to the social use perspective rather than the standard individual use perspective. The use of terms such as collective interaction (Petersen & Krogh, 2008; Fogtmann et al., 2011) and co-experience (Battarbee, 2003; Forlizzi & Battarbee, 2004) are becoming more widespread. In collective interaction, collaboration is supported as multiple users are required to fully control the system. Such a system aims to encourage users to negotiate shared goals and to become involved in collective action. Co-experience considers user experience as something that is constructed in social interaction. Meaning and emotion is created together or shared with others as people interact with a system.

Ludvigsen (2005) developed a conceptual framework for interaction in social spaces to focus the designer's attention on social interaction. This framework lists four levels of social interaction structured along a scale of engagement (from low to high): Distributed attention, Shared focus, Dialogue and Collective action. In the Distributed attention level, people are present in the same space but with a low level of social interaction (e.g. each person has a different focus around the space). In the Shared focus level, people share a single focus. In the Dialogue level, people engage in a shared activity, investing themselves and their opinions. In the Collective action level, people are working together towards a shared goal. This framework presents the different levels of social interaction that can occur when people encounter interactive technology in a social space, but it does not provide designers with clear design guidelines (e.g. how to design for one specific level of social interaction, or should all levels be present in one design?), nor does it show how people can move between different levels of social interaction over time. This chapter attempts to enhance this model by relating it to the Stages of Play model (see also Chapter 4).

CHILD DEVELOPMENT AND PLAY

Social interaction has also been widely studied in fields as sociology (Parten, 1932), child development (Broadhead, 2004; Berk, 2006) and consultancy (Acuff & Reiher, 1997).

By playing together and interacting with others, children learn social and emotional skills such as taking turns, sharing, cooperating and respecting each other's views and opinions. During play, behavior oriented towards other children is often observed. Children share an artefact or an environment, for instance when they share a ball in a soccer game or a hopscotch diagram drawn on the pavement. They negotiate about shared goals and use the same artefact or environment to achieve these goals. In our research we mostly focus on children in the age ranges of 6-8 years old. Younger children (aged 4-6) are mostly self-centered and impulsive. They are usually involved in parallel play rather than playing cooperatively or interacting with peers (Acuff & Reiher, 1997). At around the age of 6, children start to become more interested in playing together with one friend or a group of children (Parten, 1932; Acuff & Reiher, 1997). They change from being largely self-centered to more peer-oriented. Competition becomes stronger, as children want to figure out what they are good at and how this compares to others (Acuff & Reiher, 1997).

Many scholars have made classifications for social play. For example, the Play Observation Scale (Rubin, 2001) identifies three levels of social play: solitary, parallel and group play. This scale builds upon Parten's classification of play participation (1932) that divides social play into six types, related to a child's development: unoccupied play, onlooker behavior, solitary play, parallel play, associative play and cooperative play. Very young children usually engage in unoccupied play when they are not actually playing but just observing and performing random movements. In solitary play, children play on their own with no attention for other children in their surroundings. Children express onlooker behavior when they are not involved in play themselves but are observing other children who are playing. In parallel play children play next to each other, but still separately as each child focuses on his or her individual play and does not combine this play with that of others. In associative play children share their materials and interact with each other but their play activity is still self-centered. Cooperative play involves children playing an activity together. The theory of Broadhead (2004) zooms in on these social play behaviors. In her Social Play Continuum, social play behavior is described on four different levels: associative play, social play, highly social play, and cooperative play. These classifications show us how social interaction can differ in play. Further on in this chapter, we will use these classifications again to describe social interaction through the Stages of Play for two user studies with interactive play environments.

Evaluation of design cases

We carried out an evaluation of two design cases of interactive, open-ended play designs in a social context. In this section we discuss the goals and research questions, set-up and methodology, and the data analysis procedure.

GOALS AND RESEARCH QUESTIONS

We are interested to examine how interactive, open-ended play designs support social interaction through the three Stages of Play: invitation, exploration and immersion. This resulted in the following research questions: *How do children play socially in the three Stages of Play while playing with an open-ended play design? And what does this implicate for designing for open-ended play in a social context?*

We expect the research questions to lead to the following contributions: (1) an improved understanding of social play in the Stages of Play; and (2) a translation to implications for design.

SET-UP AND METHODOLOGY

To answer our research question, we analyze two recent design cases: GlowSteps and Wobble. Both design cases consists of an interactive, open-ended play environment which has been qualitatively evaluated with children in a social context. The two cases were selected because the Stages of Play model was important in their design process and the user evaluations showed that they were successful in supporting diverse gameplay (e.g. children came up with various games and forms of play). Below, we describe the developed design, the interaction scenario and the set-up of the user study for each case. After this, we discuss the process of analyzing the design cases.

GlowSteps: GlowSteps (Valk et al., 2013b) is an open-ended, interactive play environment that consists of interactive tiles that react with light output on player's actions (see also Chapter 3). The play scenario in Figure 5.1 illustrates how children can play with GlowSteps. In this scenario, Lisa comes up with the goal to step on the green light. She also mentions the rule that stepping on the ground is not allowed. The scenario shows competitive play (Lisa and Dave trying to be the first to step on the green light and Mike obstructing them) and cooperative play (Lisa cheering for Dave when he catches the green light).

Lisa and Dave are playing with GlowSteps. Lisa points at the green light: "We have to step on green!" She jumps over the tiles towards the green light. Dave runs over the floor and is faster at the light than Lisa. "You're out," she says, "You are not allowed to touch the floor." Dave shrugs his shoulders but does not protest. After a while their friend Mike joins them. He likes to obstruct Dave and Lisa. Dave makes a diversion and tricks Mike. He cheers and Lisa shouts: "Yes!" when Dave jumps on the green light.

Figure 5.1 GlowSteps: play scenario and design prototype.

GlowSteps can support different interaction scenarios. In the user study discussed in this chapter, we activated the scenario 'Catch' (see Figure 5.2). Randomly, one of the tiles lights up its corners in green briefly (1). When the light is 'caught' by stepping on the tile, all corners of the tile briefly light up in a white flash, turn green again and then fade out (2). If the light is not caught within a certain amount of time, the green light moves to another tile, performing the same actions there. If a player steps on an inactive tile (i.e. with no light), this tile turns red (3). The green light now turns blue, freezes and slowly fades out. Catching the blue light has the same effect as the green light (4).

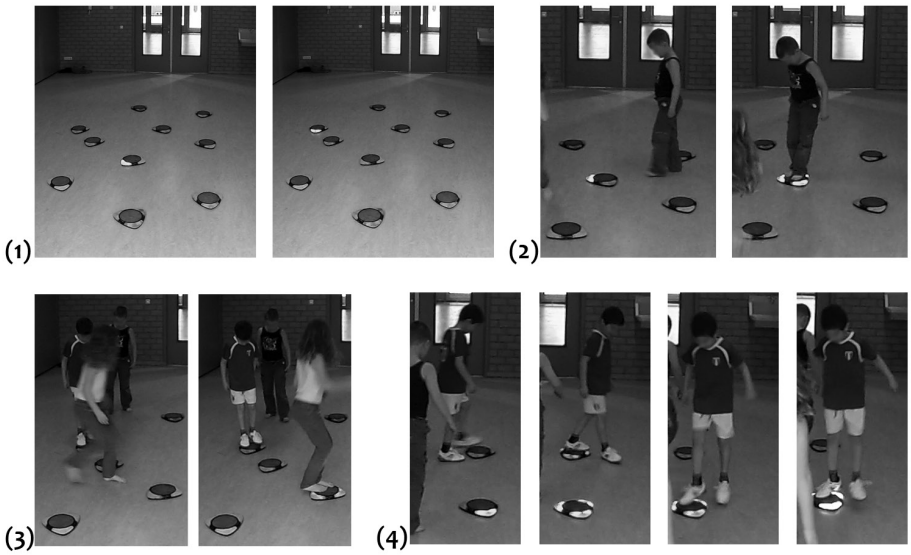


Figure 5.2 Interaction scenario 'Catch'.

We evaluated the 'Catch' scenario with 36 children during a two-day explorative user study at a primary school. Each day, six groups of three children played for about ten minutes with GlowSteps; in total 36 children divided into 12 groups. The age of the children was 6-9 years old, with an average age of 7. Groups were of mixed gender and composed by the teacher based on which children were likely to enjoy playing together. The study took place in a separate room at the primary school. Children entered the room together with the moderator (one of the researchers). They were told that they could play with GlowSteps but no explanation or specific instructions were given to prompt the children's creation of their own gameplay without any directions or hints. When children asked for instructions or approval of their ideas, the moderator would encourage them to try it out. For all groups, the moderator and another researcher present in the room made real-time observations. In consultation with the primary school, only the play sessions from the second day (six groups with 18 children in total) were video recorded due to a delayed regulation with consent forms.

Wobble: Wobble (Beukering et al., 2014) is an open-ended play environment for fantasy play consisting of a set of interactive balls on a stem (see also Chapter 3). Wobble aims to trigger children's curiosity and stimulate them to develop their own imaginary worlds. The play scenario in Figure 5.3 illustrates this. Both Alexa and Patty try to turn the lights in the balls on, but in different ways. Alexa believes in magic and makes wizard movements, while Patty tickles the balls to wake it up. In the end, they play together towards the goal of turning all the lights on.

Alexa and Patty are playing with Wobble. Alexa makes 'wizard-like' movements with her hands to control the lights. She says: "Abracadabra, lights turn on!" while pointing at one of the balls. Patty sits in front of one of the other balls. "Look," she says to Alexa, "if you tickle the ball it will wake up!" Alexa runs from one ball to another. "We have to turn all the lights on!" she shouts while still making her wizard movements. Patty joins her and says: "Oh naughty ball!" when one of the lights turns off again.

Figure 5.3 Wobble: play scenario and design prototype.

The interaction scenario of Wobble is as follows (see Figure 5.4). The objects are grouped together at a distance of approximately three feet. At the start, some balls will softly pulsate and lights will jump from one ball to another. When a child subtly pushes a ball, the lights in that ball react by changing color. When a child pushes the ball a little harder, the light will jump to another ball, as if the lights ('creatures') fly away.

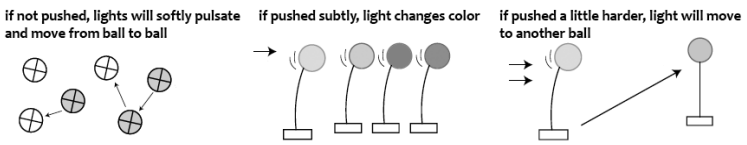


Figure 5.4 Interaction behavior of Wobble: not pushed, pushed subtly and pushed a little harder.

Wobble was evaluated in an explorative study with eighteen children, eight girls and ten boys, aged 4-6 years old. These children played with the design in groups of three during a free play session of 15-20 minutes. Some groups were same-gender. Others were mixed-gender. The teacher formed the groups based on the likeliness of how well the children would play together. The study took place at the children's school (a different school than where GlowSteps was evaluated) where Wobble was placed in an unused classroom. Each session started by guiding the children to the classroom where Wobble was set up. After entering the classroom, the moderator (the student) left the children alone with Wobble for about half a minute to evaluate the invitation stage. Next, the moderator gave the children a short introduction and invited them to explore

the design. After five minutes, the interaction was further explained and the children were asked to come up with a game. When the children got distracted or started talking to the moderator, their attention was brought back to the design. Video recordings were made of all sessions.

DATA ANALYSIS PROCEDURE

Both design cases involved a user study in which we observed how children played with the design prototypes. This section describes the analysis of these observations. Data was collected through real-time and video observations for GlowSteps and only video observations for Wobble.

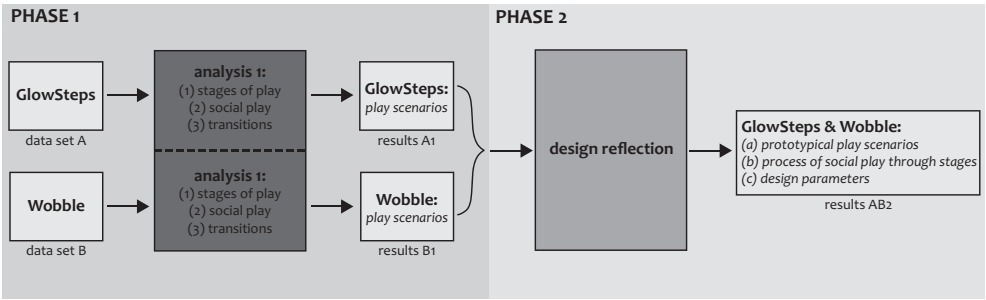


Figure 5.5 Process of analysis.

Our analysis of the data consisted of multiple phases (see Figure 5.5). In the first phase, each design case was analyzed separately through a process of open coding (Strauss & Corbin, 1990). This analysis was performed asynchronously and by a different set of researchers. For both cases, the analysis consisted of three steps, which each had a different focus for categorizing observational notes. In the first step, the Stages of Play model was used to categorize the observations as part of the invitation, exploration or immersion stage. The second step consisted of analyzing the observations with a focus on the type of social play: solitary, parallel and group play. In the third step, attention was given to the transitions between the stages and how one type of social play changed into another type of social play in the stages.

The three steps led to a collection of play scenarios, describing social play in the Stages of Play. Each design case led to around 15-20 different play scenarios divided over the three stages with the largest part of the scenarios concerning the immersion stage. The following two examples illustrate what the play scenarios look like. The first example involves children interacting with GlowSteps in the exploration stage: "*One girl steps on the tile in front of her and then over to other tiles. Quickly, the other girl also steps on the tile in front of her. The boy waits for a longer period of time, but then also jumps on a tile. Now, they all step from one tile to another without touching the ground and giggle.*" The second example concerns children playing with Wobble in the immersion stage: "*Two children are playing with one ball. They have a short conversation about possible*

interaction goals. The girl says: "Let's tickle the ball!" The boy responds: "Yes, we should wake this light up!" and they start to perform these actions." As these examples show, the play scenarios describe actions and behaviors and can include utterances pronounced by the children playing.

In the second phase of analysis, we carried out a reflection on the two design cases by comparing the play scenarios from GlowSteps and Wobble to arrive at more general results from a holistic perspective. For each of the three stages (invitation, exploration and immersion), we reflected on the social play scenarios, using constructs from related work on social interaction (e.g. social behaviors as mentioned by Gal et al. (2009), the types of play from Parten (1932), Rubin (2001) and Broadhead (2004) and the levels of social interaction by Ludvigsen (2005)). This reflection led to a number of prototypical play scenarios describing the predominant types of social play and interaction in each stage. Comparing both cases led to an improved understanding of the process of social play through the Stages of Play. Finally, the play scenarios demonstrated which design parameters influence social interaction. In the next section we will discuss the results of the design reflection.

Results

Based on the analysis of both design cases we now describe how social interaction develops through the Stages of Play. This section discusses the results of our analysis per stage, starting each stage with a short anecdote from the GlowSteps study. Then, we give a brief summary of how children played in both user studies and continue with a description of prototypical social play scenarios.

INVITATION STAGE

Two boys and one girl approach the play room and stand behind the glass door looking at GlowSteps. They wait for the moderator to open the door. The boys walk towards the tiles and look at them. One boy runs around actively and says: "Oh very cool!" The girl stays a bit behind. All children wait for the permission of the moderator to start playing with the tiles. The boys immediately approach the tiles and the girl follows a few seconds later.

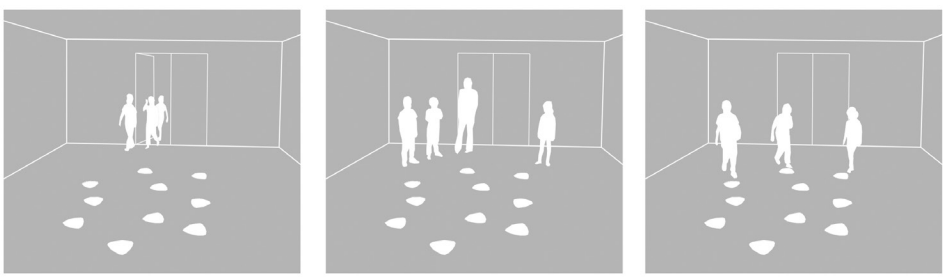


Figure 5.6 Invitation stage: entering the room, listening to the moderator and approaching the design.

Each experience of interaction with GlowSteps and Wobble starts at the **invitation stage.** In groups of three, the children enter the play room, encounter the design and make enthusiastic remarks about it ("Wow! Cool!"). Clearly, they assess the physical shape as well as the flashing green light (GlowSteps) and the pulsing lights (Wobble) positively without having experienced any interaction with it. In the GlowSteps study, the children waited for permission from the moderator to start playing. They looked at each other and giggled. As a light moved from one tile to another, the tiles clearly communicated that they were interactive. Children eagerly ran towards the design, most of the time stepping on the tile nearest to them. In the Wobble study, the moderator left the children alone for about half a minute so they could approach the design without any explanation. Children were curious about the design and reacted enthusiastically and eagerly. For example, one boy immediately started to run in between the objects while other children curiously observed the objects at close proximity. Some children were slightly hesitant and walked slowly towards an object, but were eventually persuaded to start playing with Wobble by the pulsing lights. In both cases, the *active light feedback* evidently served as an attractor of interaction.

Concerning **social interaction**, the invitation stage is characterized by individual interactions. Each child approached one of the play objects by themselves. Even when children seemed to move together towards one object, they would chose to move to different objects when getting too close to each other. Most children were not attentive to other children and rarely talked with others during the invitation stage, although some laughing and giggling occurred and some general utterances such as: "Wow, what are these objects?" Children differed slightly in their speed to approach the objects, but all children were actively involved in this. None of the children only observed how others interacted with the objects. This was supported by the designs, which consisted of multiple objects scattered around the room larger in number than the number of children. Each object could react to a single child by *local interaction feedback* (e.g. stepping on one of the tiles of GlowSteps to turn it red or subtly tapping one of Wobble's balls to change its light color). This made simultaneously performed individual actions possible. Children did not need to watch others but had enough opportunities to start acting themselves. Overall, the predominant play behavior in the invitation stage is Solitary play (Parten, 1932; Rubin, 2001). Social interaction mainly occurred in the level of Distribution attention (Ludvigsen, 2005).

EXPLORATION STAGE

One girl and two boys are standing next to GlowSteps. The girl and one of the boys step on a tile in front of them. The other boy follows slightly later. While the boys stand still on their first tile, the girl already jumps to another tile, turning this tile red. She tries to touch the ground as little as possible. The boys quickly imitate this behavior and start stepping from tile to tile as well.

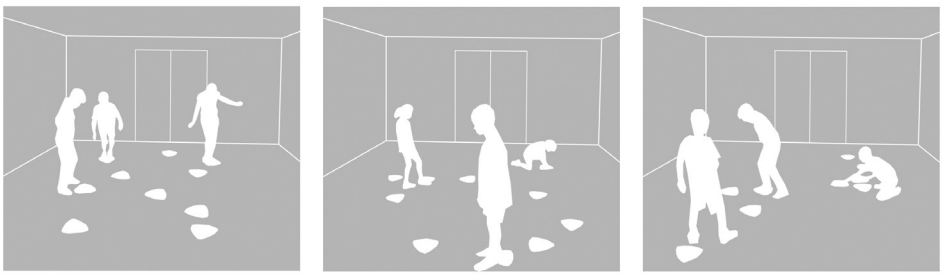


Figure 5.7 Exploration stage: stepping on tiles, trying out various interactions and moving tiles around.

As soon as children start to purposively interact with the design to explore and discover its interaction possibilities, they move towards the **exploration stage**. With GlowSteps, this transition was rather distinct and well observable; as soon as the children touched the tiles they started to explore the design. Almost all groups started with stepping on the tiles using their feet. One group of children sat down next to the tiles and inspected them, knocking on the tiles and turning them around, the *flexibility* of the tiles supporting this. The interaction behavior of the tiles showed both *active behavior* (green and blue light) and *reactive behavior* (red light) enabling children to explore possible actions and responses from the objects. With Wobble, children tried out a variety of *interaction possibilities* to control the lights inside the balls such as pushing the balls, but also clapping, waving in front of the balls and blowing towards the balls. Exploration was further supported by the *differences in local feedback* (i.e. the light intensity and color). In this stage, children already started to add dramatic elements to their exploratory play. For example, one boy started knocking on a ball while saying: "Knock, knock, who's there?"

Concerning **social interaction**, children mostly began this stage by exploring the objects in parallel, still primarily playing individually with their personal objects. The designs consisted of *multiple objects* that could be active at the same time so that each object could respond individually with *direct feedback*. For example, GlowSteps provided an effect to each action, e.g. stepping on an active tile made it flash and fade out and appear somewhere else, while stepping on an inactive tile made it turn red. Wobble provided *differences in local feedback*, which made children more attentive to each other. Children would start to compare their actions with the actions of other children and noticed differences in light intensity and color. Children explored their personal object, while sometimes watching and imitating how other children interacted with theirs. Instances of solitary play were also observed. For example, one child became so fascinated by Wobble that the child just looked at one of the balls for almost half a minute, forgetting the presence of the other children. The objects were often discussed in parallel speech (Rubin, 2001) in which the children communicated their thoughts and experiences for the benefit of other children. For example, children expressed their observations: "Now

the light is off … And now it is on again". As the exploration stage progressed, children began to respond more to each other, e.g. in interaction with Wobble, children would move together towards an illuminated ball and explore its interaction rules together while communicating with each other. Children were also confronted with one another through the *spatial set-up* of the designs, when, for instance, two children bumped into each other when running to the same tile. This social behavior happened for relatively short periods of time as children tended to move quickly towards a personal object in the system and became involved in parallel play again. To sum up, children were mostly involved in Parallel play (Parten, 1932; Rubin 2001) and Associative play (Parten, 1932; Broadhead, 2004) in the exploration stage. They were attentive to each other and engaged in parallel speech without sharing explicit rules or goals. Social interaction took place in the levels of Shared focus and Dialogue (Ludvigsen, 2005).

IMMERSION STAGE

Two girls and one boy are stepping from one tile to another without touching the ground. At one point, one of the girls moves one of the tiles, affecting the other girl's path. This girl exclaims: "What are you doing?" The other girl ignores her and continues playing. The girl stands still with her arms crossed. Behind her stands the boy, so she also cannot go back. "Where am I supposed to go?" she asks. The boy responds: "The other way." But this is not possible anymore. Eventually, the boy jumps towards another tile so that the girl can continue her way.

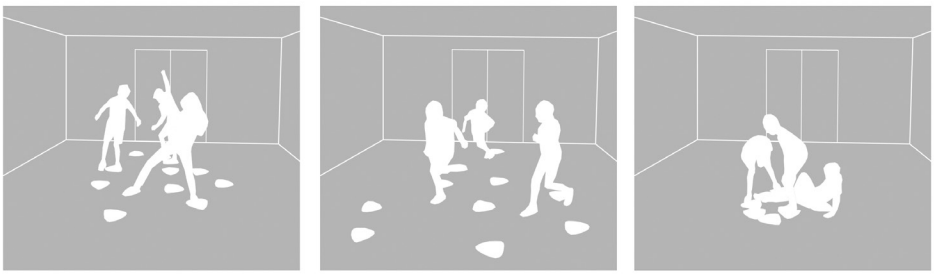


Figure 5.8 Immersion stage: Stepping game, Catching the light, and Twister.

