Designing for Social Interaction in Open-Ended Play Environments

Linda de Valk*, Tilde Bekker, and Berry Eggen

Department of Industrial Design, Eindhoven University of Technology, Eindhoven, The Netherlands

Interactive technology is becoming more strongly integrated in innovative play solutions. 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 paper, we explore the notion of social interaction in the context of open-ended play environments. We present an integrated model of interaction and transitions over time. Next, we describe two design case studies of open-ended, interactive play environments, GlowSteps and Wobble, discussing how these designs support social interaction over time. Results show that social interaction changes over time, starting with solitary play and moving towards more complex social play later on. 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.

Keywords – Open-ended Play, Social Interaction, Stages of Play, Interactive Objects.

Relevance to Design Practice – This paper presents a model of interaction over time and discusses social interaction in two design case studies, resulting in implications for the design of open-ended play environments in a social context.

Introduction

Designing interactive play environments opens up new design challenges for providing novel play opportunities. Using sensing and actuating technologies, play designs can react to players and actively invite them to undertake certain interactions. The designer's task also expands to designing the interaction behavior of such play environments, keeping in mind that interaction is a dynamic property that develops and changes over time. In this paper, we explore these dynamics in interaction within the context of interactive, open-ended play environments.

When designing play environments, we focus on children as a target group. For them, play is an intrinsically motivating activity (Huizinga, 1955) that supports the development of new skills and lets them explore the world around them (Acuff & Reiher, 1997). Play is often a social activity from which children learn specific social and emotional skills (Broadhead, 2004). Our research aims to design for open-ended play in which game rules or goals are not predefined by the designer, but rather left open to player's interpretation (de Valk, Bekker, & Eggen, 2013a). Players can attach meaning to design aspects such as interaction opportunities and physical properties of the design and can construct games in context. This relates to the theory of situated action (Suchman, 1987), which holds that people do not structure their activity beforehand, but rather attach meaning in situated interaction. Examples of designs for open-ended play include handheld designs (Iguchi & Inakage, 2006), body attributes (Rosales, Arroyo, & Blat, 2011), musical designs (Creighton, 2010) and interactive playgrounds (Sturm et al., 2008). In our view, open-ended play is a promising design philosophy that allows players to use their imagination in various ways, making play with an open-ended design more satisfying for a long period. As a design quality, Friedrich Froebel has already used open-endedness in developing open-ended toys that children can play with freely in many different configurations (Zuckerman, 2010). Open-endedness is also very important in the well-known Reggio Emilia educational approach (Edwards, Gandini, & Forman, 2011; Gandini, 2011). In this approach, open-ended materials are used to support creativity and imagination, with children being considered active participants with much freedom to create their own learning activities.

In open-ended play, play varies and develops over time. Children come up with new rules and goals, explore different interaction opportunities or invite other children to join them. To support designers in thinking about interaction as a dynamic process, we developed the Stages of Play model (de Valk et al., 2012). This model describes three different stages in a player's interaction with a playful, open-ended design over time. In the *invitation stage*, potential players are attracted towards the design. In the *exploration stage*, players start to intentionally interact with the design. In the *immersion stage*, players are involved in the actual play experience. We believe this model can serve as a tool for designers to guide their design process. In this paper, we discuss the model in more detail and relate it to existing

*Corresponding Author: l.c.t.d.valk@tue.nl.

models of interaction. As open-ended play designs are often used socially, we investigate how social interaction develops in the stages of play. Previous research has observed social interaction in open-ended play (Creighton, 2010; Rosales et al., 2011), but not looked specifically at how types of social play might change or are supported over time.

The contribution of this paper is to gain 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. Through the analysis of two design case studies, we explore how social interaction occurs over time in an open-ended, interactive play environment. We translate these insights into implications for design, presenting them in a complementary way 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.

Social Interaction

When designing for open-ended play, social interaction is an important aspect to consider. Social interaction is a process of reciprocal actions between multiple people. Social skills are the abilities to allow 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 children grow older, they develop 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

Linda de Valk is a doctoral researcher working on her PhD research on the topic of designing for open-ended play at the User-Centered Engineering group and the Playful Interactions theme of the Department of Industrial Design, Eindhoven University of Technology. She graduated in 2008 in Industrial Design 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 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 before starting her PhD research in 2011.