When children start to create a game context by attaching meaning to interaction opportunities, children enter the **immersion stage**. The transition from the exploration stage to the immersion stage occurs more gradually and sometimes asynchronously for the different children in a group. During the play sessions, it occurred often that two children were still exploring while a third child was already playing a game with rules. When these rules were made explicit (verbally or expressively), the other children could join in. We mostly observed one or two children taking the initiative in a group of three and came up with new games and rules. This initiative could shift between children. When proposing new games, children could explicitly mention the name of the game (e.g. Twister) or the goal (e.g. catch the green light), try out the proposal or play the proposed game. The *light feedback* was often integrated in the gameplay. With

GlowSteps, children were mostly engaged in stepping and catching games. The stepping game meant stepping from one tile to another without touching the ground. The tiles reacted with red light when a child stepped on it. The catching game involved catching the green or blue light. Some groups played a combination of these two games: catching the light while stepping from tile to tile and not touching the ground. Children playing with Wobble were often engaged in fantasy play and developed multiple games. Trying to turn the lights in the balls on or off was often used in these games. For example, a group of children played a game in which the goal was for each child to catch an illuminated ball. Many games also involved a *spatial element*, for example, children ran from one ball to another while pushing the lights around.

Concerning **social interaction**, the relations between multiple children and between children and objects became more apparent and more complex in the immersion stage. At the start of this stage, children moved from parallel play to group play, although some children who entered the immersion stage were still involved in parallel play, that is playing different games next to each other. For instance, one child was playing a game of protecting the light with Wobble, while another child simultaneously tried to push the light from one ball to another. In this stage, children started to negotiate about rules, goals and games. For both designs, the *spatial arrangement* of the objects made it possible for multiple children to play together at the same time, which led to social situations as obstructing each other or making room for others to pass. The *active light* of GlowSteps needed to be shared as there was only one light with this quality; this made catching the light a mutual goal leading to competitive or cooperative play. Parallel play with GlowSteps was also supported as children could create their own games at each tile. For Wobble, group play was supported by the *lights moving* from one ball to another. For instance, one group of children invented the goal to turn all the lights off. From time to time, one or more children moved back to the exploration stage by starting to explore an object individually while the other children continued playing in the immersion stage. At some point, children would return to the immersion stage. This process could happen multiple times during a play session and involve one or more children. Overall, the immersion stage showed mostly Associative and Cooperative play (Parten, 1932), Group play (Rubin, 2001) and Social, Highly social and Cooperative play (Broadhead, 2004). Some instances of Parallel play (Parten 1932; Rubin, 2001) were also observed. Concerning social interaction, children were involved in Dialogue and Collective action (Ludvigsen, 2005).

TRANSITIONS BETWEEN STAGES

Children moved **through the three stages** in various ways. One set of groups played only one game, moving in a linear way from invitation to exploration to immersion. Small modifications in the rules did occur, but this did not change the overall game. A second set of groups played a multitude of games. They did not stop after constructing one game, but rather moved back and forth between immersion and exploration. Figure 5.9 illustrates the possible interactions between players and objects in the Stages of Play.

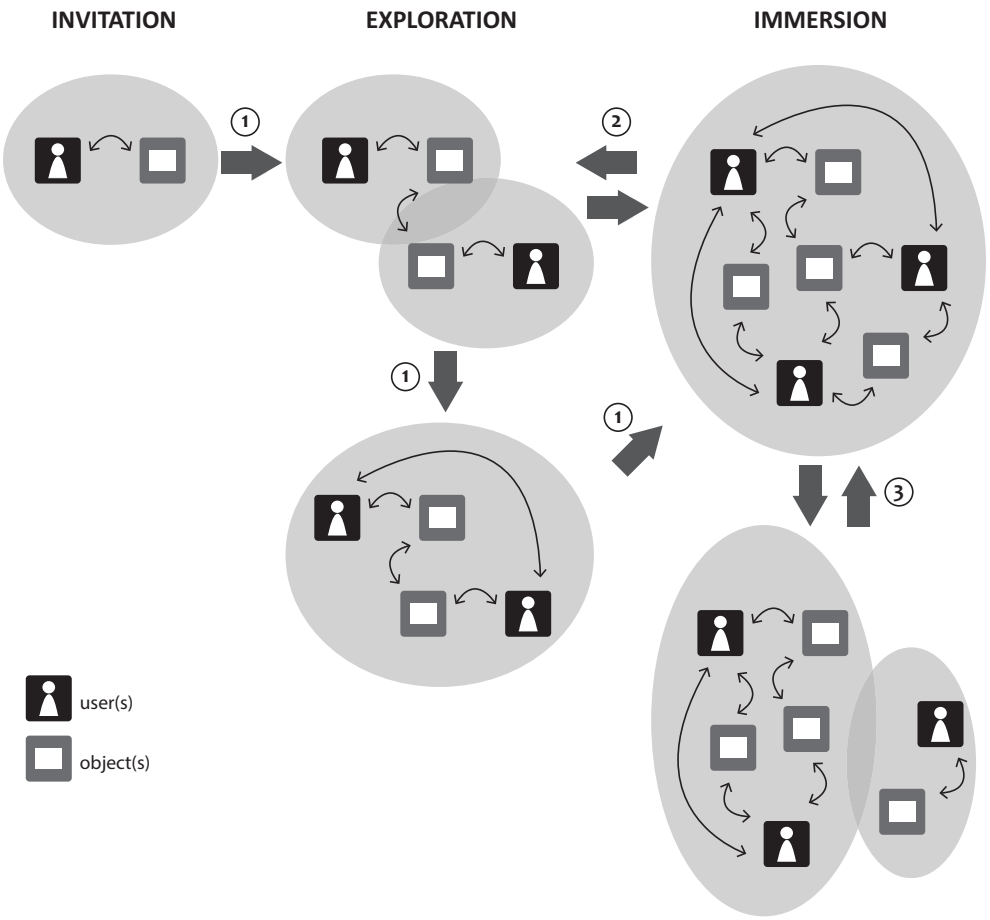


Figure 5.9 Interaction behavior between players and objects in the three stages of play.

The thick arrows indicate how most children go through the different stages. The arrows with number 1 show the process from invitation (individual) to exploration (first parallel, then together) and then to immersion. The arrows with number 2 illustrate the process of going back and forth between immersion and exploration. The arrows with number 3 show diversity in the immersion stage; playing together and playing parallel. Overall, the different interaction behaviors show how complexity increases for the three Stages of Play; more complex relations between children and objects arise and social play as competition and cooperation becomes more apparent.

Implications for design

The previous section discusses the results of our analysis on how social interaction changes through the three Stages of Play and in transition from one stage to another. In this section, these results are translated into implications for design practice. We

formulated these implications by reflecting on which design decisions support the different stages and influence social interaction. The design implications can support designers in applying the Stages of Play model as a tool with the aim to design for social interaction. Below, we describe these lessons learned concerning the Stages of Play and Social Interaction.

STAGES OF PLAY

The Stages of Play model guides designers in thinking about how users move between stages and how their playful design can support this. In Chapter 4 we formulated initial steps and constructs for the Stages of Play. The analysis of the design cases described in this chapter has further developed our knowledge on how to design for the Stages of Play. We have seen that when interacting with an open-ended design in particular, it is essential that players are guided through the interaction process so that they slowly get to know the possibilities of the design. Such guidance is called a "layered approach" (Polaine, 2010); a system should move interactors from a simple invitation to play towards first easy and later on more complex challenges, relying on the developing skills of the interactors. For the invitation stage, designs should communicate their interactive quality as well as their affordances for interaction. Potential players should notice that the design encourages active interaction. An active state such as a flashing light or a sound can communicate this interactivity. Other possibilities are using familiar shapes (e.g. a wheel provokes the action of turning it) or positioning objects in a certain way (e.g. tiles on the floor). In the exploration stage, designs should support players to try out a variety of simple and fast interactions to explore what the design can do and what they can do with it. Immediate feedback shows players what the effects of their actions are. The flexibility of the design, that is, when objects can be moved around or positioned in different ways, also supports exploration. Some players tend to be hesitant and need to encouragement to start interacting. A design can support this by incorporating not only reactive (responding to enthusiastic players), but also active (encouraging less pro-active players) behavior. In the immersion stage, designs should support the creation of different games and encourage loops back to exploration. If the design supports few interaction opportunities, it is difficult for players to come up with diverse game play. Diversity in interaction, such as various interaction opportunities and increasing challenges, can positively influence the game play and players' experience.

SOCIAL INTERACTION

The analysis of the two design cases demonstrates that social interaction moves from solitary to parallel to group and collective interaction related to the stage in which interaction occurs. Designs should support all of these different forms of social interaction, but designers can choose to focus on one specific type of social experience (e.g. fellowship or competition (Korhonen et al., 2009)). From the evaluations with GlowSteps and Wobble, we can derive the following design properties supporting social interaction:

- Multiple interaction opportunities that support parallel and collaborative exploration and play.
- One (or more) changing output(s) that need to be shared among players to create a mutual goal.
- Movable objects to stimulate joint exploration and creation of new shapes and games.
- Spatial components of objects forming a play environment together to support social play.

Designers should consciously take these properties into consideration when developing a playful design for social interaction.

Discussion

This chapter discusses the analysis of two design cases, resulting in an improved understanding of how to design for the Stages of Play in a social context. Although we believe the results presented in this chapter can already inspire and support designers, future research should examine whether the results themselves provide enough useful guidance or if design practitioners prefer them to be presented as a more detailed tool or method.

We are aware that the current analysis has some limitations. For instance, the process of analysis has been rather lengthy, consisting of multiple phases that again consist of multiple steps, carried out by different researchers. In future research, this process could be performed more rapidly and smoothly, in order to improve the throughput of the process and to communicate the process of analysis more clearly. Also, in this chapter we discuss two design cases from our own department that were developed with knowledge of the Stages of Play model. It would be interesting to reflect upon a user study with a more independently developed design or a design which stimulates a specific type of social interaction (e.g. cooperation or competition). We do think that analyzing not one but already two design cases has provided us with initial insights concerning the generalizability of our results. We believe our work can also be of value in other design research areas of interactive, open-ended systems in general. Designers of interactive systems should be aware about the nuances of the work presented here, for example, an interactive art work might purposely end at the exploration stage or other types of social interaction might become more apparent when developing an interactive installation.

As a next step, we are interested in how the three Stages of Play might change when children play with an open-ended design for a longer period of time, including recurring interactions. Currently, we only observed children's first encounter with a new design. In later encounters the invitation stage may be of less importance, while the exploration

stage may need to be better supported to encourage new interactions. In Chapter 6, we will describe a prolonged study investigating this.

Conclusion

In this chapter, we described how social interaction occurs in the three Stages of Play when interacting with an open-ended play environment. We reflected on two user studies in which children played for one episode with the design cases GlowSteps and Wobble. The analysis of children's play behavior resulted in an improved understanding of how social interaction changes and develops through the Stages of Play. The predominant types of social interaction change from solitary to parallel to group play as players move from the invitation stage to the exploration stage and on to the immersion stage. From this improved understanding of social interaction in the Stages of Play, we were able to formulate implications for design that designers can apply in their design process to frame their ideas and concepts, reflect upon them and improve them to create rich and engaging play designs. Together with the Stages of Play model, this set of results can serve as a comprehensive design advice, offering a new perspective on designing for play in a social context.

PART III:
PROLONGED PLAY

6

Prolonged open-ended play

ABSTRACT So far, our user studies on open-ended play have focused on incidental use, i.e. we observed behavior of children who played only for one occasion with the open-ended play design. This chapter describes a user evaluation that investigates prolonged use of an open-ended play design. The aim of this study is to explore how children play over time with an open-ended play design, in this case a new design prototype of GlowSteps. More specifically, we are interested in how children's creation of rules and meaning and social interaction develops over time. Besides that, we attempt to gain more in-depth knowledge on how children move through the Stages of Play (as described in Chapter 4 and 5) when involved in multiple play sessions. In this chapter, we first discuss related work on prolonged field studies of interactive, open-ended designs. Then, we present the user evaluation we carried out and the results of this study concerning designing for prolonged open-ended play as well as the design research challenges for evaluating prolonged open-ended play in the field.

Introduction to this chapter

In open-ended play, children can attach different meanings to the interaction opportunities and affordances of an interactive design. Children can be creative and use their imagination to come up with various forms of play, which can differ each time children play with the open-ended play design. As open-ended play is largely situation-dependent, this can result in a design that is used in various ways for different settings and contexts. Moreover, we believe the multi-interpretable and continuously changeable characteristics of open-ended play hold promise for engaging children on the longer term.

The previous chapters have discussed open-ended play in various manners. Chapter 2 focused on improving our understanding of open-ended play. Chapter 3 discussed the different rules involved in open-ended play in more detail. Chapter 4 presented the Stages of Play model and discussed how designers can apply this model in their process. In Chapter 5 we examined social interaction in open-ended play and updated our Stages of Play model. Together these chapters provide a broad basis on how to design for open-ended play and showed promising results of how children engaged with various open-ended play designs. But, as these user studies consisted mainly of single play sessions observing children's first encounters with an open-ended play design, we were not able to examine the full potential of open-ended play and how it changes or develops over time.

In this chapter we present a prolonged user evaluation aiming at investigating children's behavior and engagement with an open-ended play design. During a period of ten weeks, we studied children's interactions with a newly designed prototype of GlowSteps at a primary school. In total, 16 children played two to five times with GlowSteps (average: four times). In particular, we are interested in how rules, meaning and social interaction change and develop over time and how children go through the three Stages of Play when they play with an open-ended design for multiple times. Concerning the latter, we expect that in follow-up encounters the invitation stage, from the design point of view, may become less important as children become intrinsically motivated to play with the design. On the other hand, the open-ended play design should remain interesting and engaging to re-invite children to recurring play episodes.

This chapter first discusses related work on studying experience and play over time. After that, the approach of the user evaluation is described. Next we present our results, focusing on the perspective of interpretation and improvisation, Stages of Play and social play, and discuss a number of design research challenges when evaluating open-ended play design in everyday contexts. Finally, we translate our insights to implications for design.

Related work

In this section we describe related work on experience and play over time and identify challenges in carrying out prolonged studies in situ.

Over time, people come to understand and appropriate technologies (Rogers, 2011) and are motivated to use interactive products by different qualities (Karapanos et al., 2009; VandenBerghe, 2014). Karapanos et al. (2009) describe three phases in product adoption and use: orientation, incorporation and identification. In the orientation phase, users start to experience interaction with the product, explore novel features and encounter product flaws. In the incorporation phase, usability and usefulness are important aspects and the product becomes a meaningful part of the users' daily lives. Finally, in the identification phase, users express themselves through the product and it becomes part of their social interactions. Karapanos et al. (2009) focus on personal products that become a part of the user's daily life. This differs from our focus on open-ended play designs, such as GlowSteps, that are developed for social use in a semi-public space. The product is not 'theirs' but shared. Nevertheless, we expect that our open-ended play designs can become a part of the users' everyday routine in a certain context (e.g. school or neighborhood) and can support social interaction and self-expression. Moreover, we believe that the open-ended qualities of our designs closely relate to one of the design implications mentioned by Karapanos et al. (2009), which proposes that a product should be specific enough to serve a particular need, but also flexible enough to enable successful appropriation in diverse contexts.

Concerning play, experience over time changes from first-contact to engagement to nostalgia and players motivation changes in line with this (VandenBerghe, 2014). Besides that, players' skills also develop over time. Designs should anticipate this by scaling their challenges to the changing skill levels of the players, resulting in a good balance between challenge and skill as proposed by Csikszentmihalyi (1975).

A similar design to GlowSteps is the modular interactive tiles developed by Lund and colleagues (Lund et al., 2005). These square tiles contain a circular pattern that can light up in different colors. Children can play a variety of games with the tiles, among others 'Colour Race' in which children have to jump on their personal color fifteen times in order to win the game and 'Lunge' in which children will place one leg on a red circle and another leg on a blue or green circle. The tiles were evaluated with children in kindergarten for a couple of days. Observations showed that the tiles encouraged children to active play; "*The lights and the games set the player in motion*" (Lund, 2008). In comparison with GlowSteps, the modular interactive tiles offer more ready games with rules and goals and the tiles are usually connected to each other in different shapes. Some games require an introduction to explain the game mechanics. The play observations are promising as they demonstrate the potential attractiveness of interactive tiles as a play environment.

So far, a limited amount of design research has focused on open-ended play over time. From previous prolonged studies on open-ended play we have learned that designs should support diverse types of play and forms of social interaction (Hof et al., 2010; Tieben et al., 2014) and that the appearance of the design should clearly communicate how it works and can be used and behave accordingly (Fernaeus et al., 2010). In general, field studies often reveal issues that cannot be discovered during laboratory experiments and indicate how the design would actually be used in everyday practice (Rogers et al., 2007). To research the personal and societal impact of our designs, field studies fit in a cyclic research process of rapid prototyping and iterative development considering people's wild and messy real world (Lund, 2014). But researchers carrying out prolonged field studies are often confronted with a number of challenges such as choosing an appropriate evaluation methodology and organizing participants and making sure their expectations are reasonable. In field studies there are less possibilities for scaffolding such as explaining the purpose or the functionality of the design (Rogers, 2011) and researchers have to take into account a lot of external factors that make isolation of specific aspects nearly impossible (Rogers, 2011; Tieben et al., 2014). Moreover, researchers should be aware of the social relationships the participants have with each other and with the researchers (Brown et al., 2011). These relationships cause variability that makes reproduction of field studies challenging. Brown et al. (2011) propose to run field studies with the same system multiple times in multiple different ways to diminish the influence of informal factors such as the personalities of the participants and how the system is introduced to them. As this is rather time-consuming, acknowledging these factors is a first step.

To conclude, setting up and carrying out prolonged user studies is not easy and we can learn from the insights gained during previous studies. But there seems to be an interesting process in (open-ended) play and experience over time that is certainly worth investigating.

User evaluation

We carried out a user evaluation with GlowSteps at a primary school to explore how children play with an open-ended play design on the long term. In this section we discuss the goals and research questions, set-up and methodology and data analysis procedure of this study.

GOALS & RESEARCH QUESTIONS

Children involved in open-ended play get the chance to shape their own play and share their ideas with others. In earlier studies (see Chapter 3 and 5) we have seen that children enjoy appropriating open-ended play designs and applying their imagination to the play context. We are curious to further explore how children's experiences of playing with an open-ended design develop over time. Therefore, the current study addresses the

following research question: *How do children play on the long-term with an open-ended play design?*

To answer this question, we applied a qualitative and explorative approach to collect a rich and holistic set of data. By observing children's play behavior while engaged in interaction with GlowSteps and collecting observations of multiple play sessions over time, we can examine prolonged open-ended play and answer the following sub questions:

- *How do children interpret and develop rules over time?*
- *How do children improvise and create meaning over time?*
- *How do children move through the Stages of Play in multiple play sessions?*
- *How do children interact socially over time?*
- *What are the implications for designing for prolonged open-ended play?*

Besides these research questions, we are also interested in finding out which challenges occur when carrying out design research in such real-life contexts, taking into account that GlowSteps is currently still a research prototype that requires additional actions from the researchers (such as switching on the steps and changing the interaction behavior) that would be different for a finished, commercialized product. Finally, we are interested in investigating how an open-ended play design such as GlowSteps can be deployed in a school setting in consolidation with stakeholders (e.g. teachers, coordinators).

We expect the research questions to lead to the following contributions: (1) an improved understanding of prolonged open-ended play; (2) a translation of this understanding to implications for design; (3) an identification of relevant design research challenges.

SET-UP AND METHODOLOGY

The user evaluation took place over a period of 12 weeks at a primary school with one class (3rd grade in Dutch school system, equal to 1st grade in K-12 education) consisting of a total of 23 children in the age of 6-7 years old.

Figure 6.1 Children playing with the GlowSteps prototype.

The design used in the study is a newly designed prototype of GlowSteps, consisting of twenty interactive tiles (see Figure 6.1). This prototype has similar input (pressure sensor) and output (light feedback) as the previous prototype (presented in Chapter 5), but is made from a more robust and durable material. The output is also enriched as more colors of light are available to integrate in the interaction behavior of the tiles. In Chapter 5 we already discussed the interaction behavior 'Catch'. To recap, Catch is designed to encourage physical active play. A tile lights up in a certain color for a short amount of time. In this time interval, players must step on that tile to 'catch' the light. All tiles then flash in synchrony to communicate that the light has been caught. If the players are not quick enough, the light disappears and then appears again at another tile. Players can prevent the light to appear at a certain tile by stepping on that tile and, in this way, 'blocking' the tile. For this study, we have improved this interaction behavior and designed two other behaviors: 'Create' and 'Toggle'. Create is focused on expression and creativity. The interaction behavior of the tiles is more reactive than active, i.e. the tiles themselves do not light up but they react on the players stepping on them. When a player steps on a tile, this tile starts to cycle through a range of colors (e.g. from red to blue to green to yellow to purple and so on) and a player can 'stop' this by stepping down the tile again. This tile then 'freezes' in the last color. After a while, it fades out. In this way, players can 'draw' and create patterns, or they can come up with a sequence of colors that other players need to repeat as in the scenario above. Lastly, Toggle is developed to stimulate both competitive and cooperative play. All tiles light up in red, green or blue. By stepping on a tile, this tile moves to the next color in the sequence (e.g. red, then green, then blue and then red again). Players can decide to turn all tiles into one color; but if one player is aiming for red and the other for blue, they have to compete against each other. All three interaction behaviors are rather simple but have the potential to lead to diverse forms of play.

Before the present user evaluation, a number of children played informally with the new interaction behaviors on several occasions. Firstly, during a public open day event at our university targeted at families with (young) children, children could engage with GlowSteps in a more informal setting. They could play alone or with other children for as long as they wanted. During this day, all three different interaction behaviors were tried out. Throughout the day, many children (and adults) played enthusiastically with GlowSteps. Informal observations showed that the different interaction behaviors resulted in different forms of play as stepping on the tiles, catching the light or playing hopscotch or games like tic-tac-toe. Secondly, we ran a number of pilot tests with children from the target age group who played with GlowSteps at a local daycare center. In total, twelve children played in groups of three with the interaction behaviors of Catch and Create. Through real-time observational notes and video observations the behavior of the children was examined. Based on these pilot tests, we were able to improve and refine the interaction behaviors of the tiles, for instance adjusting the speed of the active light in Catch.

These improved interaction behaviors were integrated in GlowSteps and used in the current user evaluation. The study was divided into two parts: Part 1: creativity activity and Part 2: lunch break play sessions. Part 1 involved all 23 children, whilst Part 2 involved 16 (of the same 23) children. See Figure 6.2 for an overview of the children participating in the study. See Figure 6.3 for how many children (involved in Part 2) participated how many times.

Week	38	39	40	41	42	43	44	45	46	47	48	49	Total
Mike (m)				1				2			3		3
Liam (m)				1				2	3		4	5	5
Art (m)				1									1
Nick (m)				1			2	3	4		5		5
Ella (f)				1	2		3					4	4
Lisa (f)				1				2	3		4	5	5
Luke (m)		1			2		3		4			5	5
Anna (f)		1											1
Matt (m)		1											1
Oscar (m)		1									2	3	3
Leah (f)		1			2		3	4				5	5
Travis (m)			1										1
Toby (m)			1		2								2
Mitch (m)			1		2		3		4			5	5
Jack (m)			1		2		3						3
Sally (f)			1		2								2
Jane (f)			1					2			3	4	4
Mark (m)	1												1
Ian (m)	1												1
Irene (f)	1						2		3		4	5	5
Marie (f)	1						2	3			4	5	5
Tim (m)	1												1
Yves (m)	1				2			3	4			5	5

Figure 6.2 Overview of the children who participated in the user evaluation. The names of the children have been changed. Each column represents a week of the study with the number of that week above it. The light grey blocks represent Part 1 of the study and the dark grey blocks Part 2. The black blocks are weeks without play sessions because of holidays or absence of the researcher. The numbers list the number of times the children participated in playing with GlowSteps.

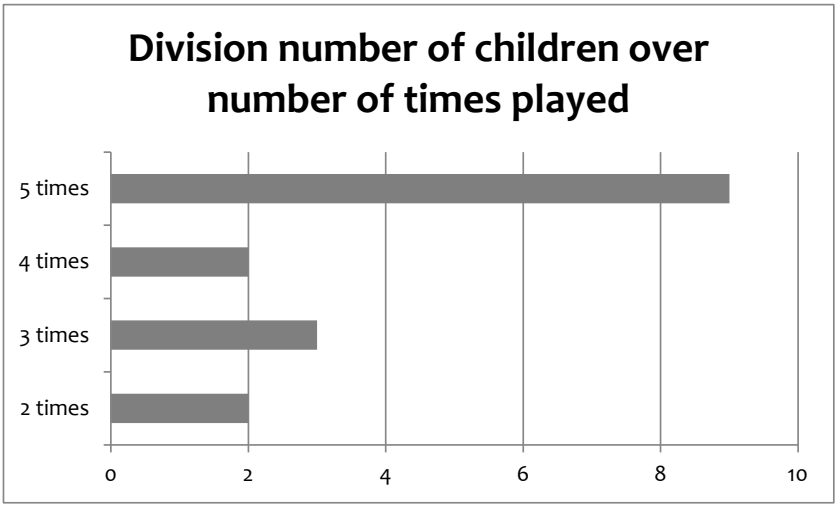


Figure 6.3 Division number of children (horizontal axis) over number of times played (vertical axis) at the end of the study. Total number of children who participated is 16. As the bars show nine children played 5 times with GlowSteps, two children 4 times, three children 3 times and two children 2 times.

In **Part 1,** the children got acquainted with GlowSteps in small groups. For a period of four weeks, the school offered a program of parallel creativity activities during one hour on Thursday afternoon. The children of the class were divided in four equal groups (5-6 children) and each group was involved in another activity each week. Besides the activity of playing with GlowSteps, other activities included tinkering and playing games. These activities were organized by adults (mostly parents), while the teacher walked around and provided assistance whenever necessary. During the activity, two researchers were present who acted as moderators and observers. The activity consisted of several steps. First, the children were introduced to the design and were invited to start playing with GlowSteps. After a short period (around 5-10 minutes), the children were asked about their impressions of the design and the researchers gave a short introduction about the (technological) functionality of the design. Then, the children were divided in two subgroups. One subgroup started playing with GlowSteps, while the other subgroup worked on a parallel coloring task. After around 10-15 minutes, the groups switched and the second subgroup played with GlowSteps for another 10-15 minutes. Throughout the activity, changes in the interaction behavior of GlowSteps were made by the researchers to familiarize the children with the different possible interaction behaviors of Catch, Create and Toggle. In the first week (week 38), the activity took place in one of the halls of the school, but this space turned out to be too small. In the following three weeks the activity took place in the school's playroom, which is also used for gym classes. GlowSteps was positioned in the middle of the room, with a couple of benches around it to mark out the play area (see Figure 6.4).

Figure 6.4 Set-up of GlowSteps in the playroom (gym) where the user evaluation was carried out.

After the four weeks of Part 1, in which all children played for one time with GlowSteps, the study continued with **Part 2**: free play sessions during lunch break. Once a week, again on Thursday as this was the day on which most of the children of this class stayed at school for lunch, the children could play with GlowSteps during their lunch break. Typically, these lunch breaks follow the same time schedule from 12:00 noon to 1:00 PM. At the start of the lunch break, children eat their lunch in the classroom. After that, they are free to play either inside (e.g. coloring or playing with LEGO) or at the playground outside. For this part of the study, we came up with the following protocol (times are approximately):

Table 6.1 Protocol of Part 2 of the user evaluation.

Before the lunch break	Setting up GlowSteps in the playroom.
12:00 noon - 12:10 PM	While children are eating lunch, the researcher enters the classroom and asks who wants to play with GlowSteps today. From the interested children, she chooses eight children.*
12:10 PM - 12:15 PM	The researcher walks with the children to the playroom and lets them play with GlowSteps, before dividing the children into two (close to) equal subgroups.**
12:15 PM - 12:35 PM	First subgroup plays with GlowSteps, while other subgroup works on 'exercise book' task.*** The play session ends with a group interview.
12:35 PM - 12:55 PM	Second subgroup plays with GlowSteps, while first subgroup works on 'exercise book' task or is allowed to go outside to play. The play session ends with a group interview.
12:55 PM - 1:00 PM	Children are escorted back to the classroom.

* As time was limited, we decided upon a maximum of eight children per week. Please note that eventually in the last week eleven children participated as they all wanted to play with GlowSteps and did not obey to the instructions given in the classroom. Children were chosen based on their willingness to play with GlowSteps and the amount of times they already played with GlowSteps before (preference was given to children who played the least amount of times).

** In order to create a situation as close to reality as possible, the researcher asked the children who wanted to play together. In one occasion (play session 5) this led to two unequal subgroups as none of the children from the larger group (p=5) wanted to play with the children of the smaller group (p=3).

*** As a parallel activity, the children were offered an 'exercise book' that included different exercises such as coloring pictures, maze puzzles, rebuses and simple mathematic calculations. During three of the six sessions, a student assistant was present to guide and support the subgroups working on the 'exercise book' task.

In total, twelve groups (two groups per week) played with GlowSteps in Part 2. In general, the groups played in each session with both Catch and Create (in various orders), unless they explicitly asked for one of the two interaction behaviors. The interaction behavior of Toggle was no longer offered as we did not want to overwhelm the children during their short playtime with GlowSteps (15-20 minutes) and we considered the other two interaction behaviors to have more potential in encouraging diverse types of play. As the children who played with GlowSteps were not the same each week, the composition of the groups changed. We decided not to regulate this too much in order to support the ecological validity of the study; in the real-world children also do not play in exactly the same groups all the time. See Appendix D for an overview of the composition of the groups concerning the division of boys and girls and the number of play sessions at that moment participated in. The researcher was present and followed the same protocol during all play sessions. She observed the groups, changed the interaction behaviors of the steps and served as contact person for the children as well as the lunch break coordinators. At moments, the researcher also had to interfere, for instance when children were arguing with each other or when they were playing with other equipment in the playroom.

Data was collected by observations (Part 1 and Part 2) and interviews (only Part 2). Observations consisted of real-time field notes and video recordings. Real-time field notes were written down by the researcher(s) present and focused on the actions of the children and their verbal and non-verbal communication. For the video recordings, consent was asked from the parents of the children. Due to the fact that not all consent forms were returned in time, we were only able to make recordings of two of the four sessions of Part 1. Of Part 2 all six play session were recorded. Interviews were held with the children at the end of each play sessions. All interviews were audio recorded.

For these interviews, four cards with different colors were created that each contain a different question (see Appendix E). In turns, children read out loud one of the questions. All children were involved in answering the questions. We tried to formulate questions that are simple, clear and comprehensible for children, in this way avoiding too abstract or too complex questions. We aimed for giving the children a voice in the study with these questions. The interview questions are:

- *How did you play with the steps and the lights?*
- *Which games did you make up?*
- *Did you play together or alone?*
- *What did you like and what did you not like that much?*

The questions relate to the research questions described before and aim to discover how the children experienced playing with GlowSteps, if this was a social situation or not and ask them about the rules and meaning they created. Through these questions, the children will be able to express their experiences in their own words. Their answers to these questions complement the observational data, which remains more or less an impression of the researchers. The procedure for the interview is as follows: At the end of the play session, the children are called together. They turn one of the cards around and speak the question out loud (with help of the researcher if necessary) and then answer the question, and this repeats until all cards are turned around and all questions are answered.

DATA ANALYSIS PROCEDURE

The observations and interviews were analyzed in a qualitative and descriptive manner, aiming at getting a holistic view of the play sessions over time. The study resulted in a large amount of data. For example, we collected over five hours of video recordings. Therefore, an iterative analysis process was necessary to come to structured results. Figure 6.5 illustrates our data analysis process, based on the Data Analysis Spiral (Creswell, 2013). As Figure 6.5 shows, data was analyzed in many iterations creating preliminary output on the way. In the process we used a mix of solitary and group activities. In total, the process consisted of eight steps:

Step 1: Work out real-time field notes and interview data for all ten play sessions.

At the start of our data analysis we prepared and organized the data in text. In total, we organized ten play sessions; four in Part 1 and six in Part 2 (See also Figure 6.2). We made a document for each play session containing the real-time field notes and the children's answers of the interview questions (for Part 2) based on the audio recordings that were made.

Step 2: Process video recordings of four play sessions.

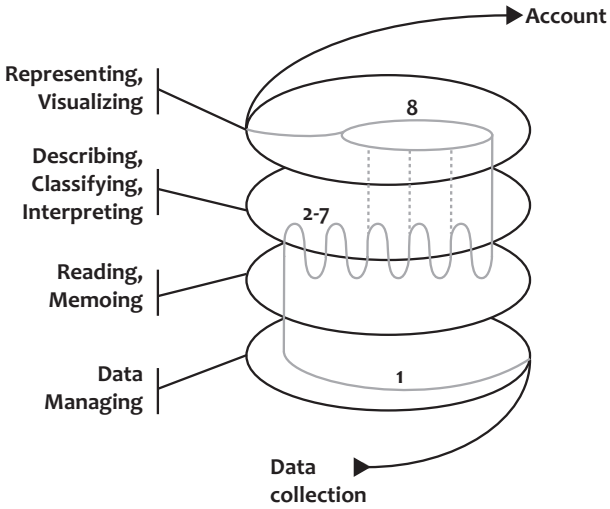


Figure 6.5 Data analysis process, based on the Data Analysis Spiral (Creswell, 2013). The grey line represents our process and the numbers correspond to the steps described in the text.

As a next step, we decided to start our analysis of the video recordings by observing the first two and last two sessions of Part 2 to get a feeling for the data and to gather preliminary insights on how children play with GlowSteps in earlier and later stages of the study. We coded the videos using labels related to our three research perspectives: Interpretation & improvisation, Stages of Play and Social play. We wrote down all actions and forms of verbal and non-verbal communication that we could observe and classified these with one of the following labels: New action, (New) Rules, (New) Game, Meaning; Invitation, Exploration, Immersion; Social, Imitation.

Step 3: Make summaries of four play sessions, combining real-time field notes, interview data and video observations.

For the four play sessions that we processed in step 2, we combined the video coding data with the real-time field notes and interview data and extended our coding process by further interpreting the data. This resulted in a general textual description ('story') of each of the four play sessions together with a summary of the rules and games that the children invented, the social dynamics of the group, how children behaved in the exploration and immersion stage and the distractions that they faced.

Step 4: Discussion session with researchers involved.

The first three steps were carried out by the main researcher. In the fourth step, we organized a discussion session in which the main researcher watched and discussed a number of video fragments together with two other researchers who are involved in

the PhD project as well to gain a shared understanding of the data. Furthermore, the researchers agreed on an approach for the rest of the analysis.

Step 5: Create timelines with screenshots for eight play sessions.

As a next step, we watched all videos (eight in total; two in Part 1 and six in Part 2). For each play session we made three physical timelines: introduction, subgroup 1 and subgroup 2. These timelines demonstrated the different play episodes, which summarized a certain type of play or game that the children played in a session. Each timeline was constructed on large sheets of paper and consisted of screenshots of the play episodes and a short description on Post-It notes underneath the screenshots that explain the play episode.

Step 6: Use the timelines to analyze the last two play sessions of Part 2 in detail.

As we are interested in prolonged open-ended play, we decided to focus on the last two play sessions in which children played for approximately the fourth or fifth time with GlowSteps. We qualitatively analyzed these sessions using their timelines. This analysis was again based on the three research perspectives: Interpretation & improvisation, Stages of Play and Social play. The analysis led to a textual description of children's play behavior for the three perspectives.

Step 7: Organize discussion session with fellow design researchers.

In the seventh step of analysis, we organized a discussion session with four fellow design researchers who were not involved in the earlier steps of analysis. In these earlier steps, we delved deep into the data. The aim of this session was to receive fresh perspectives from researchers with a background in play design research but with different expertise and frame of reference (e.g. designing playful interactions for teenagers or designing for emergent behavior). The set-up of the session is based on the Interaction Analysis method (Jordan & Henderson, 1995). In this method, video recordings are analyzed qualitatively and collaboratively, free from predetermined categories or coding schemes. Instead, categories are expected to emergence during the session. This method is "*particularly powerful for neutralizing preconceived notions on the part of the researchers and discourages the tendency to see in the interaction what one is conditioned to see or even wants to see*" (p. 44). After the session, the organizer of the session reviews and analyzes the collected insights more intensively.

During the discussion session, we watched video fragments from the user evaluation together. We asked the other researchers to write down what attracted their attention on Post-it notes, focusing on the children's game play and interaction with the design. After each video fragment, the notes were discussed and grouped. Some fragments were viewed multiple times if the discussion asked for this. In total, we watched five video fragments. We started with three fragments of the last play session and then continued

with two fragments from one of the first sessions as a comparison. Eventually, three categories were formed: Play dynamics, Play actions and Roles. We ended the session with discussing suggestions for the analysis, such as emphasizing the different types of players and thinking about what would be our 'pitch' (what would we tell our students?) to formulate our main insights. The session lasted for around 90 minutes.

Step 8: Finalize analysis based on output from previous steps.

Lastly, we finalized our analysis based on the output created in previous steps (e.g. the textual description of step 6 and insights from the discussion session of step 7). We qualitatively compared our observations from the later play sessions with the earlier sessions and with the insights from single play sessions as discussed in earlier chapters (e.g. Chapter 5). This resulted in a textual description of our insights, which can be found in the next section.

Results

In this section we discuss the results of our analysis, focusing on the research questions mentioned in the previous section. Overall, the aim of this study was to explore: *How do children play on the long-term with an open-ended play design?*

In general, our results show that children remain engaged in playing with the open-ended design. Figure 6.6 gives an impression of children playing with GlowSteps during the study and shows various examples of their play behavior. Every week the researcher visited the school the children were enthusiastic and wanted to play with GlowSteps again. Until the end of the study, more children than allowed wanted to play with GlowSteps. This indicates that designs for open-ended play remain interesting to play with over time, although we also observed moments in which children were involved in play without GlowSteps or in non-play behavior (e.g. taking a break, being distracted or involved in conversation). We discuss our results in more detail below. We describe our observations using the perspectives of interpretation and improvisation (Chapter 3), the Stages of Play (Chapter 4) and the types of social play (Chapter 5) to structure our results. For each perspective, we describe the main observations and illustrate these with prototypical play scenarios. The play scenarios describe a sequence of actions and events assembled from our observations. We describe our observations of the later play sessions with GlowSteps in detail to explore prolonged open-ended play, as on average in these sessions children played for the fourth or fifth time with GlowSteps (see also Appendix D). We compare these observations with our insights from single play sessions described in earlier chapters (e.g. Chapter 3 and Chapter 5). We end this section with a discussion of a number of identified design research challenges.

Figure 6.6 Children playing with GlowSteps during the user evaluation.

INTERPRETATION AND IMPROVISATION

If we concentrate on the actions of interpretation and improvisation, essential step in children's understanding and creation of rules (see Chapter 3), the observations show that children shape their play using their past experiences with GlowSteps (as well as other previous play experiences) but also create new utilizations, rules and meanings. In the later play sessions, we observed that children continue to play in diverse ways with the design and vary in how they apply meanings and rules, indicating that open-ended play designs offer opportunities for different types of play that remain interesting and useful over time. The following play scenario illustrates this:

The children walk over the tiles and make them light up in different colors. One girl walks behind the other children and only steps on the tiles that are already lit. A boy climbs on one of the benches and shouts: "Three, two, one!" He jumps from the bench to one of the tiles. Another boy says: "Let's try to make only blue!" The other boy responds: "Yes, and when you have red you are dead and become a zombie." He starts to walk like a zombie and makes growling sounds. One of the girls moves the tiles further apart: "Otherwise it is no fun." The other girl starts to help her while the boys continue to walk over the tiles.

Because of their previous experiences with playing with GlowSteps, children are aware of many of the different possible interaction behaviors. They actively request either the interaction behavior of Catch ("We want to catch!") or Create ("More colors! All colors!"). While playing with the Create interaction behavior, children step on the tiles in order to make them light up in different colors as in the scenario above. This game play is still interesting and satisfying in the later sessions of the study. It seems that children enjoy the 'sensation' of the light feedback and this simple action-reaction pattern. They implement additional actions to this game play, such as jumping on the tiles from one of the benches that bound the GlowSteps play area or moving over the tiles on their hands and knees. Besides that, children continue with meanings created at the early play sessions such as: 'the floor is made of lava and should not be touched' or 'if someone touches the floor, s/he has to sit on the bench for ten seconds'. Also, children continue to move the steps around in the playroom. They move them closer together or further apart to adjust the difficulty of the game they are playing (e.g. stepping game). With the Catch interaction behavior children continue to play the game of catching the lights. They help each other in this, but also try to be faster than the other players. Catching a light is considered a kind of reward; they cheer when a light is caught and call out cries of joy ("Yes!"). In one of the later play sessions, children attach the meaning of 'hating' the colors as a reason to catch them (and in this way turn them off and 'kill' them). They extend this action by starting to hit themselves and others, in this way 'hating' the colors that they are wearing.

Although GlowSteps does not actively encourage fantasy play, we observed children coming up with fantasy elements in their play in both early and later play sessions. For example, they imagine themselves to be zombies (like in the scenario above), crocodiles, dragons, wolves, dogs or cats. This indicates that children enjoy and are capable of using their fantasy to create an imaginary world. When children imagine themselves to be dogs or cats, they crawl over the tiles and invent accompanying rules. For example, one girl drops down on her knees and acts like she is a cat crawling in between the tiles, but she becomes a human again when she stands upright on a tile.

Children almost never play the same game for the entire play session. It seems that their natural playing style and concentration abilities ask for a support of short play activities. They vary between different types of play, which can result in chaotic situations. The designs flexibility and open-endedness resulting in degrees of freedom support this and the children seem to incorporate and embrace this even more in the later play sessions. During some sessions, we observed children taking a break and resting on one of the benches. At times, children play outside the GlowSteps play area and do not use the tiles in their play. It seems they need more space than offered by the (bounded) play area. When children play a game which does not involve the tiles (e.g. trying to tag one of the other children or sliding over the floor), they often step on the tiles every now and then, in this way using GlowSteps as a playing field to run or jump over. Children seem to enjoy touching the tiles once in a while and the interactivity of the tiles keeps attracting their

attention, but they do not always relate a meaning or purpose to it. For example, in one of the later sessions, while playing the game of catching each other (tag), children come up with the rule that when standing on a tile one cannot be caught. In this way, the tiles have a function in supporting the children's play and the interactivity of the tiles provides them with visual feedback that all players can see and comprehend. Eventually, this rule develops further: the catcher determines a time limit for standing on a tile to increase the chance of catching the other players.

To sum up, in the later play sessions children still use the GlowSteps in their game play, interpret the interaction opportunities and improvise diverse game play besides continuing and extending previous games. Fantasy elements remain to return as part of their play. Children are very comfortable in their interaction with GlowSteps; they know what to expect from the tiles and how they behave in general. Compared to early and single play sessions, children seem to be less shy and more at ease because instead of playing with something new they are now playing with something increasingly familiar and yet surprising anew every time. Also, we observed more transitions between games and the degrees of freedom are used optimally, which sometimes resulted in rather chaotic situations.

STAGES OF PLAY

Concerning the three Stages of Play, our observations of the later sessions indicate that the children are mostly involved in the immersion stage. However, some instances of children situated in the exploration stage were also observed. The invitation stage hardly ever occurs anymore. Children start to play their familiar games with GlowSteps almost automatically; there is no need to attract or invite them anymore. See also the play scenario below:

The children run into the playroom and immediately jump on the tiles. One boy sighs: "Ah, I don't want all red!" The other children are trying to catch the light. They are running around and laughing. One girl drops down on her knees: "I am going to make a little path." With her hands she moves the tiles closer together. One of the boys protests: "No, no path!" He moves the tiles further apart. The girl stands up and joins the others in catching the light.

As children have experience with and knowledge of the design based on prior play sessions, they are less occupied with understanding the design and the different actions in the exploration stage. Extra elements in the playroom (e.g. benches, hoops, balls) facilitate them to try out new actions. Besides that, children explore how they can use the tiles in different ways in their game play. For example, while playing a game of tag children invent the rule that they cannot be tagged when they stand on a tile. Or a child starts to move over the tiles on his hands and knees instead of upright on his feet. Children continue to reposition the tiles, mostly with a goal in mind (e.g. creating a hopscotch diagram or moving the tiles closer together to make stepping from one tile to another easier).

The immersion stage is the core of the later play sessions. In this stage, children usually play multiple games or include various types of play in one session. They change meanings and rules, add new rules, change roles or characters, create stories together and vary between different games. This can happen gradually, but often children explicitly discuss the rules of the game they are about to play or are already playing. They play together, in large and smaller groups, but they are also involved in parallel or even solitary play (e.g. when the other children are distracted or involved in a game which does not involve GlowSteps).

Throughout the play sessions we observed moments in which children are involved in non-play behavior, for instance, when children are distracted by other children or other play equipment in the room. We also observed children taking a rest, indicating that they somehow needed to recharge their energy (e.g. after a phase of running and being physically active). Overall, children seem to like to move in-and-out of the magic circle of play, just like in other traditional play or classroom activities (see also Read & Markopoulos, 2008; Kors, 2012). Usually, they return to the steps in a short while either by purposively moving towards the tiles again or by 'stumbling' upon them. We also saw children changing their role from active player to onlooker. In this new role, they can still be involved in playing with GlowSteps, although rather passively. For instance, one child lies on one of the benches and looks at another child who is interacting with GlowSteps. He points to the tiles that illuminate in order to help the other child to catch the lights.

To sum up, the exploration and immersion stage are most important in the later play sessions. Children are familiar with GlowSteps and do not need to be invited to play anymore. However, the active lights still attract their attention. Instances of exploration also decline, but do not totally disappear as children are still involved in restructuring and trying out new things. The types of play in the immersion stage are similar to single and early play sessions. Children are involved in physical, social, fantasy and expressive play. They try to be the fastest, create stories and challenges and increase their difficulty. Compared to single play sessions, these stories more often go 'beyond the tiles', i.e. mimicking their behavior on the tiles to physical movement in the space. For instance, children first run around on the tiles to 'kill' the active lights (colors) of GlowSteps and then continue with 'killing' colors in the space such as their clothes.

SOCIAL PLAY

In the later play sessions, children still enjoy playing together with GlowSteps and are often involved in social play, especially when playing the games of tag or catching the lights. Also, children engage in shared fantasies such as 'dragon and wolf' or 'hating colors'. The following play scenario illustrates some frequent social play behaviors:

Two boys are playing with GlowSteps. A third boy is lying on one of the benches. One boy calls out the colors: "Red! Blue! Red again!" The other boy starts to chase the light in order to catch it. The boy imitates him. They cheer when they catch a light: "Yes!" and react

disappointed when they didn't. The other boy tries to be faster and catch all the lights himself. The boy on the bench starts to help them by pointing at the tiles that light up: "There! There!" But the other boys are not fast enough. He stands up and starts to help them in catching the light.

At the start of the play sessions, when the children are not yet divided into two smaller groups, they usually play with a large group of children on the tiles. They are involved in social play as they share the tiles, express similar behavior and interact with each other. But there also seems to be some separation as the children act rather self-centered; they do not work towards a mutual goal and are mostly concerned with the tile underneath their own feet.

We observed many situations in which the children play in parallel groups next to each other with GlowSteps, while using the tiles in different ways in their play. For example, in a sessions one subgroup plays stepping on the tiles without touching the ground, while the other subgroup is playing tag running around the playroom and only using the tiles for short periods to stand on in order to be 'free' from the child who is it. In certain situations, one of the parallel 'groups' consists of only one child, who plays solitary on the tiles.