Tilde Bekker is an Associate Professor in the Department of Industrial Design at Eindhoven University of Technology. She has a Master degree and a PhD in Industrial Design (Delft University of Technology). She is champion of the Playful Interactions theme, which arranges design projects for bachelor and masters students in that department. Her research interests include the development of user-centered design tools and methods, designing for playful interaction and designing products for children and older adults. She leads and participates in research projects on playful interactions that examine how to persuade people to adopt a healthier lifestyle. She has over 90 publications in international peer-reviewed journals and conference proceedings and is co-founder of the Interaction Design and Children conference series.

Prof. Dr. **Berry Eggen** is a full professor and vice-dean of the Department of Industrial Design at Eindhoven University of Technology where he chairs the User-Centered Engineering research group. He is also an adjunct professor at the School of Design of the Faculty of Design, Architecture and Building of the University of Technology, Sydney. Over the years, he has led design research groups in the areas of information ergonomics, multimodal interaction (including lighting and sound) and intelligent interfaces. His current research includes interaction design research for playful interactions and the exploration of decentralized systems approaches to ambient intelligence. Within the field of multimodal research, his interests include lighting and sound innovations in the living room and public spaces, and the exploration of light and sound as calm environmental information displays.

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, Sturm and Barakova (2010) 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 and understanding another person's interests and emotions (e.g., Tentori & Hayes, 2010; Hourcade, Bullock-Rest, & Hansen, 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). In the next sections, we further explore social interaction in the field of HCI as well as in relation to 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 (Fogtmann, Krogh, & Markussen, 2011; Petersen & Krogh, 2008) 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 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 paper attempts to enhance this model by relating it to the Stages of Play model in the Result section.

Child Development and Play

Social interaction has also been widely studied in fields as sociology (Parten, 1932), child development (Berk, 2006; Broadhead, 2004) 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 such as when they share a ball in a soccer game or a hopscotch diagram drawn on the pavement. They negotiate shared goals and use the same artefact or environment to achieve these goals. In our design research, we mostly focus on children in the age ranges of 4-6 and 6-8 years old. 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 start 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 on Parten's classification of play participation (1932), which 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, where they are not actually playing, but just observing and performing random movements. In solitary play, children play on their own with no attention to 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 their 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 paper, we use these classifications again to describe social interaction over time for two user studies involving interactive play environments.

Interaction over Time

We consider interaction as a dynamic property that develops and changes over time. In this section, we first discuss related work on models of interaction. Then, the Stages of Play model is presented. This model is developed to guide designers in thinking about how interaction can change over time and goes through several stages of invitation, exploration and immersion.

Related Models of Interaction

Three related models of interaction have inspired the Stages of Play model: the language of interactivity (Polaine, 2010), the model of creative engagement (Edmonds, Muller, & Connell, 2006) and the curiosity process (Tieben, Bekker, & Schouten, 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 such as 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 identified. 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. They 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 that 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 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 to support the development of interaction scenarios in the design process of interactive systems. Based on various theories of curiosity, the authors visualized different principles for evoking curiosity and their role in the explorative process. 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.

Stages of Play Model

In a previous paper, we presented the Stages of Play model, which is developed to support the design process of open-ended play (de Valk et al., 2012). In this paper, we expand the model with related literature and use it to analyze design cases. The Stages of Play model describes interaction with a playful design over time in three stages: invitation stage, exploration stage and immersion stage (see Figure 1). It brings together multiple theories on play and interaction, and further strengthens them by focusing on nuances and details over time. In the *invitation stage*, potential players are attracted to the design. The design intrigues its audience and makes them curious. Perceived affordances (Norman, 2001), expectation feedback (Eggen, Haakma, & Westerink, 1996) or feedforward (Vermeulen, Luyten, van den Hoven, & Coninx, 2013) can communicate the opportunities and purposes for interaction. For example, a design can start to blink when someone walks by. In this way, players build up an expectation that they can interact with the design. When they start to interact with the design, for example, by purposely moving in different directions in front of the design, they enter the next, *exploration stage*. Through various actions, players try out what the design does and what they can do with it (Hutt, 1985). They are involved

in exploratory play, not yet bound by rules. In this stage, the first steps are taken into the magic circle (Huizinga, 1955; Salen & Zimmerman, 2003), a play space separated from the real world in time and place. From the exploration stage, players move towards the *immersion stage*. In this stage, players are seduced to remain inside the magic circle. 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. From this 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. In previous work, we have explored how to design for the Stages of Play. Our investigation focused on a player's individual interaction with the design, social interactions and experiences were not examined in detail. In this paper, we present a next step in developing the model by focusing on social interaction.