In their social play, not all 'roles' are equal. For example, while one child plays catching the light with GlowSteps, another child observes him from one of the benches and helps him to achieve his goal by pointing at the tiles that light up. Also, some children naturally assume leadership and suggest rules and games and the other children conform. Moreover, children intentionally divide their group in smaller groups and appoint different roles, for instance two children (who are 'it') try to tag two other children (their 'targets'). Children try to impress each other, for instance with their jumps.

During the play sessions, there is a lot of social interaction in the shape of pushing, playing around and grabbing each other. As all children are from the same class, they know each other and social bonds (such as friendships and hostilities) already exist. A lot of times, these actions are considered to be fun and part of their play. But on a number of occasions, children are feeling uncomfortable and react angry or annoyed. Children are also involved in many discussions and even disagreements when playing with GlowSteps. They negotiate about game rules and goals and share their fantasies with each other. Children have apparent preferences with whom of the other children they want to play. Again, this is influenced by the fact that the children already know each other very well. Related to this, we observed a lot of imitation, in which children copy each other's behavior and follow each other through the room.

We observed some instances of competitive behavior, especially when children play the game of catching the lights (see also the scenario above). Children try to catch the light themselves and sometimes awarded themselves with points for this. However, we also

saw children allowing other children to catch the light when for instance these children are closer to the light or when the children share a mission and cooperate to 'destroy' the colors together. If children then run into each other on their way to a light they try to be faster than the other but not a lot of pushing or obstructing the other occurs. Besides challenges set by the system (as in catching the light), we also observed children creating challenges for each other, e.g. moving the steps further apart to increase the difficulty of the stepping game.

To sum up, social interaction remains high when playing with GlowSteps in the later play sessions. Similar to single play sessions, children often negotiate with and imitate each other. They take on different roles and take turns. If we compare these results to the insights gained in Chapter 5, in which we discussed social play with Wobble and an earlier version of GlowSteps, we can develop our understanding of social play in the three stages of play further. In Chapter 5, we concluded that children in their first interactions with an open-ended play design move from mostly solitary play in the invitation stage to parallel play and group play in the exploration stage and the immersion stage. The results from our prolonged study indicate that all three types of social play still occur over time, although instances of solitary play become more limited, which probably has to do with the invitation stage that hardly occurs anymore. Parallel and group play were both observed many times, of which parallel play mostly in the exploration stage and group play in the immersion stage (often with several groups playing in parallel).

DESIGN RESEARCH CHALLENGES

In this user evaluation we evaluated a design prototype (GlowSteps) with real users (children) in a close to real-life setting (playroom at school). Doing this kind of in-situ design research brings forward a number of challenges and considerations that we would like to emphasize here.

First of all, we have experienced that evaluating 'in the wild' asks a lot of flexibility and improvisation from the researchers. Researchers can plan a study beforehand in detail, by for instance thinking about possible conflict situations and creating a protocol accordingly. But they should always expect unforeseen circumstances when evaluating in such real-life contexts and be prepared to make small or even large adjustment to the structure of their study. For instance, the time of day can affect the moods and motivations of the participants (Rogers et al., 2007) or the location of the study might change last-minute because the playroom is occupied for another activity. Overall, researchers have to make considerations on how to react to this and experience in such evaluations as well as having a clear perspective of the relevant research questions can help in this.

Secondly, researchers should be aware of their role during the play (evaluation) sessions and how this might influence the results of the study. For example, during the user evaluation described in this chapter, one researcher was present during all play sessions.

She talked to the children and decided when each group could start and stop playing. She was also in charge of switching the steps on and off and changing the interaction behavior. As the GlowSteps design was still a prototype, these actions needed to be facilitated, but the children did not seem to be affected by this. Children came to the researcher to chat, complain about other children or ask for another interaction behavior. There was clearly a social relationship between the researcher and the children (Brown et al., 2011). When researchers are aware of their role and influence, they can better anticipate on what is going on and make decisions on the spot, but it also helps in reflecting on the observations in the analysis. For example, researchers may observe that children are provoking them by demonstrating rude behavior such as hitting other children or by trying to impress them with expressive behavior (e.g. weird dances) or by showing off their skills. Taking into account such behavior helps researchers in deciding which observations are most relevant to represent as output.

Thirdly, evaluating in a school setting has taught us that there are more stakeholders involved than simply the children who are playing with the design. We spend a considerable amount of time on understanding and getting familiar with the evaluation context and its people (as is also advised by Tieben et al., 2014). By observing how the lunch breaks are usually organized, we were able to create a protocol that aligns with this. This eventually resulted in a good working protocol and a friendly atmosphere in which many things were possible. Teachers, parents and lunch break volunteers were all very enthusiastic about the design. We were even approached by after school-care coordinators if we could also organize a play session for their children with GlowSteps.

Implications for design

Based on the analysis described in the previous sections, we can formulate specific design advice for prolonged open-ended play. Table 6.2 on the next page gives an overview of the implications for design for the three perspectives. The table lists design advice, explains how designers can implement this advice and gives example of the design advice with GlowSteps.

Concerning Interpretation and Improvisation, we argue that designs for open-ended play should support short and simple play activities that can vary over time. Children, in particular the age group of 6-8 years old, mostly integrate straightforward action-reaction patterns in their play and do not seem to be interested in complex, layered interactions that involve multiple connected steps. For example, in the user study described in Chapter 5 we observed that most children did not understand that they could influence the green active light by standing on another inactive tile. Children were mostly concerned with the direct feedback they received at the tile they were standing on and interacting with. By offering simple interactions, designers can stimulate children to take these interactions as a starting point and continue building on this. We observed

Table 6.2 Overview of the implications for design.

Interpretation & Improvisation	**Design advice:** *Offer short and simple interactions that can vary over time*
	How: Combine fixed recognizable elements with possibilities for adjustments, resulting in a richness of simple interaction opportunities.
	Example: GlowSteps offers the same interaction behaviors (Catch and Create) over time. But the design also supports different spatial configurations, supporting diversity in play. Other options could be to add sounds over time or to enlarge the collection of tiles with some 'special' ones (with unique behavior).
Stages of Play: Invitation stage	**Design advice:** *Facilitate that the design remains exciting and pleasurable*
	How: Active properties of the design should keep going and encourage play.
	Example: The active lights of GlowSteps show that the design is 'on' and ready to play. If the game play comes to a temporary stop, the active lights acts as a trigger to invite children back to the design.
Stages of Play: Exploration stage	**Design advice:** *Continue to encourage exploration*
	How: Support extensions, repositioning and different forms of interactions. Continue to give immediate feedback to provide quick understanding of interaction opportunities.
	Example: Children who are playing with GlowSteps can continue to explore the design by using other (play) material at hand, moving the tiles around or using their hands instead of their feet to interact with the tiles. The tiles react immediately when they are touched or placed on top of each other.
Stages of Play: Immersion stage	**Design advice:** *Keep children engaged in game play*
	How: Present challenges and opportunities to which children can attach meaning. Let the design 'grow' together with the (skills of the) children.
	Example: When children play with GlowSteps, they can attach meaning to the different colors of light and are challenged to catch the light or to move from one tile to another without touching the ground. GlowSteps could be enriched by adapting to the increased skills of the children, moving from simple to more complex interactions.
Social Play	**Design advice:** *Consider the types of social play and factors influencing social interaction*
	How: Design for specific roles or certain social behavior.
	Example: GlowSteps is designed for social play, but as the design consists of multiple tiles, children can play with the tiles on their own or parallel to each other. The single active light of Catch promotes competition; although children can also decide to help each other in catching the light. The visual output is perceptible both for active players and onlookers.

that in prolonged open-ended play children continue with past experiences but also develop new or additional utilizations (in the shape of rules, games or meanings). Therefore, we argue that designers should consider both options in their designs, by not changing recognizable elements (e.g. similar interaction behavior over time) but providing possibilities for adjustments (e.g. different configurations or changes in difficulty).

The model of the Stages of Play remains relevant for prolonged open-ended play, although changes occur in the process of going through the stages compared to first encounters with an open-ended play design as the focus shifts from invitation and exploration to long-term immersion. This means that designers for prolonged open-ended play have to reconsider their initial design decisions. For the invitation stage, designers have to invent ways to facilitate that interacting and playing with the design remains exciting and pleasurable. The active properties of the design (e.g. the active lights of GlowSteps) need to keep going and encouraging play. This is important for every start of a new play session as well as at moments in a session when children temporary quit playing with the design and need to be drawn in the play activity again. From the observations we have seen that in the later play sessions children want to try out new actions, which indicates that the exploration stage remains an essential stage in prolonged open-ended play. Designers can respond to this by intentionally continue to encourage exploration, for instance by supporting extensions (e.g. additional material), repositioning (e.g. new configurations) and different forms of interactions (e.g. by using hands instead of feet). Immediate feedback that provides quick understanding of the different interaction possibilities remains advisable. In these later play sessions, children spend the majority of their playing time in the immersion stage. Designers can prepare for this by presenting challenges to the children and offering embodiments and interaction opportunities to which children can connect attach rules and meanings. Moreover, designers can consider increasing the difficulty level of the designed interactions as they expect the children to develop their skills over time. For example, for the interaction behavior Catch, the speed of the active light could increase over time so that it becomes more difficult to catch the light. The design can also support adjustments such as more players or more (interactive) objects.

With regard to Social play, we observed that children are involved in various types of social play over time. We are aware that our user evaluation was carried out in a social setting and that this influenced the types of social play that were observed, but we argue that this setting resembles reality as children often play in a social context. When designing for social play, there are several factors that designers can take into account or can specifically design for. For example, we have seen that children can take on many different roles; they can be active players or onlookers, they can be leaders or followers, they can be 'it' or targets, and so on. Designing for specific roles can influence design decisions. Designs can provide visual and auditory feedback accessible for onlookers or can actively support games with different roles (such as tag). Designers can also

choose to design for certain social behavior such as imitation or competition. Interaction behaviors can actively encourage such social behavior, for instance by rewarding repetitive steps when children are imitating each other or by allowing multiple children to aim for a similar goal.

Discussion

In this chapter we accomplished a first step in exploring prolonged open-ended play by evaluating GlowSteps with a group of children of a period of ten weeks. The results are promising and indicate potential implications for design, but carrying out this user evaluation also made us aware of certain limitations and subjects of discussion that we want to address in this section.

REFLECTIONS ON SET-UP OF THE STUDY

First, we reflect on a number of aspects concerning the set-up of the study. The user evaluation was carried out in a playroom of a primary school. In this room, children usually have their gym (physical education) classes. For every play session, we moved the gym equipment to the sidewalls to put the focus on GlowSteps which was positioned in the middle of the room. Although the location worked well as a playroom, we are aware that the context might have influenced how children played with GlowSteps. For example, the room is an open space that allows children to be physically active and run around, as we often observed. Some groups slid through the room, supported by the soft and smooth surface of the floor. The color of the floor evoked additional meanings that were integrated in the game play (e.g. the red part of the floor is considered to be 'lava' that the children should not step on).

Another aspect worth mentioning is the focus on exploration instead of comparison. We chose to aim at a set-up that would respect children's real-life play routines and in this way gain a holistic overview of how children play with GlowSteps over time. In this field study, we are able to discovering how an open-ended play design such as GlowSteps would be used in children's everyday life (Rogers et al., 2007). The exploratory set-up allowed us to answer the research questions we had. Alternatively, we could have chosen for a stricter set-up in which the same group of children would play with GlowSteps for a sequence of weeks in order to compare their individual play behavior over time. In our case, this would lead to a number of practicalities, e.g. not all children were present or wanted to participate each week and other children would be asked to wait for their turn, which could negatively influence their willingness to participate.

A last aspect is the variety in the groups that played with GlowSteps. Some groups consisted of boys and girls, others of only boys, or mostly girls and one boy. In some groups, there was one dominant leader while in others the characters of the children were more alike. Children were close friends or teased each other. In our observations

we took along these social relationships, as proposed by Brown et al. (2011). Again, we tried to resemble real-life play situations as close as possible and therefore allowed many different situations to occur.

CHILDREN'S PERCEPTION OF OPEN-ENDED PLAY

In this user evaluation we evaluated GlowSteps, a design developed to support open-ended play. The design was presented to the children as a new play design that they could explore and play with in whatever way they wanted. In this way, we tried to emphasize the open character of the design. However, it is difficult to estimate how children actually perceived the open-ended qualities of the design. The children referred to the design as 'GlowSteps' or 'stepping stones', but this does not say much about their perceptions and ideas about the design. In the interviews after each play session we asked the children to tell about the games they played. Their answers show a variety of invented games and play activities (see Appendix E), such as: "All the time a light would turn on and then we had to step on it. Green or yellow, then we stepped on it and then all tiles started to blink. And then we had one point."; "We made piles and who had the most won"; "I made a hopscotch diagram". This indicates that they played in diverse ways with GlowSteps and did not stick to a single set of rules and meanings. In order to examine their perception of GlowSteps in more detail, we could have asked them to explain the design to for instance another group of children, but it is hard to predict if they would include the open-ended qualities in their description of the design. Another option is to use Laddering to discover which attributes, consequences and values children attach to the design. Laddering is an interview technique in which the interviewer tries to reveal which attributes of a product are preferred by the interviewee and keeps asking 'Why?' to discover the related consequences and values. Previous research (Vanden Abeele et al., 2012) shows that laddering is possible with children aged five years and older although children are more likely to express attributes and consequences than values.

INTERACTIVE QUALITIES

In this chapter we attempted to demonstrate the value of prolonged open-ended play with interactive objects. In the discussion of our results, we have emphasized how children used the interactive qualities of the design in their game play. We do not argue here that interactive open-ended play is the ideal and only way; children can also play in diverse ways with non-digital open-ended play designs such as a ball or a set of blocks. But we have seen that the interactivity adds certain qualities to the children's play experience with an open-ended design. For example, we observed that in later sessions the active lights of the design continue to encourage play, in the Catch as well as the Create interaction behavior. The interactive qualities continue to attract children's attention and stimulate their interest. Also, the interactive qualities encourage children to come up with rules and create games and stories. Children purposively involve the interactive qualities (e.g. the colors of the lights) in their game play and attach meaning to them.

DIFFERENT AGE GROUPS

The main body of research presented in this thesis concentrated on children in the age range of 6-8 years old. The participants of the user evaluation described in this chapter are also from this age group. We consider this age group to be suitable for the aims and characteristics of open-ended play, but we also see possibilities for younger and older children. To gain a better understanding of how children from other age groups play with an open-ended play design such as GlowSteps, we organized two additional play sessions at an after school child care center. During the user evaluation at the primary school, the researcher present was approached by employees from this center who asked if their children could also play with GlowSteps. In consultation with the different group leaders, we organized one play sessions with children in the age of 4-5 years old and one with children in the age of approximately 6-9 years old. Again, the play sessions took place at the same school's playroom. See Appendix F for a summary of both play sessions.

Overall, the sessions showed clear differences between the age groups and emphasized the variety in types of play that children can be engaged in with GlowSteps. Children from the younger age group, who were not yet able to create complex rules and games, enjoyed stepping around on the steps and attaching simple meanings to the colors. If we look back at persona Tommy (4 years old) as described in Chapter 1, we see similarities between Tommy and the observations of the younger children at the after school child care. The children were mostly involved in simple forms of play, such as jumping and walking over the steps. Just like Tommy, pretend play involving magic had a great attraction on the children. Furthermore, the children from this age group played alone or in small groups; both compositions are applicable to Tommy's play as well. Older children, who have progressed in their cognitive, physical and social development, could create games with rules, involved other children to express themselves with the design. For these we can discover similarities between the observations and the persona of Louise (7 years old) as described in Chapter 1. The children often played together with friends of the same gender in small groups. Especially the girls involved dancing and singing in their play and expressed themselves in this way. They play rather easy games and discuss about the rules. They try to win or prevent others from winning (for instance by protecting the steps), but a loss is soon forgotten and a game is easily restarted. Although these additional play sessions were again incidental and rather informal, we can argue that we found initial evidence that an open-ended play design such as GlowSteps encourages diverse play behavior appropriate for different age groups. These insights are in line with another study that focuses on comparing children's play behavior with interactive open-ended play objects (called 'Rings') for two different age groups: four to six and ten to twelve (Hooft van Huysduynen, 2014).

Figure 6.9 Children playing with the Rings: rolling them over the floor (Hooft van Huysduynen, 2014).

This study demonstrates that the younger children (between the ages four to six) stayed at a basis level of interaction and play, incorporating one or two feedback modalities. An example of a game the younger children played is changing the color of the objects by shaking or rolling the objects. In contrast, the older children (between the ages of ten to twelve) embraced more complexity in their games by incorporating multiple rules. An example of a game the older children played is using the objects to catch and throw a ball around, but the children were not allowed to catch the ball when their objects was lit up in red or blue.

Conclusion

Open-ended play offers a lot of opportunities for children to create their own game play and change this over time. This indicates that open-ended play has much potential to engage children on the long term, as they can play with the same design in different ways.

So far, prolonged open-ended play has been examined in a small number of studies such as exploring families interacting with an open-ended robotic pet in their homes (Fernaeus et al., 2010), investigating teenagers' interaction with an open-ended interactive installation at their school yard (Tieben et al., 2014) and examining children's social play and communication while playing with an open-ended play design in three sessions (Hof et al., 2010). In this chapter, we present a user evaluation which focuses on exploring prolonged open-ended play with children aged 6-8 years old in a school context. The aim of this study is to gain an improved understanding of how open-ended play develops over time and how to design for this. Compared to previous work, the set-up of our

evaluation differs concerning the user group, context, duration and foci of analysis. In our analysis we combine the perspectives of interpretation and improvisation (related to rules and meaning), Stages of Play and the types of social play and we translate our insights for these perspectives into implications for design.

The observations clearly demonstrate that open-ended play is an attractive and engaging type of play that remains rich and interesting over time. Children enjoyed playing with GlowSteps and their enthusiasm did not decrease over time. In the later sessions, children still liked to play with GlowSteps and expressed different types of play. The observations resulted in novel and extended insights on prolonged open-ended play concerning the perspectives of interpretation and improvisation, Stages of Play and types of social play. Children varied in their created meanings and rules, recalling past experiences or developing new meanings. Over time, children developed preferences for certain interaction behaviors. In the later sessions, exploration occurred less often as children used rules and meanings they invented during previous play sessions as a starting point. Children still came up with new or extended rules and meanings and remained performing exploratory behavior such as moving the tiles around. Social interaction remained high over the play sessions: children often played together, but moments of solitary and parallel play were also observed.

The implications for design suggest how designers can influence how children use their designs by the design decisions they make. For example, by providing possibilities for adjustments, designers can encourage children to change their play over time, and designers can stimulate cooperation among children by integrating shared goals. Moreover, designers can optimize their designs for prolonged use by giving extra attention to for instance the exploration and immersion stage and to consider adaptive mechanisms that can 'grow' with the children over time. These implications for design contribute to existing knowledge on designing for open-ended play and provide designers with useful considerations that can guide them in designing meaningful open-ended play designs that stay engaging over time.

7

Conclusions

Introduction to this chapter

Children's play is an important activity in their development of skills and abilities and allows children to express themselves and play together with others. In the last decade, interactive technology is becoming more present in children's play, but often directs and controls children's play leaving little to the imagination of the children. There is a growing demand for interactive play objects that do not direct children's play but that support them in being creative in open-ended ways. In response to this, this thesis explored open-ended play with interactive objects; a form of play that does not predefine game rules and goals, but instead offers interaction opportunities for children to attach their own meaning to. In open-ended play, children get a chance to be creative, express themselves, involve in various forms of social interaction and experience their preferred type of play while playing with interactive technology. Although this sounds promising, the question remains how to design for this; how to create meaningful interactive open-ended play designs that stimulate creativity and social play? To gain a better understanding of how to design for open-ended play we have adopted a research through design approach. We developed a number of interactive prototypes according to the design vision of open-ended play. The prototypes were used to explore open-ended play in real-life use contexts. In numerous occasions, we studied how children interacted with open-ended play designs and which design decisions influenced this in order to formulate design advice in the shape of models and guidelines that can support design researchers and practitioners.

The first part of the thesis aimed at improving our understanding of open-ended play. We described the concept of open-ended play in relation to existing literature on play and games. Moreover, we provided a definition of open-ended play and examined relevant design parameters. We studied the different types of rules in open-ended play and the accompanying actions of interpretation and improvisation. In the second part of the thesis, we proposed the model of the Stages of Play aiming to support the process of designing for open-ended play by presenting a more nuanced view of interaction with different requirements. This model describes interaction with an open-ended play design in three stages: invitation, exploration and immersion. We analyzed the usefulness of

the model by reflecting upon a number of design cases in which Industrial Design Master students used the model. Furthermore, as play often occurs in a social context, we examined how open-ended play designs can support social interaction in these three stages. We observed that social play varies in the three stages and discussed how to design to support these shifts in social interaction. Finally, in the third part of the thesis we investigated prolonged open-ended play during a user evaluation at a local primary school. Based on the results of this study we identified implications for design concerning interpretation and improvisation, the Stages of Play and social play over time.

In this chapter, we summarize the contributions of our research, discuss and reflect on our work and propose directions for future research.

Contributions

The research presented in this thesis has resulted in a number of contributions concerning defining and supporting how to design for open-ended play, referring back to the research questions presented in Chapter 1. We discuss each of these contributions below and end with some proposals of how the contributions can be useful for designers and design researchers.

UNDERSTANDING OPEN-ENDED PLAY

As a first contribution, we improved our understanding of the concept of open-ended play in the context of digital play. The research presented in this thesis contributes to the field of interactive play and games. Although previous research has explored open-ended play with interactive technology, knowledge on the definition of open-ended play and how it relates to other research on play and games was missing.

In Chapter 2, we developed knowledge on open-ended play further by providing a refined definition of open-ended play, which describes open-ended play as: "*play without predefined (game) rules in which players can attach meaning to the design properties and the interactions while playing. Its goal is to trigger a player's creativity and stimulate a variety of playful experiences by leaving room for interpretation so that players can play in diverse ways with an open-ended play design.*" This definition summarizes important aspects for open-ended play such as rules, creativity and diverse types of play that were not yet explicitly combined in previous work on open-ended play. Such a definition helps in clarifying the field of designing for open-ended play, illustrates related aspects worth investigating and can even propose directions for future research.

Based on existing literature we positioned open-ended play in between games and (free) play with the ability to move either way. Games are structured, rule-bound and goal-directed while free play is unstructured, spontaneous and improvisational (Caillois, 1961). Open-ended play allows players to (re)define play and continuously change the

game play. Both this positioning and the refined definition can support understanding the concept of open-ended play, which is a first step in being able to design for it. As a third step we analyzed existing designs for open-ended play on a number of parameters: players (single/multi), procedures (no steps/sequence), rules (simple/complex), output modalities (one/more than one), ownership (personal/shared) and communication between objects (present/not present). This analysis showed how different design decisions based on these parameters can lead to a variety of open-ended play designs. Designers should consider these parameters in their design process to create a playful open-ended design that fits their goal and context.

In Chapter 3 we focused on one specific important aspect of open-ended play, namely the types of rules. We created an enhanced model of communication, based on the model described by Crilly et al. (2008). Our model illustrates the communication between designers and users through an open-ended play design. We argue that in this communication there are two types of rules: interaction behavior rules and created game rules, and accompanying actions of interpretation and improvisation. We presented empirical evidence for this through two design cases that illustrate these rules and the diversity in game play they offer. This can support designers in understanding and applying designing for rules in open-ended play.

GUIDELINES FOR THE DESIGN PROCESS

Our second contribution consists of a set of guidelines that we formulated for the process of designing for open-ended play based on interviews with Industrial Design students. We argue that, when designing for open-ended play, designers and design researchers should follow an iterative process with decision moments. We formulated a number of design guidelines as presented in Chapter 2 on framing the design early, deciding quickly what to and what not to design and carrying out early and frequent user evaluations with working interactive prototypes. These guidelines were extracted from interviews we held with Industrial Design students who worked on an open-ended play project. The students shared their experiences, which led to a better understanding of the values and challenges of designing for open-ended play, such as finding a balance between ambiguity and complexity and taking into account the benefits and limitations of the context of use. We believe these guidelines give direction in developing open-ended play designs and support designers and researchers at different moments of the design process. We do not consider these guidelines as a warranty for better designs, but together with other activities such as reading literature on child development and play and coming up with varying play scenarios we do think they strengthen the core of a design project on open-ended play.

INTERACTIVE PROTOTYPES

Thirdly, we demonstrated and evaluated open-ended design qualities through a number of interactive prototypes. From practicing our research we learned that interactive prototypes are necessary in order to be able to evaluate open-ended play. These

prototypes need to be at a certain functional level in order to evaluate its actual use. As open-ended play occurs in context, evaluating a design can only be done when the design is actually playable.

Eleven design cases have been examined in the various chapters of this thesis. Two of these design cases were developed as part of the PhD research of this thesis. The other nine cases are student projects related to our research. Besides these eleven, students also developed other designs that are not discussed in this thesis. All these design cases demonstrate open-ended design qualities such as diverse interaction opportunities and output modalities. Figure 7.1 gives an impression of a number of the design cases. The cases show diversity in form, functionality and form of play and provide an inspiring portfolio for aspirant designers of open-ended play designs.

Figure 7.1 Examples of interactive prototypes developed in the vision of open-ended play at our Department of Industrial Design. From left to right, top to bottom: Wondrous Imagination (Gijs Houdijk), Wobble (Alice van Beukering), Lusio (Hanneke Hooft van Huysduynen), ZooMor (Daniel van Paesschen), GlowSteps (Pepijn Rijnbout & Linda de Valk) and Toinggg (Bas van Hoeve).

STAGES OF PLAY MODEL

As a fourth contribution, we developed a model to support designing for open-ended play focusing on the dynamics of interaction and demonstrated possibilities of utilization (see Chapter 4). Through reflections on practice, we identified a need for more guidance in the design process of open-ended play designs. The Stages of Play model describing interaction as a dynamic process that goes through several stages: invitation, exploration and immersion. Although the model of the Stages of Model seems quite trivial, our experiences showed us that it can be difficult to design playful interactions without any guidance. We argue that this model supports designers as it helps them focus on core aspects of interaction. Many designers immediately strive for the immersion stage, forgetting about the nuances to get people involved and help them explore before they

can get immersed. Designers have to consider how to invite potential players, how to support their exploratory actions and engage them in playing with the design.

Reflections of students who applied the model in their design projects demonstrated a variety of possible uses of the model. We argue that the model can help designers in noticing approaching pitfalls and can be used as a tool to communicate and explain the design and its credibility to others. Moreover, studies carried out with the model further demonstrated how children move through the stages in a rich social context (see Chapter 5). We believe the Stages of Play model can be useful to inspire and guide designers who have little experience in designing playful interactions as well as more experienced designers to analyze their insights and communicate the nuances of their design knowledge with support of the model.

PROLONGED OPEN-ENDED PLAY

Our fifth and final contribution consists of insights on how children play on the long-term with an open-ended play design and guidelines on how to design for that. We carried out a prolonged user evaluation in which children played for several weeks with the interactive open-ended play design GlowSteps (see Chapter 6). Data was collected through observations and interviews and analyzed using the three perspectives of interpretation and improvisation, Stages of Play and types of social play.

Results show that during the study children continued to play enthusiastically and in diverse ways with GlowSteps. Also at the later stages in the study, children kept on inventing new rules and meanings, which demonstrates that the open-ended play qualities remain present and useful over time. Concerning the Stages of Play, we observed a shift towards the immersion stage. However, instances of exploration, such as moving the tiles around or exploring new rules and meanings for the interaction behavior of the tiles, also occurred at the end of the study. Over time, children often played together, but we also observed solitary and parallel play. We argue that designers for prolonged open-ended play have to take into account children's interaction and play behavior with an open-ended play design over time. To support designers in this, we formulated a number of implications for design, such as offering possibilities for adjustments and emphasizing new forms of exploration over time.

APPLYING THE CONTRIBUTIONS

Designers and design researchers can apply the contributions discussed above in several design activities, see Table 7.1. For instance, when brainstorming new ideas the Stages of Play model (Chapter 4 & 5) can give guidance as well as the definition of open-ended play and its design parameters (Chapter 2) and the examples of other interactive prototypes (throughout the thesis). When improving existing concepts, the guidelines for the design process of open-ended play (Chapter 2), the different rules in open-ended play (Chapter 3) and prolonged play (Chapter 6) can be helpful together with the Stages of Play model (Chapter 4 & 5) to refine the details. In analysis of existing designs, the

interactive prototypes (throughout the thesis), the Stages of Play model (Chapter 4 & 5) and the design parameters of open-ended play (Chapter 2) can support critical reflection. Especially for design researchers, we see opportunities for the Stages of Play model (Chapter 4 & 5) and the different guidelines and implications for design (Chapter 2, 3 & 6) to be helpful in formulating new research questions or proposing new studies.

Table 7.1 Examples of applying the contributions in the design process.

	Understanding open-ended play	Guidelines for the design process	Interactive prototypes	Stages of Play model	Prolonged open-ended play
Brainstorming new ideas	X		X		
Improving concepts	X	X		X	X
Analyzing existing designs	X		X	X	
Setting up new research studies	X	X		X	X

Discussion

Through carrying out the design research presented in this thesis, we have gained insights on how to design for open-ended play. In this section, we reflect on these insights and further position them.

CHILDREN'S PLAY AND INTERACTIVE TECHNOLOGY

Play is an important part of children's lives. Children enjoy playing and being active, social and spontaneous. A large part of their play is aimed at using their imagination and creativity to invent new rules and games or to shape fantasy worlds. Children can play in countless ways, using toys, games, natural props and many other elements.

The last decade, interactive technology has taken a more prominent role in children's play. Think of video games, tablet applications and smart toys. During the time in which the work presented in this thesis was carried out (2011-2015), we have seen a number of interactive, open-ended play design that have been brought to the market, such as Hackaball (www.hackaball.com) and Sphero (www.gosphero.com). Both are smart, responsive balls that children can program or control to invent and play their own games. Another example of an open-ended design is Minecraft (www.minecraft.net): a tremendously popular open world game created out of simple blocks, with which children can build anything they can imagine. The game does not come with instructions and the low resolution graphics and blocks keep interactions open and support exploration. Each child can find their own way in the game, because they can choose from many activities

such as playing hide-and-seek with friends or building giant castles. We argue that such interactive designs have opened new possibilities that can exist next to traditional play material, but should not be designed to replace them. Interactive technologies can respond to children's interactions and let them be in control of their game play (Kafai, 2006). This offers opportunities to support children's creativity and imagination in open-ended ways (D'Hooge et al., 2000; Cassell & Ryokai, 2001).

In our user studies with GlowSteps and other designs mentioned throughout this thesis (e.g. Wobble, Bababa, Lusio; see also Figure 7.1 and the List of Design Cases on page 7) we have seen that children enjoy playing with the interactive technology of the designs. For instance, in the studies with GlowSteps, children are intrigued by the light feedback and make this part of their play, e.g. by attaching meaning to the different colors of light. Interactive technology is an additional design parameter that invites potential players, shows behavior and can become intelligent in interaction with players. Intelligent play environments can adapt to the interactions of the users (Lund & Thorsteinsson, 2011; Rijnbout et al., 2011), for instance by speeding up when the reaction time of users improves or by providing more interaction opportunities when the number of users increases. In this sense, the interactive technology clearly adds something to the experience of play.

In this thesis, we have not discussed the technological challenges in designing interactive play design in much detail as our focus has been on the user (children) and their interactions with the design. However, we do acknowledge that designing the right technology, or designing technology in the right way, is highly important and influential on the quality of play, creativity and social interaction. For example, selecting sensors, programming output behavior and determining reaction speed all contribute to the overall play experience. Related to this, we argue that designers of new interactive play designs should be aware of the effects of their design decisions in terms of the targeted competences and types of play they are promoting. Concerning physical and social skills, many interactive designs on a tablet or computer involve mostly fine motor skills and are played individually while sitting on the couch or on a chair. Moreover, interactive designs often direct children's play, leaving little control and creativity to the child. We propose the development of interactive designs that support children to go outside, be physically active and develop their gross motor skills. Children should be able to play together, negotiate and reach consensus on rules, make new friends and enhance existing friendships. Designs should encourage children to be creative and invent their own ways of playing.

DESIGN RESEARCH FOR AND WITH CHILDREN

Design research for and with children is often fun and worthwhile, but it also has its challenges. Children are curious, enthusiastic and have a mind of their own. Every child has his or her own personality, preferences and characteristics. Working with children can be highly rewarding, especially when a design is clearly contributing to the children's development or when they express their pleasure when interacting with the design.

But children are also still developing their skills and abilities. Comparing working with adults to working with children, adults can obviously execute more complex tasks and can reflect more easily on their behavior and experiences. Furthermore, it can be less challenging to deal with adult research subjects as they are more capable in listening to instructions and keeping their attention to the task. Children on the other hand are easily distracted and need to be intrinsically motivated to play. Sometimes, they even try to 'test' the researchers by demonstrating inappropriate behavior (e.g. bullying other children) or by yelling and talking all at the same time (Soute & Sturm, 2011).

What does this mean for the role of the researcher? In spite of their own memories, experiences and emotions, researchers should consciously take the child perspective in their work, excluding their own points of view and prejudices. Researchers should be objective describers and interpreters of children's behavior and they should be aware of their role and the relationships they have with the children who act as research subjects. Evaluations in school or other 'children's places' are safe and comfortable for the children, but can be uncomfortable for adult researchers (Markopoulos et al., 2008). Adults are advised to visit the children's space in an informal role to find out how the place functions and to discuss their plans with adults familiar to the context (e.g. teachers).

Other researchers have examined diverse methods and techniques for involving children in the design process as co-designers or informants as a way to understand children's roles and needs to make informed design decisions (Scaife & Rogers, 1999; Druin, 2002). Such a participatory approach can be valuable in the process of creating and refining ideas and concepts, but it is a rather time-consuming approach that is especially suitable for older children (7+ years old). Therefore, in the research described in this thesis, we have chosen different strategies such as observing children's play and carrying out quick design iterations with user evaluations involving children. In these evaluations we deliberately did not direct children's play by proposing games or demonstrating rules. When evaluating in a school environment children are used to obey orders from adults, but we wanted them to come up with their own game play. Moreover, we often made video recordings to look back play sessions multiple times, as initial observations can be inaccurately interpreted. We also asked children several questions after a play session to gather information about their personal experiences.

EVALUATING OPEN-ENDED PLAY

In this thesis, we have described a number of user studies in which we evaluated open-ended play designs with children. From these studies we have learned various lessons, concerning evaluating open-endedness, evaluating with children, and evaluating in a real-life context. We discuss these lessons below.

Evaluating open-endedness demands a balance between freedom and control. When one decides to design for open-ended play, this implies that the design offers a lot

of freedom in use and interpretation and consequently the designer has less control over these actions. Instead of considering this as a threat, we believe this diversity in play opportunities is actually an important strength of open-ended play; but it makes evaluating open-ended play a challenge. In many evaluation studies, specific test tasks are used to make sure that the data gathered during testing is valid and consistent between participants (Markopoulos et al., 2008). Such test tasks support the evaluation of certain functions or characteristics of the design as it focuses children's actions. When evaluating open-ended play, such test tasks are not suitable as the open-ended design supports different children to play with the design in totally different manners. This makes it difficult to compare and generalize results. Therefore, it is important to formulate feasible expectations and research questions. Through the user evaluation studies described in this thesis, we were able to collect a rich set of qualitative data. For most of these studies, we decided to work with a semi-controlled natural setting, in which children were asked to play with the design for a certain amount of time. We purposively decided to not place the design in a public space where everyone could interact with it at any time (this would be considered 'free play'; see also Chapter 2) in order to at least control the moments of play (and thus the moments of data collection).

Evaluating with children requires a creative and flexible attitude from the researchers. As already discussed before, children are still developing their skills and abilities. Therefore, evaluation methods that are successful with adults are often not suitable for children. For example, depending on their age children might not yet be able to read and write, understand questions that are too abstract or complex or formulate appropriate answers. Socio-emotional aspects, such as confidence, self-expression and the desire to please, can also influence children's responses. Together, these factors diminish the suitability of evaluation methods such as questionnaires and (written) diaries. Read and colleagues (2002; 2006) developed the Fun Toolkit especially for children. This toolkit consists of a number of evaluation methods, such as the Fun Sorter and the Again-Again table. These methods are simple to use and visually strong, which makes them very suitable for children. Unfortunately, these methods do not provide the results that we were looking for. For example, the Fun Sorter asks children to rank a number of activities in order to discover which activity is considered most or least fun. Instead of focusing on the fun aspect, we were more interested to explore how children interacted with the design and what rules and games they created. Furthermore, we believe that the evaluation environment also influences the appropriateness of a method. If we would have asked the children to perform a task individually at their classroom desk, it would be easier to let them fill in an evaluation form afterwards. Our user evaluation settings were much messier: children enjoyed playing and running around and it was sometimes difficult for them to sit quiet again and pay attention to the interview.

Evaluating in a real-life context (such as a school or a day-care center) instead of a lab environment puts forward additional challenges (Rogers, 2011; Brown et al., 2011). The major challenge is to be aware of and potentially adjust to the daily routine of the context

in which the evaluation takes place. Researchers need to be flexible and able to improvise considering the execution of the study. Plans that were made beforehand might need to be altered on the spot. For example, Soute & Sturm (2011) experienced unforeseen circumstances in their longitudinal study researching the play use of a commercial design at a primary school. Rules and regulations at school prevented children from playing with the design during lunch breaks and the school program offered limited time for reflection interviews after the play sessions. Eventually, the decision was made to alter the study from a free play setup to a more controlled set up in which children played with the design during gym classes. As already discussed above, we made similar decisions for our user evaluation studies by determining certain factors as place, time and people. For instance, during the prolonged study described in Chapter 6 children played in a separate room at the school for a fixed time in close to equal groups. Before we were able to run this study, we needed to get acquainted to the school routines. We achieved this by observing the daily activities, talking to the teachers and care providers and consulting with them about the set-up of the study.

Future work

The research presented in this thesis has led to several promising insights, yet further research is needed to examine designing for open-ended play more extensively. In this section, we present possible directions for future work.

DEVELOPMENT OF A DESIGN TOOLKIT FOR OPEN-ENDED PLAY

This thesis offers a collection of results such as a design model, guidelines and inspiring designs. Future research can concern how to combine these results in a comprehensive design toolkit for open-ended play. We have already made a first step in this by formulating an initial toolkit for playful interactions (Bekker et al., 2014) consisting of four lenses: forms of play, playful experiences, open-ended play and stages of play. These lenses provide different perspectives on designing playful interactions and can serve as inspiration in the design process. Although this thesis concentrates on open-ended play and the stages of play, we have also touched upon forms of play (e.g. by describing children's diverse play behavior in several user evaluations) and playful experiences (e.g. by describing how children experienced playing with our open-ended play designs). Recently, a fifth lens on emergence has been added to the toolkit, based on design knowledge gained in the second sub-project of the I-PE project as discussed in Chapter 1 (see also Rijnbout et al., 2013). Future work can examine how and when these perspectives are useful in the design process.

We translated the knowledge gathered through several design research activities on the lenses into a tangible design tool consisting of a set of cards (see Figure 7.2). These 'Lenses of Play' cards are designed to inform designers and to inspire them in the process of creating playful designs. So far, we have evaluated the usage and value of the

cards in several small user evaluations such as design workshops and a one-week class. Participants were Master and PhD students involved in a summer school on play and games (half-day workshop), intermediate vocational education level Human Technology students (half-day workshop) and Master students from our department of Industrial Design (one-week class). Initial analysis shows that students recognized the value of the tool and used the tool in various ways, such as for inspiration, to critically reflect on initial concepts or to structure information. More research is needed, preferably involving design practitioners, to further improve the design tool and validate its use beyond the walls of our department.

Figure 7.2 Lenses of Play cards: the first version of the cards used during the summer school workshop (left) and the updated second version of the cards (right).

In this thesis we have presented the Stages of Play model and discussed its usefulness as a design tool. For this model, we also see a number of future directions. For example, additional evaluation and design activities could address applying the model on a different target group or enhancing the model by investigating all possible lines of interaction in the model. As already mentioned in Chapter 4 and Chapter 5, the social and environmental context for which a design is developed, influences its actual use. Imagine that newcomers still need to be invited to start interacting with the design while people who have interacted with the design before might be more intrinsically motivated by their positive previous experiences. The newcomers' perspective is relevant when for instance designing for a public space (e.g. a city square where a lot of tourists come), whilst the experienced perspective relates more to contexts such as a neighborhood playground or a school environment. The Stages of Play model can be enhanced by a more complex visualization including several of these possibilities and taking along recently developed models such as the Layers of Free Play framework (Tieben, 2015) describing three layers in public free play: encounter, attention and commitment. In this way the level of guidance the model provides as well as its usefulness as a design tool can be improved.

INVESTIGATING OTHER APPLICATION AREAS FOR OPEN-ENDED INTERACTION

In this thesis we presented our research on open-ended interaction with a focus on children and play. We conducted a number of studies at schools and day-care centers

involving children, their teachers and child-care providers. Besides this focus on children's play, future research could explore several other application areas for open-ended interaction such as interactive art, public installations or learning environments. Developing a wide range of design prototypes for different contexts can support generalizing the results and insights on understanding and designing for open-ended interaction. In student projects we already made a first step in this by investigating open-ended play in the context of way finding in an amusement park and a children's hospital. These projects resulted in various promising designs that need to be analyzed in more detail to be able to draw solid conclusions.

We expect that open-ended interaction also has value in the design field of interactive systems in general. Open-ended interaction encompasses unique features that can be useful and meaningful for designers aiming at supporting creativity and freedom in interaction. Users are in control as their interpretation gives meaning to the design. This corresponds with the work on ambiguity by Gaver and colleagues (2003). Ambiguity, just as open-endedness, provides a designed product with multiple possible meanings which allows users to interpret and appropriate designs into their everyday life. Future work could review the benefits of open-ended interaction in the field of Human Computer Interaction in more detail.

EXPLORING METHODS AND TOOLS FOR EVALUATING OPEN-ENDED PLAY

A large part of our research has consisted of evaluating how children play with open-ended, interactive design prototypes. These evaluations were mainly analyzed by reflecting upon observations and short interviews in a qualitative and explorative manner. These methods provided us with valuable insights, as we were mainly interested in exploring children's play behavior and the design decisions that support children in their play.

Future research could investigate different methods and tools for evaluating open-ended play such as diaries, group interviews or expert reviews. Using less explorative but more structured methods can lead to more extensive and better-grounded insights. Another approach could be to develop a new method that is suitable for the free and open character of research on open-ended play. When choosing an appropriate method, researchers should be aware of the abilities and concentration span of the children (or any other user group) that are the subjects of their investigation as well as the evaluation context and the expected outcomes.

When the goal of the research is to examine the children's experiences in detail, a method to consider is the Experience Sampling Method (ESM). ESM aims at measuring user's experiences, behaviors and emotions in-situ by prompting users at the moment of occurrence. In this way, users do not have to recall anything but instead simply report their current activities and feelings (Consolvo & Walker, 2003). ESM originates from psychology, but has been applied in Human Computer Interaction studies as well. One

major drawback of ESM is that the method can substantially disrupt the user's activities (Scollon et al., 2003). Moreover, we are unsure to what extent children are capable to reflect on their experiences, behaviors and emotions in the first place. One of the other sub-projects of our research project I-PE (see Chapter 1) aims at investigating how user experience can be measured through the use of an interactive experience assessment tool (Rozendaal & Vermeeren, 2014; Rozendaal et al., 2015). Currently, this tool is not yet integrated into the play activity. We see opportunities for future work to examine this further. Interesting questions include: How can we integrate such a method into the play activity? What is the best way to support children in reflecting on their play behavior and experiences?

Another challenge in evaluating open-ended play is to understand the different types of rules. In this thesis, we clarified the different types of rules and actions in open-ended play (see Chapter 3), making a distinction between designed interaction behavior rules and created game rules that children develop while playing. As one can imagine, not all created game rules can be easily observed, as players are not inclined to make all of them explicit by words or gestures. Additional methods seem to be necessary to discover created game rules. Further research is necessary to explore this.

PRODUCT SERVICE SYSTEMS FOR OPEN-ENDED PLAY

As mentioned in Chapter 1, the work of this thesis is part of the I-PE project which is funded within the Creative Industry Scientific Programme (CRISP). The overall aim of CRISP is to explore how designers can develop intelligent and user-centered Product Service Systems (PSS). In the I-PE project we made initial steps in examining PSS concepts for interactive, open-ended play environments. We followed a product-oriented approach in which PSS concepts were used as vehicles of research and helped us to further develop our design vision and philosophy. Besides that, we worked on our PSS vision and explored the potential of PSS in the context of open-ended play. A PSS within the I-PE project vision is unique because both the product(s) and the services can be combined in flexible ways, resulting in tailored designs for particular contexts of use. Besides that, the open-endedness in the design puts part of the knowledge in the mind of the players, which adds a level of unpredictability to the PSS.

In a number of discussion and brainstorm sessions with our project partners, we investigated how open-ended play designs could possibility fit in real-world (commercial) designs, providing a combination of products and services. We looked at different contexts such as schools, physiotherapy and neighborhood playgrounds, and possible extensions or adjustments, combining traditional and interactive play objects. For example, in one scenario we envision GlowSteps as a tool for physical exercise during gym class. The gym teacher has a set of GlowSteps ready to use and can activate an interaction set for specific exercises through a control device or a smartphone application. In this scenario, a company is the owner of the concept of GlowSteps and manages the research and development of the design, if necessary assisted by software

development or production companies. An online platform can support the use and further development of GlowSteps. Teachers can propose additional interaction sets and can discuss how they use GlowSteps in their classes with other teachers, creating an online community. Some teachers may even make their own interaction sets. In another scenario, GlowSteps is a play element in the urban environment, for instance integrated in a neighborhood playground. Other than the previous scenario, in this scenario GlowSteps is a public design that needs to be shared among the people living or walking through the neighborhood. Initiation for a new playground can come from the city council or from a neighborhood association. Again, a company is responsible for developing GlowSteps (hardware and software) and integrating the design in the urban environment, possibly together with an architect. Decisions have to be made concerning exploitation and maintenance of the design and how to facilitate updates or new interactions. For example, the people living in the neighborhood may be able to buy additional personal steps that connect with the design in the playground.

Developing these scenarios made us aware how one design can lead to different product-service combinations in various contexts and how stakeholders can be arranged around the product and related services. We propose an initial design process for PSS consisting of the following steps: defining stakeholders and their roles and characteristics; developing global concept idea and deciding who is involved where; mapping stakeholders with product and service elements; prototyping and evaluating in the wild. Future work can focus on carrying out these steps and reflecting on them. Related directions for future research include: examining the uniqueness of open-endedness in PSS in detail; exploring PSS with stakeholders in the wild; developing guidelines and processes for such PSSs; investigating the role of the designer in PSS design.

References

Ackermann, E.K. (2005). Playthings that do things: A young kid's "incredibles"! In Proceedings of the International Conference on Interaction Design and Children (IDC 2005), ACM Press, 1-8.

Acuff, D.S. & Reiher, R.H. (1997). What kids buy and why; the psychology of marketing to kids. Free Press.

Bateman, C. (2005). The anarchy of paidia. Retrieved from http://onlyagame.typepad.com/only_a_game/2005/12/the_anarchy_of__1.html.

Battarbee, K. (2003). Defining co-experience. In Proceedings of the International Conference on Designing Pleasurable Products and Interfaces (DPPI 2003), ACM Press, 109-113.

Bekker, M., Sturm, J., Eggen, B. (2010a). Designing playful interactions for social interaction and physical play. Personal and Ubiquitous Computing, 14(5), 385-396.

Bekker, T., Hummels, C., Nemeth, S., Mendels, P. (2010b). Redefining toys, games and entertainment products by teaching about playful interactions. International Journal Arts and Technology, 3(1), 17-35.

Bekker, T., Sturm, J., Barakova, E. (2010c). Designing for social interaction through physical play. Special Issue Editorial, Personal and Ubiquitous Computing, 14(5), 281-283.

Bekker, T., Valk, L. de, Eggen, B. (2014). A toolkit for designing playful interactions: The four lenses of play. Thematic Issue on Playful Interactions and Serious Games, Journal of Ambient Intelligence and Smart Environments, 6(3), 263-276.

Bergström, K. (2010). The implicit rules of board games – on the particulars of the lusory agreement. In Proceedings of the International Academic MindTrek Conference (MindTrek 2010), ACM Press, 86-93.

Berk, L.E. (2002). Child development (6th ed.). Allyn & Bacon.

Berk, L.E. (2006). Development through the lifespan (4th ed.). Pearson, Boston.

Beukering, A. van, Valk, L. de, Bekker, T. (2014). Wobble: Supporting social play through an open-ended play environment. In Proceedings of the Chi Sparks 2014 Conference (Chi Sparks 2014), 91-99.

Bevans, A., Hsiao, Y.-T., Antle, A. (2011). Supporting children's creativity through tangible user interfaces. In CHI'11 Extended Abstract on Human Factors in Computing (CHI EA 2011), ACM Press, 1741-1746.

Broadhead, P. (2004). Early years play and learning: developing social skills and cooperation. RoutledgeFalmer, London.

Brown, B., Reeves, S., Sherwood, S. (2011). Into the wild: Challenges and opportunities for field trial methods. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2011), ACM Press, 1657-1666.

Bruce, T. (2001). Learning through play: babies, toddlers and the foundation years. David Fulton Publishers, London.

Caillois, R. (1961). Man, Play and Games. Free Press of Glencoe, New York.

Carroll, J.M. (Ed.) (1995). Scenario-based design: Envisioning work and technology in system development. John Wiley & Sons, New York.

Carse, J.P. (1987). Finite and infinite games: A vision of life as play and possibility. Ballantine Books.

Cassell, J. & Ryokai, K. (2001). Making space for voice: technologies to support children's fantasy and storytelling. Personal and Ubiquitous Computing, 5(3), 169-190.

Chu, S. & Quek, F. (2013). Things to imagine with: Designing for the child's creativity. In Proceedings of International Conference on Interaction Design and Children (IDC 2013), ACM Press, 261-264.

Consolvo, S. & Walker, M. (2003). Using the experience sampling method to evaluate ubicomp applications. Pervasive Computing, 2(2), 24-31.

Costello, B.M. & Edmonds, E.A. (2009). Directed and emergent play. In Proceedings of the ACM Conference on Creativity and Cognition (C&C 2009), ACM Press, 107-116.

Creighton, E. (2010). jogo: an explorative design for free play. In Proceedings of International Conference on Interaction Design and Children (IDC 2010), ACM Press, 178-181.

Creswell, J.W. (2013). Qualitative inquiry and research design: Choosing among five approaches. 3rd Edition. Sage Publications, Inc.

Crilly, N., Maier, A., Clarkson, P.K. (2008). Representing artefacts as media: Modelling the relationship between designer intent and consumer experience. International Journal of Design, 2(3), 15-27.

Csikszentmihalyi, M. (1975). Beyond boredom and anxiety: Experiencing flow in work and play. Jossey-Bass Publishers.

Deen, M. (2015). G.A.M.E Games Autonomy Motivation & Education - How autonomy-supportive game design may improve motivation to learn. Doctoral Dissertation. Eindhoven University of Technology, Eindhoven, The Netherlands.

Design with intent toolkit (n.d.). Retrieved from http://www.danlockton.com/dwi/Main_Page.

Decortis, F., Rubegni, E., Bationo Tillon, A., Ackermann, E. (2013). Interactive technologies that enhance children's creativity. In Proceedings of International Conference on Interaction Design and Children (IDC 2013), ACM Press, 596-599.

DeKoven, B. (1978). The well-played game. Doubleday, New York.

D'Hooge, H., Dalton, L., Shwe, H., Lieberman, D., O'Malley, C. (2000). Smart toys: Brave new world? In CHI '00 Extended Abstracts on Human Factors in Computing Systems (CHI EA 2000), ACM Press, 247-248.

Dormans, J. (2012). Engineering emergence – Applied theory for game design. Doctoral dissertation. University of Amsterdam, Amsterdam, The Netherlands.

Druin, A. (2002). The role of children in the design of new technology. Behaviour & Information Technology, 21(1), 1–25.

Edmonds, E., Muller, L., Connell, M. (2006). On creative engagement. Visual Communication, 5(3), 307-322.

Edwards, C., Gandini, L., Forman, G. (2011). The hundred languages of children: The Reggio Emilia experiences in transformation. 3rd edition. Praeger, Santa Barbara, California.

Eggen, J.H., Haakma, R., Westerink, J.H.D.M. (1996). Layered Protocols: hands-on experience. International Journal of Human-Computer Studies, 44(1), 45-72.

Escobedo, L., Nguyen, D.H., Boyd, L., Hirano, S., Rangel, A., Garcia-Rosas, D., Tentori, M., Hayes, G. (2012). MOSOCO: a mobile assistive tool to support children with autism practicing social skills in real-life situations. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2012), ACM Press, 2589-2598.

Fallman, D. (2007). Why research-oriented design isn't design-oriented research: on the tensions between design and research in an implicit design discipline. Knowledge Technology & Policy, 20(3), 193-200.

Fernaeus, Y., Håkansson, M., Jacobsson, M., Ljungblad, S. (2010). How do you play with a robotic toy animal? A long-term study of Pleo. In Proceedings of International Conference on Interaction Design and Children (IDC 2010), ACM Press, 39-48.

Fjørtoft, I. & Sageie, J. (2000). The natural environment as a playground for children: Landscape description and analyses of a natural landscape. Landscape and Urban Planning, 48(1/2), 83-97.

Fogtmann, M.H., Krogh, P.G., Markussen, T. (2011). Spatial sharing – designing computational artifacts as architecture. In Proceedings of the International Conference on Designing Pleasurable Products and Interfaces (DPPI 2011).

Forlizzi, J. & Battarbee, K. (2004). Understanding experience in interactive systems. In Proceedings of the ACM Conference on Designing Interactive Systems (DIS 2004), ACM Press, 261-268.

Fuller, D. & Magerko, B. (2011). Shared mental models in improvisational theatre. In Proceedings of the ACM Conference on Creativity and Cognition (C&C 2011), ACM Press, 269-278.

Fullerton, T., Swain, C., Hoffman, S. (2004). Game Design Workshop: Designing, Prototyping and Playtesting Games. CMP Books, San Francisco.

Gal, E., Bauminger, W., Pianesi, F., Stock, O., Zancanaro, M., Weiss, P. (2009) Enhancing social communication of children with high-functioning autism through a co-located interface. AI & Society, 24(1), 75-84.

Gandini, L. (2011). Play and the hundred languages of children: An interview with Lena Gandini (2011). American Journal of Play, 4(1), 11-18.

Gaver, W., Beaver, J., Benford, S. (2003). Ambiguity as a resource for design. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2003), ACM Press, 233-240.

Gielen, M. (2010). Essential concepts in toy design education: Aimlessness, empathy and play value. Int. J. of Arts and Technology, 3(1), 4-16.

Gray, P. (2009). Play as a foundation for hunter-gatherer social existence. American Journal of Play, 1(4), 476-522.

Goldstein, J. (2011). Technology and play. In: A.D. Pellegrini (Ed.). The Oxford handbook of the development of play. Oxford University Press, New York.

Goldstein, J. (2012). Play in children's development, health and well-being. Toy Industries of Europe, Brussels.

Goldstein, K. (1971). Strategies in counting out. In: E.M. Avedon, B. Sutton-Smith (Eds.). The study of games. John Wiley & Sons, New York.

Hewett, T.T., Baecker, R., Card, S., Carey, T., Gasen, J., Mantei, M., Perlman, G., Strong, G., Verplank, W. (1996). ACM SIGCHI Curricula for Human-Computer Interaction. Chapter 2: Human-Computer Interaction: http://sigchi.org/cdg/cdg2.html.

Hinske, S., Langheinrich, M., Lampe, M. (2008). Towards guidelines for designing augmented toy environments. In Proceedings of the ACM Conference on Designing Interactive Systems (DIS 2008), 78-87.

Hof, L. op 't, Pee, J de., Sturm, J., Bekker, T., Verbeek, J. (2010). Prolonged play with the ColorFlares: how does open-ended play behavior change over time. In Proceedings of International Conference on Fun and Games (Fun and Games 2010), ACM Press, 99-106.

Hooft van Huysduynen, H. (2014). Do you want to play? Internal Final Master student report.

Hopma, E., Sturm J., Bekker, T. (2009). Interactive play objects: the influence of multimodal output on open-ended play. In Proceedings of the International Conference on Intelligent Technologies for Interactive Entertainment (INTETAIN 2009), Springer, 78-89.

Hourcade, J.P. (2008). Interaction design and children. Foundations and Trends in Human-Computer Interaction, 1(4), 277-392.

Hourcade, J.P., Bullock-Rest, N.E., Hansen, T.E. (2011). Multitouch tablet applications and activities to enhance the social skills of children with autism spectrum disorders. Personal and Ubiquitous Computing, 16(2), 157-168.

Hsi, S. & Eisenberg, M. (2012). Math on a sphere: Using public displays to support children's creativity and computational thinking on 3D surfaces. In Proceedings of International Conference on Interaction Design and Children (IDC 2012), ACM Press, 248-251.

Hughes, L.A. (1995). Children's gaming. In: B. Sutton-Smith, J. Mechling, T. Johnson, F. McMahon (Eds.). Children's folklore: a sourcebook. Garland, New York, 93-119.

Huizinga, J. (1955). Homo Ludens: A Study of the Play Element in Culture. Beacon Press, Boston.

Hunicke, R., LeBlanc, M., Zubek, R. (2004). MDA: A formal approach to game design and game research. In Proceedings of AAAI Workshop on Challenges in Game Artificial Intelligence, AAAI Press, 1-5.

Hutt, C. (1976). Exploration and play in children. In: J.S. Bruner, A. Jolly & K. Sylva (Eds.). Play: its role in development and evolution. Basic Books, New York, 202-215.

IDEO method cards (2002). Retrieved from http://www.ideo.com/work/method-cards.

Iguchi, K. & Inakage, M. (2006). Morel: remotely launchable outdoor playthings. In Proceedings of the International Conference on Advances in Computer Entertainment Technology (ACE 2006).

Johnson, J.E. (2006). Play development from ages four to eight. In: D.P. Fromberg & D. Bergen (Eds.). Play from birth to twelve: contexts, perspectives, and meanings (2nd edition). Routledge, Taylor & Francis Group, New York.

Jordan, B. & Henderson, A. (1995). Interaction analysis: Foundation and practice. The Journal of the Learning Sciences, 4(1), 39-103.

Juul, J. (2002). The open and the closed: Games of emergence and games of progression. In Proceedings of Computer Games and Digital Cultures Conference, 323–329.

Juul, J. (2005). Half-Real: Video Games between Real Rules and Fictional Worlds. The MIT Press, Cambridge, MA.

Kafai, Y.B. (2006). Play and technology: Revised realities and potential perspectives. In: D.P. Fromberg & D. Bergen (Eds.). Play from birth to twelve: contexts, perspectives, and meanings (2nd edition). Routledge, Taylor & Francis Group, New York.

Karapanos, E., Zimmerman, J., Forlizzi, J., Martens, J.-B. (2009). User experience over time: An initial framework. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2009), ACM Press, 729-738.

Karoff, H.S. (2013). Play practices and play moods. International Journal of Play, 2(2), 76-86.

Kompan Speelbrein (n.d.). Retrieved from http://www.speelbrein.nl/onderzoeken/

Korhonen, H., Montola, M., Arrasvuroi, J. (2009). Understanding playful experiences through digital games. In Proceedings of the International Conference on Designing Pleasurable Products and Interfaces (DPPI 2009), 274-285.

Kors, M. (2012). Creating Play: Can a (sub-) system stimulate co-operative behavior amongst children? Internal Master student report.

Krippendorff, K. & Butter, R. (1984). Product semantics: Exploring the symbolic qualities of form. Innovation: The Journal of the Industrial Designers Society of America, 3(2), 4-9.

Krogh, P.G. & Petersen, M.G. (2008). Collective interaction – Let's join forces. In Proceedings of the International Conference on the Design of Cooperative Systems (COOP 2008), 193-204.

Kudrowitz, B.M. & Wallace, D.R. (2010). The play pyramid: A play classification and ideation tool for toy design. Int. J. of Arts and Technology, 3(1), 36-56.

Lucero, A. & Arrasvuroi, J. (2010). PLEX cards: a source of inspiration when designing for playfulness. In Proceedings of International Conference on Fun and Games (Fun and Games 2010), ACM Press, 28-37.

Ludvigsen, M. (2005). Designing for social use in public spaces – A conceptual framework of social interaction. In Proceedings of the International Conference on Designing Pleasurable Products and Interfaces (DPPI 2005), 398-408.

Lund, H.H., Klitbo, T., Jessen, C. (2005). Playware technology for physically activating play. Artificial Life and Robotics, 9(4), 165-174.

Lund, H.H. (2008). Research observations: Indoor playground in kindergarten. Retrieved from: http://www.e-robot.dk/articles/Diary Indoor Playground Kindergarten.pdf

Lund, H.H. & Thorsteinsson, A.T. (2011). Adaptive playware in physical games. In Proceedings of the International Conference on Foundations of Digital Games (FDG 2011), ACM Press, 271-273.

Lund, H.H. (2014). Playware research - Methodological considerations. Journal of Robotics, Networks and Artificial Live, 1(1), 23-27.

Magerkurth, C., Cheok, A.D., Mandryk, R.L., Nilsen, T. (2005). Pervasive games: Bringing computer entertainment back to the real world. Computers in Entertainment, 3(3).

Malone, K. & Tranter, P. (2003). Children's environmental learning and the use, design and management of schoolgrounds. Children, Youth and Environments, 13(2).

Markopoulos, P. & Bekker, M. (2003.) Interaction design and children (Editorial). Interacting with Computers, 15(3), 141-149.

Markopoulos, P., Read, J.C., MacFarlane, S., Höysniemi, J. (2008). Evaluating children's interactive products: Principles and practicies for interaction designers. Morgan Kaufmann.

Mazalek, A. & van den Hoven, E. (2009). Framing tangible inter-action frameworks. Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 23(3), 225-235.

Morrison, A., Viller, S., Mitchell, P. (2011). Building sensitizing terms to understand free-play in open-ended interactive art environments. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2011), ACM Press, 2335-2344.

Nachmanovitch, S. (1990). Free play: improvisation in life and art. J.P. Tarcher, Los Angeles.

Nielsen, J. (1994). Heuristic evaluation. In: J. Nielsen & R.L. Mack (Eds.), Usability inspection methods. John Wiley & Sons, New York.

Norman, D.A. (2001). The design of everyday things. The MIT Press, London, England.

Oxford dictionaries (n.d.). Retrieved from http://www.oxforddictionaries.com.

Paesschen, D. van, Graaf, M. de, Bekker, T. (2013). ZooMor: Three stages of play for a sleeping creature. In Proceedings of International Conference on Advances in Computer Entertainment (ACE 2013), Springer, 646-648.

Parten, M.B. (1932). Social participation among preschool children. Journal of Abnormal Psychology, 27 (3), 243-269.

Patrick, G.T.W. (1916). The psychology of relaxation. Houghton Mifflin.

Piaget, J. (1962). Play, dreams and imitation in childhood. W.W. Norton, New York.

Polaine, A. (2010). Developing a language of interactivity through the theory of play. Doctoral dissertation. Sydney University of Technology, Sydney, Australia.

Read, J.C. & Bekker, M.M. (2011). The nature of child computer interaction. In Proceedings of the BCS Conference on Human-Computer Interaction (BCS-HCI 2011), ACM Press, 163-170.

Read, J.C., MacFarlane, S., Casey, C. (2002). Endurability, engagement and expectations: Measuring children's fun. In Proceedings of International Conference on Interaction Design and Children (IDC 2002), ACM Press, 189-198.

Read, J.C. & MacFarlane, S. (2006). Using the fun toolkit and other survey methods to gather opinions in child computer interaction. In Proceedings of International Conference on Interaction Design and Children (IDC 2006), ACM Press, 81-88.

Read, J.C. & Markopoulos, P. (2008). Understanding children's interactions: Evaluating children's interactive products. Interactions, 15(6), 26-29.

Resnick, M. (2007). All I really need to know (about creative thinking) I learned (by studying how children learn) in Kindergarten. In Proceedings of the ACM Conference on Creativity and Cognition (C&C 2007), ACM Press, 1-6.

Rheinfrank, J. & Evenson, S. (1996). Design Languages. In: T. Winograd (Ed.). Bringing design to software. Addison-Wesley, New York, 63-80.

Rijnbout, P., Valk, L. de, Graaf, M. de, Bekker, T., Schouten, B., Eggen, B. (2011). i-PE: A decentralized approach for designing adaptive and persuasive intelligent play environments. In Proceedings of AmI 2011 Workshops (AmGam 2011), Springer, 238-244.

Rijnbout, P., Valk, L. de, Vermeeren, A., Bekker, T., Graaf, M. de, Schouten, B., Eggen, B. (2013). About experience and emergence: A framework for decentralized interactive play environments. In Proceedings of the International Conference on Intelligent Technologies for Interactive Entertainment (INTETAIN 2013), Springer, 104-115.

Riggio, R.E. (1986). Assessment of basic social skills. Journal of Personality and Social Psychology, 51(3), 649-660.

Rogers, Y., Connelly, K., Tedesco, L., Hazlewood, W., Kurtz, A., Hall, R.E., Hursey, J., Toscos, T. (2007). Why it's worth the hassle: The value of in-situ studies when designing ubicomp. In Proceedings of the International Conference on Ubiquitous Computing (Ubicomp 2007), Springer, 336-353.

Rogers. Y., Sharp, H., Preece, J. (2011). Interaction design: beyond human-computer interaction. 3rd edition. John Wiley & Sons, Chichester, UK.

Rogers, Y. (2011). Interaction design gone wild: Striving for wild theory. Interactions, 18(4), 58-62.

Rosales, A., Arroyo, E., Blat, J. (2011a). FeetUp: A playful accessory to practice social skills through free-play experiences. In Proceedings of the International Conference on Human-Computer Interaction (INTERACT 2011), Springer, 37-44.

Rosales, A., Arroyo, E., Blat, J. (2011b). Evocative experiences in the design of objects to encourage free-play. In Proceedings of AmI 2011 Workshops (AmGam 2011), Springer, 229-232.

Rozendaal, M.C. & Vermeeren, A.P.O.S. (2014). Physical hypotheses: Things we learned and think you should know too. CRISP Magazine (3), 26-27.

Rozendaal, M.C., Vermeeren A.P.O.S., Issidorides, D. (2015) Using mobile technologies to capture the visitor experience. Manuscript submitted for publication in Curator Journal.

Rubin, K.H., Fein G., Vandenberg, B. (1983). Play. In: E.M. Hetherington (Ed.). Handbook of child psychology: Socialization, personality, and social development (Vol. 4). Wiley, New York.

Rubin, K.H. (2001). The Play Observation Scale (POS), http://www.rubin-lab.umd.edu/CodingSchemes. Published by the Center for Children, Relationships, and Culture, University of Maryland.

Salen, K. & Zimmerman, E. (2003). Rules of play: game design fundamentals. The MIT Press, Cambridge, MA.

Santer, J., Griffiths, C., Goodall, D. (2007). Free play in early childhood: a literature review. National Children's Bureau, England.

Scaife, M. & Rogers, Y. (1999). Kids as informants: telling us what we didn't know or confirming what we knew already. In: A. Druin (Ed.). The design of children's technology. Morgan Kaufmann Publishers San Francisco, CA.

Scarlett, W.G., Naudeau, S., Salonius-Pasternak, D., Ponte, I. (2005). Children's play. Sage Publications, Inc.

Scollon, C.N., Kim-Prieto, C., Diener, E. (2003). Experience sampling: Promises and pitfalls, strengths and weaknesses. Journal of Happiness Studies, 4(1), 5-34.

Seitinger, S., Sylvan, E., Zuckerman, O., Popovic, M., Zuckerman, O. (2006). A new playground experience: going digital? In CHI '06 Extended Abstracts on Human Factors in Computing Systems (CHI EA 2006), ACM Press, 303-308.

Shwe, H. & Francetic, A. (1999). Smarter play for smart toys: the benefits of technology-enhanced play. Zowie Intertainment White Paper 3208.

Sniderman, S. (1999). Unwritten Rules. The Life of Games, 1, 2-7.

Soute, I., Markopoulos, P., Magielse, R. (2010). Head Up Games: combining the best of both worlds by merging traditional and digital play. Personal and Ubiquitous Computing, 14(5), 435-444.

Soute, I. & Sturm., J. (2011). Towards a setup for longitudinal evaluation of children's play behavior. Presented at International Workshop on Evaluating Player Experience in Games (EPEX 2011).

Souza, C.S. de (2005). The semiotic engineering of human computer interaction. The MIT Press, Cambridge, MA.

Spencer, H. (1873). The principles of psychology (Vol.2). D. Appleton, New York.

Stolterman, E. & Wiberg, M. (2010). Concept-driven interaction design research. Human-Computer Interaction, 25(2), 95-118.

Strauss, A.L. & Corbin, J.M. (1990). Basics of qualitative research: Grounded theory procedures and techniques. Sage Publications Inc, California.

Sturm, J., Bekker, T., Groenendaal, B., Wesselink, R., Eggen, B. (2008). Key issues for the successful design of an intelligent, interactive playground. In Proceedings of International Conference on Interaction Design and Children (IDC 2008), ACM Press, 258-265.

Suchman, L. (1987). Plans and situated actions. Cambridge University Press, Cambridge.

Suits, B. (1990). Grasshopper: Games, Life, and Utopia. David R. Godine, Boston.

Tentori, M. & Hayes, G.R. (2010). Designing for interaction immediacy to enhance social skills of children with autism. In Proceedings of the International Conference on Ubiquitous Computing (Ubicomp 2010), Springer, 51-60.

Tieben, R., Bekker, T., Schouten, B. (2011). Curiosity and interaction: making people curious through interactive systems. In Proceedings of the BCS Conference on Human-Computer Interaction (BCS-HCI 2011), ACM Press, 361-370.

Tieben, R., Valk, L. de, Rijnbout, P., Bekker, T., Schouten, B. (2014). Shake up the schoolyard: Iterative design research for public playful installations. In Proceedings of International Conference on Interaction Design and Children (IDC 2014), ACM Press, 175-183.

Tieben, R. (2015). Activating Play: a design research study on how to elicit playful interaction from teenagers. Doctoral dissertation. Eindhoven University of Technology, The Netherlands.

Titman, W. (1994). Special places; special people: The hidden curriculum of schoolgrounds. World Wide Fund for Nature UK, Surrey (UK).

VandenBerghe, J. (2014). Engines of play: How player motivation changes over time. In Proceedings of the ACM SIGCHI annual symposium on Computer-human interaction in play (CHI PLAY 2014), ACM Press, 476.

Valk, L. de, Rijnbout, P., Bekker, T., Eggen, B., Graaf, M. De, Schouten, B. (2012). Designing for playful experiences in open-ended intelligent play environments. In Proceedings of IADIS International Conference Game and Entertainment Technologies (IADIS GET 2012), 3-10.

Valk, L. de, Bekker, T., Eggen, B. (2013a). Leaving room for improvisation: Towards a design approach for open-ended play. In Proceedings of International Conference on Interaction Design and Children (IDC 2013), ACM Press, 92-101.

Valk, L. de, Rijnbout, P., Graaf, M. de, Bekker, T., Schouten, B., Eggen, B. (2013b). GlowSteps – A decentralized interactive play environment for open-ended play. In Proceedings of International Conference on Advances in Computer Entertainment (ACE 2013), Springer, 528-531.

Vanden Abeele, V., Zaman, B., Grooff, D. de (2012). User experience laddering with preschoolers: Unveiling attributes and benefits of cuddly toy interfaces. Personal and Ubiquitous Computing, 16(4), 451-465.

Veitch, J., Salmon, J., Ball, K. (2010). Individual, social and physical environmental correlates of children's active free play: a cross-sectional study. International Journal of Behavioral Nutrition and Physical Activity, 7(11).

Vermeulen, J., Luyten, K., Hoven, E. van den, Coninx, K. (2013). Crossing the bridge over Norman's Gulf of Execution: Revealing feedforward's true identity. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2013), ACM Press, 1931-1940.

Vygotsky, L. (1976). Play and its role in the mental development of the child. In: J.S. Bruner, A. Jolly & K. Sylva (Eds.). Play: its role in development and evolution. Basic Books, New York.

Vygotsky, L. (1978). Mind in society: the development of higher psychological processes. Harvard University Press, Cambridge, MA.

Zimmerman, E. (2003). Play as research: The iterative design process. In: B. Laurel (Ed.). Design research: Methods and perspectives. The MIT Press, Cambridge, MA.

Zimmerman, J., Forlizzi, J., Evenson, S. (2007). Research through design as a method for interaction design research in HCI. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2007), ACM Press, 493-502.

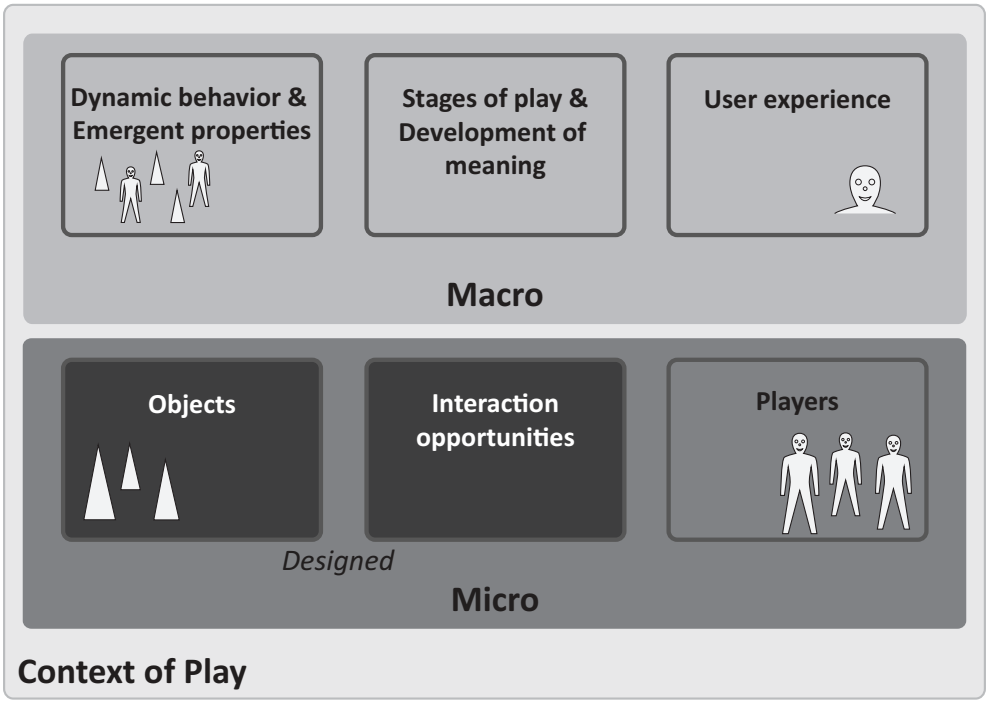
Zuckerman, O. (2010). Designing digital objects for learning: lessons from Froebel and Montessori. International Journal of Arts and Technology, 3(1), 124-135.

Appendices

Appendix A: I-PE framework

The I-PE framework aims at providing a structured overview of focus areas that are important for developing engaging play opportunities that have the potential to lead to different types of play experiences. It illustrates the link between designed objects and emergent events. The framework can support designers in explaining and understanding open-ended, interactive play environments.

The framework is structured around three levels (see Figure below). These levels are not mutually exclusive and can influence each other. The levels are: Context of Play, Micro and Macro. Context of Play focuses on the social and physical context of use and the overall design aim. Understanding the context of play is important as it can provide both possibilities and restrictions for (the use of) open-ended designs. The Micro level describes the basic elements in an open-ended interactive play environment. This level describes the elements of the system that are actually designed and can be directly influenced: Objects and Interaction Opportunities, and the Players that interact with these elements. The Macro level indicates which factors of the design emerge from interaction and can only be influenced indirectly. It includes Dynamic Behavior & Emergent Properties and Stages of Play & Development of Meaning.



Appendix B: Questions interview study

Start of project	Middle of project	End of project
How was your design space defined? What was fixed at this point? Was there a clear design brief? How were choices made on user group / technology / context?	Did your design space definition change? What was fixed at this point? How were choices made on user group / technology / context?	Did your design space definition change? What was fixed at this point? How were choices made on user group / technology / context?
How did you start designing for open-ended play? What was the process planning at this point?	How did you continue designing for open-ended play? What worked or didn't work and why?	Looking back at your design process, how did you design for open-ended play?
What were your intentions? What kind of play scenarios did you envision?	What were your intentions? What kind of play scenarios did you envision?	What were your intentions? What kind of play scenarios did you envision? Did this work out the way you envisioned?
What were your values? What did you want to accomplish? How did you get to these values?	What were your values? What did you want to accomplish? How did you get to these values?	What were your values? What did you want to accomplish? How did you get to these values? Did you manage to accomplish these values?
How open-ended did you envision your design at this point? Were there structures / restrictions / stakeholders involved that determined open-endedness at this point?	How open-ended did you envision your design at this point? Were there structures / restrictions / stakeholders involved that determined open-endedness at this point?	How open-ended did you envision your design at this point? Were there structures / restrictions / stakeholders involved that determined open-endedness at this point?
What influence did the stakeholders in your project have at this point? How did they influence the choice on values?	What influence did the stakeholders in your project have at this point? How did they influence the choice on values?	What influence did the stakeholders in your project have at this point? How did they influence the choice on values?

Appendix C: Design briefs student projects

SHAPING PLAY 2009-2010

Brief Description: Embodiment deeply influences action. That is true for our own actions, but also for the physical objects we are interacting with. According to Norman, affordances are the perceived action possibilities, suggested by the physical appearance of an object. For a designer, affordances provide a powerful tool to influence the behaviour of our intended users. In this project the concept of affordances will be explored for an interactive playground. The ultimate goal is to come with a coherent set of design proposals for interactive objects for play that engage children in physical activities like running, jumping, balancing and swinging.

Objectives / Specifics: M11 students are expected to use an experimentative approach. M12 students will do a systematic exploration of design opportunities, based on insights from motor development stages of children. There are many opportunities for competency development.

Essential in this project are: Idea Generation: you have to create a coherent set of archetypical interactive objects; Integrating Technology: working interactive prototypes are required. Several technologies are available, like Arduino's, PIC microprocessor boards, ZigBee wireless communication; User Focus: you will have to build an understanding of your users early in the project, and involve them in the design process. User testing is required after each design iteration. Forms and Senses: the design iterations will lead to a finalized design proposal.

Good opportunities are further possible for: Descriptive and Mathematical Modeling: when a concept is spread over a larger area in for example a city, and consists of multiple connected objects, it is an interactive system. It will be a challenge to manage the complexity of it, during the design process and in the final deliverable; Naturally, Self-Directed Learning and Research and Design Processes are always important.

Planning: A global planning for the project is:

First quartile interim: Present design research outcomes; First iteration of concepts, low tech prototypes; First iteration of user testing; Concept focus.

Semester interim: Second iteration of concepts, interactive prototypes; Second iteration user testing; Final design specs.

Second quartile interim: At least one of the designs presented at end quality.

Final exhibition: Present full set of interactive play objects.

Deliverables: Several iterations of prototypes, demonstrators / working models of

interactive objects. Design studies. Report. Exhibition.

Information Sources: A selection of relevant literature is available.

SHAPING PLAY 2010-2011

Brief Description: Embodiment deeply influences action. That is true for our own actions, but also for the physical objects we are interacting with. Norman provides the theoretical framework for this: affordances. Affordances are the perceived action possibilities, suggested by the physical appearance of an object. For a designer, affordances provide a powerful tool to influence the behaviour of our intended users. In this project the concept of affordances will be explored for interactive play objects.

But we want you to go further. Affordances focus on the static appearance of objects. In the interaction however, more is possible. Sounds, haptic behaviour, light patterns, can give a user more clues about possible uses. And, can allow users to use the objects in different framings. Framing is a way to put play in context: the same object can be a light sabre in a StarWars fight, a magic wand in when playing a wizard, or a dance object when a kid imagines being a dance star.

To give you a kick start, you can start with one of the end concepts from the previous edition of this project.

Objectives / Specifics: This project asks for an experimentative approach. Try different implementations, experiment with modalities.

There are many opportunities for competency development. Essential in this project are: Idea Generation: you have to create a coherent set of object behaviours that allows for a range of framings; Integrating Technology: working interactive prototypes are required. Several technologies are available, like Arduino's, PIC microprcessor boards, ZigBee wireless communication. User Focus: you will have to build an understanding of your users early in the project, and involve them in the design process. User testing is required after each design iteration. Forms and Senses: the design iterations will lead to a finalized design proposal.

Good opportunities are further possible for: Descriptive and Mathematical Modeling: defining this coherent set of behaviours requires you to define an overall model. It is possible to do this in a more formal way; Naturally, Self-Directed Learning and Research and Design Processes are always important.

Planning: End of week 1: present first concept, roughly specify multimodal behaviours. Define first implementation of prototypes.

End of week 3: present results of first iteration of user tests with these prototypes.

First quartile interim: present second concept, with improved behaviours.

End of week 6: present results of second iteration of user tests.

Semester interim: present third concept, planning for second quartile.

Second quartile interim: at least one of the designs presented at end quality.

Final exhibition: present full set of interactive play objects.

Deliverables: Several iterations of prototypes, demonstrators / working models. Design studies. Report. Exhibition.

Information Sources: A selection of relevant literature is available.

CREATING PLAY 2011

Introduction and background project: Play! In the Playful Interaction theme, we believe that play is a powerful and enjoyable design element, used through the world. People play, and people are social beings: this combination offers an exciting range of design opportunities. In this project, we want you to explore, develop and show the way in which play can be used to enrich and solve design problems.

In the design-research world, and especially in the PI theme, we focus on eliciting physical and social play. We try to answer questions such as: how can we invite people to perform certain behavior? Should we do this in a playful way, or through play? How can we motivate physical and social play? How can we use play to enrich designs for children, teenagers or elderly?

Concrete on-going studies, related to this project, are: The PlayFit project, in which we try to seduce teenagers to little moments of physical activity throughout the day; The I-PE project, in which we want to create intelligent play environments for social and physical play; The business side of such implementations: what business models are required to create successful field labs for playful systems; The larger fields of playful interaction, game design, intelligent play, open-ended play and decentralized play

Theories about play and playfulness can provide inspiration for what kind of activities to support. Theories about social play can provide ideas for how players can discuss game goals and rules, and how to combine verbal statements and actions to interact with each other.

Theories about decentralised behavior can provide novel ideas for how many different small behaviours of play objects can lead to only partly predictable but really playful interaction situations. What small 'animal' rules in play objects will lead to an overall playful interaction of all players.

Overview of all sorts of playful experiences, such as challenge, curiosity and exploration (described by Korhonen) and game design rules can provide pointers for what playful interaction to incorporate in the play environments.

Previous projects have explored variations in open-ended pay solutions contributing to a more nuanced view on how and when to apply this approach (Bekker paper, Schouten paper). They have also explored how children play with decentralised play environments and have led to some initial understanding of what contributes to a fun experience, such as having some level of control in the interaction (Graaf paper). Also, prototype designs for teenagers have led to a design philosophy of designing for expression, through casual active play activities which are interwoven with everyday activities (Tieben paper). Theme name Project code 2

Design challenges / research questions: The design (research) challenges lie in creating appealing play experiences for specific user groups, that develop new challenge over time, that use interaction agent rules that lead to interesting emergent play behaviour, that incorporate knowledge from complementary stakeholders (technological, user play expert, physical activity expert, city/municipal partners) in social innovation.

The project can be tailored to students' competency development and interest by selecting a predefined project scenario, or by exploring the best combination of a number of design parameters in a more general scenario. Important design parameters are: values and needs of user groups, focus on decentralized rules and emergent play behaviour, more simple or more complex set of stakeholder considerations in the project, influence of output media on play experience, and designing for variations in physical and or social activities.

Two example scenarios are:

1. In this play environment that consists of various play objects, multiple players explore different interactions, they have to run to quickly give all the objects a different colour, they have to balance one of the objects to the right angle so that it triggers new play opportunities in the other objects, and over time the challenges become more difficult because they have to collaborate better

2. A play concept is created that uses various social media solutions to get youngsters through the school to put different objects into the correct positions.

Some of the questions that you could answer: Can we let teenagers play and move in a shopping mall? Can we design an interactive playground that remains interesting to play in, time-after-time? Can we use play to prevent elderly from becoming socially isolated? Can we design and implement a game that is played throughout the school, and even on the way home?

Development theme: The focus of Playful Interactions is on changing people's lives by designing systems that seduce people to activities that contribute to their health and wellbeing. As Huizinga wrote in his book 'Homo Ludens' (1938) people are inherently playful beings. How can we design products that allow for this playfulness in daily activities and in this project related to social interaction?

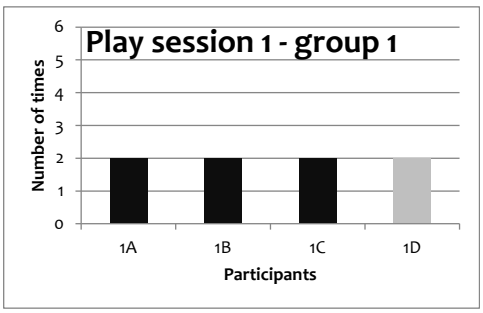
The project will contribute in terms of prototypes illustrating the value of the playful design philosophy. It will contribute to design guidelines for how to select playful mechanisms for specific user groups and contexts.

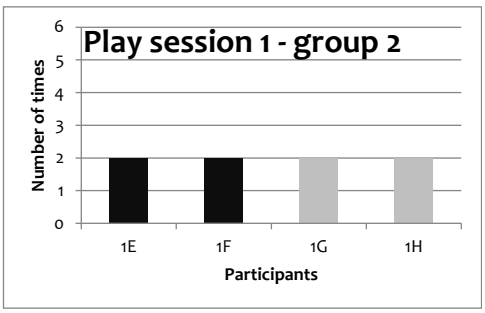
It will contribute in our understanding of how to seduce children to physical activities and to understanding how to design for emergent play behaviour.

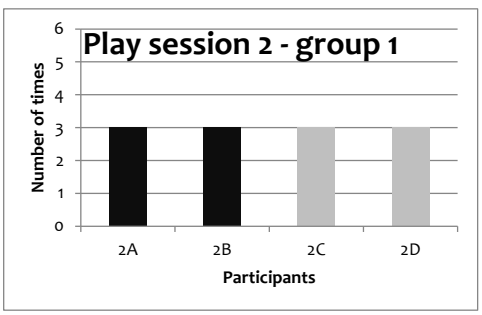
References / information sources: Previous student projects; A selection of relevant literature is available.

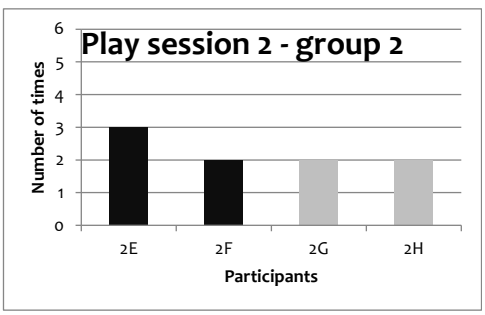
Appendix D: Composition groups

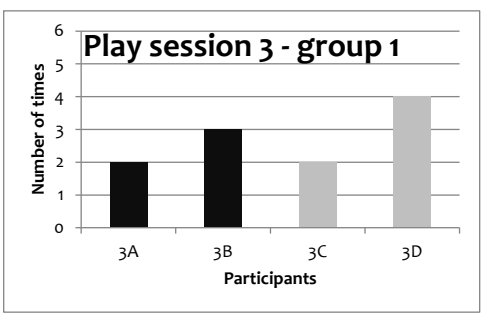
The graphs below illustrate the twelve groups (two groups per week) that played with GlowSteps over the six weeks and show the division of boys (black) and girls (grey) over the groups as well as the number of play sessions the children, at that moment, participated in. The participants are on the horizontal axis and the number of times they played (1-5) on the vertical axis.

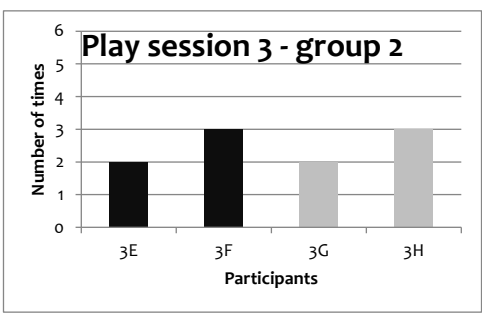


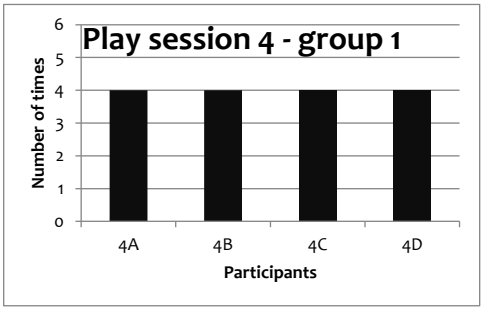


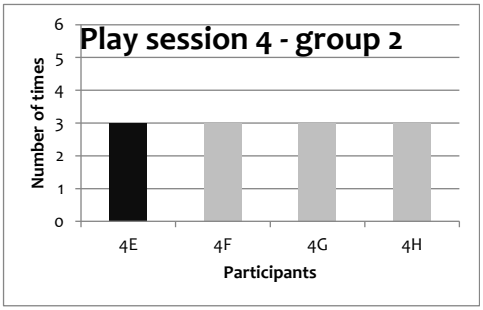


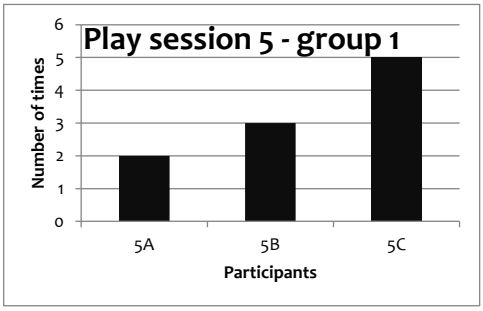


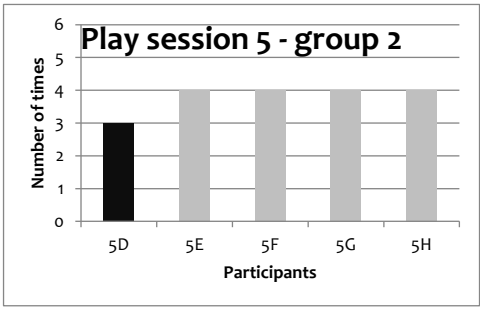


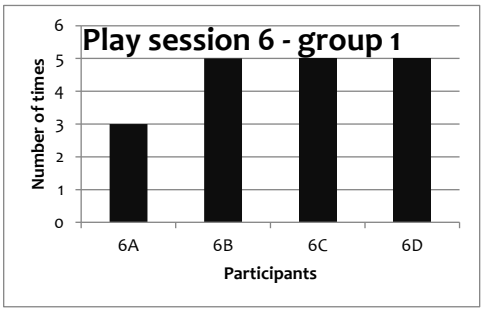


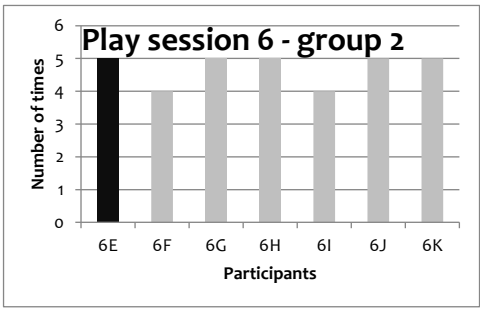

Play session 4 - group 1
Number of times
0
1
2
3
4
5
6
4A
4B
4C
4D
Participants


Play session 4 - group 2
Number of times
0
1
2
3
4
5
6
4E
4F
4G
4H
Participants


Play session 5 - group 1
Number of times
0
1
2
3
4
5
6
5A
5B
5C
Participants


Play session 5 - group 2
Number of times
0
1
2
3
4
5
6
5D
5E
5F
5G
5H
Participants


Play session 6 - group 1
Number of times
0
1
2
3
4
5
6
6A
6B
6C
6D
Participants


Play session 6 - group 2
Number of times
0
1
2
3
4
5
6
6E
6F
6G
6H
6I
6J
6K
Participants

Appendix E: Interview questions

QUESTION CARDS

Speelden jullie samen of alleen?

Welke spelletjes hebben jullie verzonnen?

Hoe speelden jullie met de stapstenen en de lichtjes?

Wat vonden jullie leuk en wat niet zo leuk?

ANSWERS CHILDREN

At the end of each play sessions, we carried out a short interview with the children. Below we give an impression of the answers that the children gave during these interviews.

How did you play with the steps and the lights?

We stamped on them. And we lay down on them. [Week 42]
We stamped and we ran. [Week 42]
Sometimes the lights turned off and then we had to do it again. [Week 44]
When there was a green light we stepped on it and then they all started to blink. [Week 44]
I invented to make our own field. And then we stepped on the tiles, but sometimes we had the lights and they did not. Then we also stepped on them, but sometimes their tiles lit up while they maybe did not want that. [Week 44]
We put them all on top of each other and then we wiggled. Who fell off first, was out [Week 45]
We made colors a little bit. [Week 45]
We played 'Catch'. [Week 46]
We played 'I hate colors'. [Week 49]
Well, I was a cat and when I stood on a tile I became human. [Week 49]

Which games did you make up?

We made piles. And we jumped off the bench. [Week 42]
We played 'Catch'. And we stood on 'Glowstones' and they turned into another color.
We made piles and who had the most won. [Week 42]
Trying o hop to the other side. And trying to... The red… When you have a red color, you are dead. And if you have the blue color or the yellow color, you are not yet dead. [Week 44]
[Other child] and I made a thing where you have to jump over one to step on. [Week 44]
All the time a light would turn on and then we had to step on it. Green or yellow, then we stepped on it and then all tiles started to blink. And then we had one point. [Week 45]
I made a hopscotch diagram. [Week 45]
We played tag. [Week 45]
Monsters attack. Firemonster. And Zombie. [Week 46]
Lava stepping stones. [Week 46]
Dragon against wolf. And we played knights; you had to run to the other side and then attack home and so on. I liked that the most. [Week 48]
And we played this, catching the light. [Week 48]
Hitting the colors. [Week 49]

Did you play together or alone?

Together. [Week 42]
Together. Well, not really together. [Other child] and I played together. But not with the four of us. [Week 44]
We played together and they played together. [Week 44]

Together with all of us and then together with [other child]. [Week 45]
We played together with the two of us. [Week 45]
They played together, but I played alone. They attacked me. [Week 46]
Together. [Week 46]
Together. [Week 48]
Together. [Week 49]

What did you like and what did you not like that much?
I liked everything actually. I liked making the pile with all the red tiles the most. [Week 42]
I did not like that you had to step on one all the time. Constantly stepping until it was the right color. [Week 42]
I liked that we could stamp on them, but I did not like when [other child] dropped them. [Week 42]
[Other child] took away one GlowStep. [Week 42]
I did not like that they took away our steps. [Week 44]
And that they [other children] bored us. [Week 44]
[Other child] tried to push me from the bench, but I did like that because he tried to push me, but then he fell off himself! [Week 44]
I liked that we could make a hopscotch diagram. [Week 44]
I did not like that [other children] were so busy. [Week 44]
I did not like… When [other child] said that you could not stand on other colors than red and blue and then I had yellow all the time. [Week 44]
I liked everything. [Week 45]
I liked playing with the GlowSteps stones. [Week 45]
I did not like when [other child] nagged us. [Week 45]
I liked when we played the game of wiggling. [Week 45]
I liked when this one turned green and then we stepped on them and then we got one point all the time. [Week 45]
I also did not like when [other child] said: "We beat the girls." [Week 45]
I liked everything. [Week 46]
I did not like it that they nagged me. [Week 46]
I like the game of catching the zombie. [Week 46]
I liked playing a monster and catching [other child]. [Week 46]
I liked playing with the stepping stones. [Week 48]
We liked everything. [Week 49]
I did not like two things. At the start I could not join. And then [other child] said she would do something but she did not. [Week 49]
I liked hitting bottom colors. [Week 49]

Appendix F: Summary extra play sessions

During the user evaluation at the primary school, the researcher present was approached by employees from the after school child care whether playing with GlowSteps could be organized as an activity during their working hours after school is finished. At the after school child care, children are divided into several groups by means of their age. In consultation with the different group leaders, we organized two play sessions: one with children in the age of approximately 6-9 years old and one with younger children in the age of 4-5 years old. Again, the play sessions took place at the school's playroom.

The sessions show clear differences between the age groups and emphasize the variety in types of play that children can be engaged in with GlowSteps.

The younger children (4-5 years old) played in groups of six with GlowSteps. In total, fifteen children played with the design (three children played two times). Each group played for around five minutes with the interaction behavior Create. During all play sessions, the group leader was present as well. Most of the children were rather shy in approaching the steps. At the start of the play session, they would carefully stand on one step and jump on it multiple times to make different colors, while naming the colors of their step out loud. As a next step, children would start to walk over the steps, or use their hands or knees to touch the steps. Other observed actions include hopping from one step to another and walking closely behind each other in a row. The different colors were a sensation for the children. Some children even believed they had magic powers for instance when a step turned green for a couple of times in a row. A number of children also attached meaning to the different colors, for instance red is fire and blue is water, and added some kind of 'judgment' to these colors, for instance they should not make water (blue) or they had to stand still when they were on a red step. Social interaction was quite diverse; some children interacted with each other, while other children seem to be more in their own 'play cocoon' and did not communicate with other children at all. When walking over the steps, children directed other children who were in their way to move to another step: "You have to go there".

Overall, the young children were very enthusiastic about the steps. When the group leader told the children to return to the after school child care facility and thus to stop playing with the steps, they kept looking and pointing at the steps and calling out the colors of the steps that lit up. Some children even wanted to go back to the steps and play with them but this was not allowed by the group leader. If we look back at persona Tommy (4 years old) as presented in Chapter 1, we see similarities between Tommy and the observations of the younger children at the after school child care. The children were mostly involved in simple forms of play, such as jumping and walking over the steps. Just like Tommy, pretend play involving magic had a great attraction on the children. Furthermore, the children from this age group played alone or in small groups; both composition are applicable to Tommy's play as well.

The older children (6-9 years old) played in two groups with GlowSteps. The first group consisted of six boys and two girls. They played with interaction behaviors Create, Catch and Toggle for around twenty-five minutes in total. The second group consisted of eleven girls and one boy. They played with interaction behavior Create for a maximum of forty-five minutes. Some children returned to the after school care facility earlier or were picked up by their parents. From the second group, two girls already played with GlowSteps for a number of times before, as they were part of the class that participated in the user evaluation. During these play sessions, no group leader was present.

The older children also needed some time to explore the functionality and possibilities of GlowSteps, but they were more straightforward in approaching the researcher present and asking questions such as: "What are we supposed to do with this?". They came up with the idea to dim the lights in the playroom in order to increase the visibility and the sensation of the steps' colored lights. The children of the second group started with similar behavior of the younger children: all of them walked over the steps from one step to another. But, as they were with a large amount of children, this soon became too crowded and there were no places to walk which was frustrating. The children played a variety of games with GlowSteps, usually in smaller groups of 2 to 7 children. They divided the steps over the groups. Some children simply jumped on and danced around the steps or skated around the room with their feet on the steps, while others played tag, foot off the floor or walked in turns over a row of steps, etcetera. They also tried to protect the steps by lying on top of them. To give an impression of other games the older children invented, we will now describe two games in more detail. In the first game, children sit in front of their 'personal' step and drum with their hands on this step. When their step turns red, they pick it up and hold it above their head. The last one with a red step above his or her head loses the game. The game then starts over again. In a variation of this game, the children stand in front of their step and jump on it to change its color. One child chooses a color, e.g. "Blue!", and all children jump on their steps until it turns blue. When that happens, they stand still on their step. Again, the last one with their step in the preferred color loses the game. The second game consists of walking over a long path of steps (preferably in a circle or a hopscotch diagram). From a certain starting point, children walk over the steps without touching the ground. One or two children are appointed as jury who watch if nobody touches the ground and move steps closer if necessary. A variety of rules can be applied in this game. For example, the color of the step determines if you collect or loose points ("If you step on blue, you lose one point"), or the players have to pick one 'personal' color and try to get as many steps in that color as possible, or they can only collect points when walking on a selection of the steps. Whenever the rules have changed, the game starts again.

Overall, the older children played in various ways with GlowSteps and enjoyed doing so. When parents came to pick up their children, they often had trouble with persuading them to leave as the children preferred to stay and play with GlowSteps. During the play session of the second group, one of the group leaders had to come to pick up the last

girls eventually (after around forty-five minutes); otherwise they would have continued playing. Again, we can discover similarities between the observations of the older children and the persona of Louise as described in Chapter 1. The children often played together with friends of the same gender in small groups. Especially the girls involved dancing and singing in their play and expressed themselves in this way. They play rather easy games and discuss about the rules. They try to win or prevent others from winning (for instance by protecting the steps), but a loss is soon forgotten and a game is easily restarted.

To sum up, these observations show that an open-ended play design such as GlowSteps encourages diverse play behavior appropriate for different ages. Children from a younger age group, who are not yet able to create complex rules and games, enjoy stepping around on the steps and attaching simple meanings to the colors. Older children, who have progressed in their cognitive, physical and social development, can create games with rules, involve other children and express themselves with the design.

Summary

Imagine an interactive play environment filled with play objects, which actively attract children to start interacting and react to their actions in play. The play objects are open-ended; they do not offer pre-defined goals and rules but instead stimulate children to come up with their own game play. For example, objects can light up when children approach them or make sounds when they are touched. Children are encouraged to use their creativity and improvisation in play. In this way, play becomes a result of the dialogue between players and the design. Designing for open-ended play offers a lot of possibilities for children to be creative and social, but it also offers a challenge for designers as they should deliberately leave interaction opportunities open to support children's improvisation. This thesis explores how to design for open-ended play and investigates the design process, as well as children's play behavior when involved in open-ended play with interactive objects. The work follows a research through design approach, in which several design prototypes are developed and evaluated with potential users, in this case children in the age of 6-8 years old. For example, in an iterative process of design and evaluation we developed the open-ended play design GlowSteps; a set of interactive tiles that can light up in different colors, which encourages children to create their own game rules and goals and attach meaning to the light output and interaction opportunities. Besides that, Industrial Design students carried out various design explorations related to our research in which they built on the developed knowledge and tools and at the same time contributed to our research by providing new insights and increasing existing design knowledge. This PhD research is part of the Intelligent Play Environments project that focuses on developing interactive play environments for social and physical play, supported by a grant from FES funding from the Dutch government. The thesis is divided into three parts on examining open-ended play, considering Stages of Play and investigating prolonged open-ended play.

In the first part of the thesis we propose a design approach for open-ended play. In Chapter 2, we position and define open-ended play in relation to existing literature on play and games and interactive open-ended play designs. To explore the design process of open-ended play, we carried out an interview study in which we asked students about their experiences in designing for open-ended play. This resulted in the identification of a set of essential actions in the design process, including framing the design space, making design decisions on what and what not to design, and verifying the open-ended properties through early prototyping and frequent user confrontations. In Chapter 3, we discuss the relevance of rules in open-ended play and present a division into two types of rules for open-ended play: interaction behavior rules (behavior that a designer programs into a open-ended play object) and created game rules (rules that players create in the context of open-ended play). Furthermore, we describe the actions of interpretation and improvisation that connect these two types of rules.

In the second part of the thesis, we present a model developed to guide designers in

their process of developing interactive, open-ended play designs. This model is called the Stages of Play model and consists of three stages in interaction: invitation, exploration and immersion. The model helps to design more nuanced interaction behaviors by considering different steps in how users interact with a system over time. In Chapter 4, we relate this model to existing models of interaction over time and discuss various ways in which the model was applied in a number of design cases. In Chapter 5, we focus on social interaction in these three stages by analyzing two evaluation studies with interactive, open-ended prototypes. This analysis showed that the types of social play change over time, starting with individual actions in the invitation and exploration stage towards more complex social play in the immersion stage.

In the third part of the thesis, we discuss an evaluation study in which we examined how children play on the long-term with an open-ended play design. During a period of ten weeks, we carried out a user study in which children at a local primary school played with the interactive, open-ended play design GlowSteps, as discussed in Chapter 6. In total 16 children played multiple times (at most five times) in small groups with the design. Over the weeks, children's interest and enthusiasm to play with GlowSteps remained high. Based on observations and interviews, we were able to qualitatively analyze how children's play behavior with an open-ended play design such as GlowSteps developed and changed over time. For instance, over time children varied the rules and the meaning they allocated to the interactions and developed preferences for certain interaction behaviors. We translated these results to implications for designs, such as offer short and simple interactions that can change over time and continue to encourage exploration.

This thesis concludes that children are able to create their own diverse game rules and goals and enjoy playing with interactive, open-ended play designs, both in initial sessions as over time. Designing for open-ended play, although challenging and difficult, can benefit from design knowledge and tools as presented in this thesis. The contributions of this thesis include a design approach for open-ended play, a model of interaction over time and numerous design considerations. Together these contributions serve to support designers in creating engaging and meaningful open-ended play designs in various domains such as children's play environments, interactive art, public installations and interactive systems in general.

Samenvatting

Stel je een nieuwe speelomgeving voor waar kinderen uitbundig spelen met verschillende interactieve speelobjecten. Deze objecten proberen kinderen te verleiden om te komen spelen door bijvoorbeeld van kleur te veranderen als ze voorbij lopen. Ook reageren de objecten door bijvoorbeeld geluid te maken als één van de kinderen een object aanraakt. Maar de objecten bieden geen vooraf gedefinieerde doelen of regels aan. In plaats daarvan stimuleren ze kinderen om hun eigen spel met de objecten te bedenken. De speelobjecten zijn 'open-ended'; ze hebben een open einde dat kinderen zelf kunnen invullen. Kinderen worden aangemoedigd om hun creativiteit en verbeelding te gebruiken en hun eigen spel te creëren. Zo wordt spel een resultaat van de dialoog tussen de spelers en de objecten. Open-einde spel biedt kinderen veel mogelijkheden om creatief en sociaal bezig te zijn, maar het is een uitdaging om voor dit soort spel te ontwerpen. Ontwerpers voor open-einde spel streven ernaar om speelobjecten met open interactiemogelijkheden te ontwerpen die verschillende interpretaties en improvisatie ondersteunen. Dit proefschrift biedt inzichten en handvatten voor het ontwerpen voor open-einde spel met interactieve speelobjecten. Zowel het ontwerpproces als het speelgedrag van kinderen in de context van open-einde spel wordt uitgebreid bestudeerd. Het onderzoek volgt een 'research through design' aanpak waarin verschillende ontwerp-prototypes worden ontwikkeld en geëvalueerd met gebruikers; in dit geval kinderen in de leeftijd van 6-8 jaar oud. Een voorbeeld van een ontwerp-prototype is GlowSteps; een set van interactieve tegels die in verschillende kleuren kunnen oplichten. GlowSteps ondersteunt open-einde spel doordat het kinderen aanmoedigt om hun eigen spelregels en doelen te verzinnen. Daarnaast hebben studenten Industrial Design in verschillende projecten nieuwe ontwerp-verkenningen gedaan en zo de kennis en inzichten over ontwerpen voor open-einde spel verder aangevuld en uitgebreid. Het promotieonderzoek is onderdeel van het 'Intelligent Play Environments' project dat zich richt op het ontwikkelen van interactieve speelomgevingen die sociaal en fysiek spel ondersteunen. Dit project wordt gefinancierd door FES-gelden van de Nederlandse overheid. Het proefschrift is onderverdeeld in drie delen: open-einde spel, Stages of Play (fases van spel) en langdurig open-einde spel.

Het eerste deel van het proefschrift (Hoofdstuk 2 & Hoofdstuk 3) beschrijft een ontwerpbenadering voor open-einde spel. In Hoofdstuk 2 positioneren en definiëren we open-einde spel met interactieve speelobjecten in relatie tot bestaande literatuur over spel en games. We beschrijven een interview-studie waarin we studenten vroegen naar hun ervaringen in het ontwerpen voor open-einde spel. Gebaseerd op deze interviews hebben we drie essentiële acties in het ontwerpproces voor open-einde spel kunnen identificeren: definiëren van de ontwerpruimte,; beslissingen maken over wat wel en wat niet vast te leggen in het ontwerp; en vroeg in het proces ontwikkelen van ontwerp-prototypes en deze regelmatig testen met potentiële eindgebruikers. Hoofdstuk 3 beschrijft de relevantie van regels in open-einde spel. We presenteren twee soorten regels: interactieve gedragsregels (gedrag dat een ontwerper in een open-einde

speelobject programmeert) en verzonnen spelregels (regels die spelers bedenken tijdens open-einde spel). Verder bespreken we de acties van interpretatie en improvisatie die deze twee soorten regels verbinden.

In het tweede deel van het proefschrift (Hoofdstuk 4 & Hoofdstuk 5) presenteren we een model dat is ontwikkeld om ontwerpers voor interactief, open-einde spel te ondersteunen in hun ontwerpproces. Dit model heet de 'Stages of Play' (fases van spel) en bestaat uit drie fases: invitation (uitnodiging), exploration (exploratie) en immersion (onderdompeling). Het model zet ontwerpers aan het denken over hoe gebruikers omgaan en interacteren met een ontwerp. Dit helpt ontwerpers om genuanceerd interactiegedrag te ontwerpen. In Hoofdstuk 4 bespreken we het model in relatie tot bestaande modellen van interactie over tijd en demonstreren we hoe het model op verschillende manieren kan worden toegepast in het ontwerpproces. In Hoofdstuk 5 richten we ons op sociale interactie in de drie Stages of Play. We analyseren twee evaluaties met interactieve, open-einde speelontwerpen: Wobble en GlowSteps. Deze analyse toont aan dat sociaal spel verandert over de drie fases: van individuele acties in de eerste en tweede fase naar meer complexe, sociale acties in de laatste fase.

Het derde deel van het proefschrift (Hoofdstuk 6) bestaat uit een evaluatie waarin we onderzoeken hoe kinderen over een langere tijd met een interactief, open-einde ontwerp spelen. Gedurende een periode van tien weken konden kinderen op een lokale basisschool meerdere malen met het ontwerp-prototype GlowSteps spelen. In totaal speelden 16 kinderen tot vijf keer in kleine groepjes met GlowSteps. In de loop van de studie bleef de belangstelling en het enthousiasme om met GlowSteps te spelen hoog. Op basis van observaties en interviews hebben we kwalitatief geanalyseerd hoe het speelgedrag van kinderen met een open-einde speelontwerp zoals GlowSteps ontwikkelt en verandert over tijd. Uit deze analyse blijkt bijvoorbeeld dat kinderen de regels en betekenissen van bepaalde interactiemogelijkheden veranderen over tijd en dat ze een voorkeur ontwikkelen voor een bepaald interactiegedrag. Deze inzichten zijn vertaald naar ontwerp suggesties zoals het blijven stimuleren van exploratiegedrag en het bieden van korte en eenvoudige interacties die mee veranderen over tijd.

Dit proefschrift concludeert dat kinderen in staat zijn om hun eigen diverse spelregels en doelen te creëren en zo te genieten van het spelen met interactieve, open-einde speelobjecten, zowel in eerdere speelsessies als over tijd. Ontwerpen voor open-einde spel, hoewel uitdagend en lastig, kan zeker profiteren van de ontwerpkennis die gepresenteerd wordt in dit proefschrift. De bijdragen van dit proefschrift zijn: een ontwerpbenadering voor open-einde spel, een model wat interactie in de tijd beschrijft, en tal van ontwerpadviezen en –overwegingen. Samen kunnen deze bijdragen ontwerpers ondersteunen bij het maken en verzinnen van aantrekkelijke en betekenisvolle open-einde speelontwerpen in verschillende toepassingen, zoals speeltuinen, interactieve kunst, openbare installaties en algemene interactieve systemen.

List of publications

Journal articles

RELATED TO THIS THESIS

Valk, L. de, Bekker, T., Eggen, B. (2015). Drawing up the rules: Encouraging children's rule creation in interactive open-ended play. Accepted for publication in International Journal of Child-Computer Interaction.

Valk, L. de, Bekker, T., Eggen, B. (2015). Designing for social interaction in open-ended play environments. International Journal of Design, 9(1), 107-120.

Bekker, T., Valk, L. de, Eggen, B. (2014). A toolkit for designing playful interactions: The four lenses of play. Thematic Issue on Playful Interactions and Serious Games, Journal of Ambient Intelligence and Smart Environments, 6(3), 263-276.

OTHER

Romero, N.A., Sturm, J., Bekker, M.M., Valk, L. de, Kruitwagen, S. (2010). Playful persuasion to support older adults' social and physical activities. Special Issue on Inclusive Design, Interacting with Computers, 22(6), 485-495.

Peer-reviewed conference articles

RELATED TO THIS THESIS

Tieben, R., Valk, L. de, Rijnbout, P., Bekker, T., Schouten, B. (2014). Shake up the schoolyard: Iterative design research for public playful installations. In Proceedings of International Conference on Interaction Design and Children (IDC 2014), ACM Press, 175-183.

Beukering, A. van, Valk, L. de, Bekker, T. (2014). Wobble: Supporting social play through an open-ended play environment. In Proceedings of Chi Sparks 2014 Conference (Chi Sparks 2014), 91-99.

Valk, L. de, Rijnbout, P., Graaf, M. de, Bekker, T., Schouten, B., Eggen, B. (2013). GlowSteps – A decentralized interactive play environment for open-ended play. In Proceedings of International Conference on Advances in Computer Entertainment (ACE 2013), Springer, 528-531.

Hoeve, B. van, Valk, L. de, Bekker, T. (2013). Toinggg: How changes in children's activity level influence creativity in open-ended play. In Proceedings of International Conference on Advances in Computer Entertainment (ACE 2013), Springer, 642-645.

Rijnbout, P., Valk, L. de, Vermeeren, A., Bekker, T., Graaf, M. de, Schouten, B., Eggen, B. (2013). About experience and emergence: A framework for decentralized interactive play environments. In Proceedings of International Conference on Intelligent Technologies for Interactive Entertainment (INTETAIN 2013), Springer, 104-115.

Valk, L. de, Bekker, T., Eggen, B. (2013). Leaving room for improvisation: Towards a design approach for open-ended play. In Proceedings of International Conference on Interaction Design and Children (IDC 2013), ACM Press, 92-101.

Valk, L. de, Rijnbout, P., Bekker, T., Eggen, B., Graaf, M. de, Schouten, B. (2012). Designing for playful experiences in open-ended intelligent play environments. In Proceedings of IADIS International Conference Game and Entertainment Technologies (IADIS GET 2012), 3-10.

OTHER

Valk, L. de, Kruitwagen, S., Bekker, M.M., Romero, N.A., Sturm, J. (2010). Activator: Playful persuasion to support older adults' social and physical activities. In Proceedings of International Society for Gerontechnology 7th World Conference (ISG 2010), 257.

Bekker, M.M., Romero, N.A., Sturm, J., Valk, L. de, Kruitwagen. S. (2010). Persuading older adults' to social and physical activities. In Proceedings of International Society for Gerontechnology 7th World Conference (ISG 2010), 194.

Terken, J., Joris, I., Valk, L. de (2007). Multimodal cues for addressee-hood in triadic communication with a human information retrieval agent. In Proceedings of International Conference on Multimodal interfaces (ICMI 2007), ACM Press, 94-101.

Informal conference articles

RELATED TO THIS THESIS

Valk, L. de, Bekker, T., Eggen, B. (2013). Creativity & play: Designing for improvisation with interactive play objects. Presented at Workshop on Interactive Technologies that Enhance Children's Creativity, International Conference on Interaction Design and Children (IDC 2013).

Valk, L. de. (2012). Designing for emergent play. In Proceedings of International Conference on Interaction Design and Children (IDC 2012), ACM Press, 335-338.

Rijnbout, P., Valk, L. de, Graaf, M. de, Bekker, T., Schouten, B., Eggen, B. (2011). i-PE: A decentralized approach for designing adaptive and persuasive intelligent play environments. In Proceedings of AmI 2011 Workshops (AmGam 2011), Springer, 238-244.

OTHER

Valk, L. de, Chisik, Y., Bakker, S., Soute, I. (2014). Design for repurposing: Rethinking children's interaction with tangibles. Workshop organized at International Conference on Interaction Design and Children (IDC 2014).

Curriculum vitae

Linda de Valk was born on 7 November 1984 in Boxtel, The Netherlands. She studied Industrial Design at the Eindhoven University of Technology (TU/e), The Netherlands. In 2008 she graduated with a project called "Loneliness in the care home", which was nominated for the thesis award 'Innovations in Health Care 2009'. After graduation, Linda traveled around in South America for several months. In 2009, she started working as a design researcher at the department of Industrial Design at the TU/e on the project "Independent Living", which aimed to motivate older adults to become more socially and physically active. After this project finished, she worked as a freelance designer for ConnectedCare, carrying out various focus group sessions with seniors and based on these sessions designing an initial interface for a communication system. In 2011, she started her PhD research at the User Centered Engineering group and the Playful Interactions theme of the department of Industrial Design at the TU/e. In 2012, she won a Best Paper award for one of her scientific publications. Linda currently works as Usability Engineer at Philips Healthcare. This thesis is the result of her PhD research on designing for open-ended play.

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