Integrated Model of Interaction

Figure 2 shows an integrated picture of interaction over time, combining all models in one visual to emphasize all relations between the models and to be able to extract relevant design properties. The invitation stage resembles the invitation to play (Polaine, 2010) and aligns with the action of encounter (Tieben et al., 2011) as well as the attribute of attractors (Edmonds et al., 2006). The invitation stage aims to set an initial promise (Polaine, 2010) and arouse interest and curiosity. The exploration stage corresponds with exploring boundaries, affordances and rules (Polaine, 2010; Tieben et al., 2011). Sustainers (Edmonds et al., 2006) start engaging users to explore different interaction possibilities. In the immersion stage, users further discover and adjust (Tieben et al., 2011) and boredom, anxiety and challenge are of importance (Polaine, 2010). The attribute of sustainers (Edmonds et al., 2006) aims to keep users engaged to create diverse game play. At this point, the initial promise should be delivered (Polaine, 2010). After initial encounters, relaters (Edmonds et al., 2006) can stimulate future interactions.
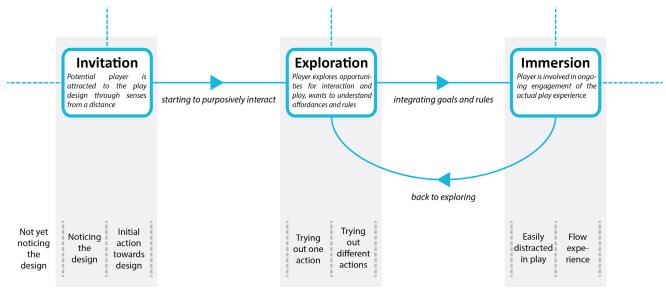

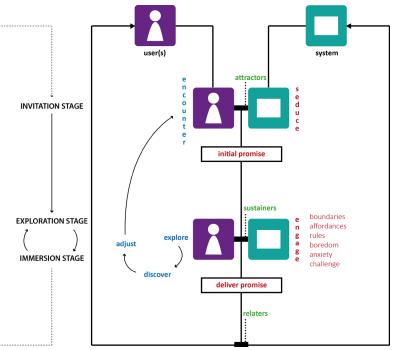**Figure 1. Three stages of play: invitation, exploration and immersion.**

Figure 2. Integrated model of interaction over time.

For the three stages of play, this reflection on existing models of interaction has given us some initial insights on relevant steps and constructs. To sum up:

- 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.*

Design Cases

To examine how playful designs can support social interaction over time, we now present two recent design cases in which an interactive, open-ended play environment was developed and 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 continuous play (e.g., children came up with various games and forms of play). Below, we describe the developed design, interaction scenario and the set-up of the user study for each case. After this, we discuss the process of analyzing the design cases.

Design Case 1: *GlowSteps*

GlowSteps (de Valk et al., 2013b) is an open-ended, interactive play environment that consists of ten interactive tiles with a pressure sensor as input and three colors of light (red, green and blue) as output (see Figure 3). GlowSteps is designed to stimulate

social and physical play. Children are encouraged to run around, step on the tiles and move the tiles closer or further away from each other. GlowSteps offers interaction opportunities where children can invent their own game rules and goals. In this way, the design lets children be creative and use their imagination. Figure 3 illustrates this. In the 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 from tile to tile towards the green light. Dave runs over the ground and is faster at the light than Lisa. "You're out," she says, "You are not allowed to touch the ground." Dave shrugs his shoulders but does not protest. After a while, their friend Mike joins them. Instead of catching the green light, he likes to obstruct Dave and Lisa in their attempts to do so. Dave makes a diversion and tricks Mike. He cheers and Lisa shouts: "Yes!" when Dave jumps on the green light.

Figure 3. GlowSteps prototype (up) **and play scenario** (down).

Interaction Scenario

GlowSteps can support different interaction scenarios. In this paper, we discuss the scenario Catch (see Figure 4). 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).

User Study

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 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, the first author of this paper. They were told that they could play with GlowSteps, but no explanation, specific instructions or hints were given to prompt the children's creation of their own gameplay. 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.

Design Case 2: *Wobble*

Wobble (van Beukering et al., 2014) is an open-ended play environment for fantasy play and was developed by Master Student Alice van Beukering. Wobble consists of multiple interactive objects in the form of balls on a stem, which contain an accelerometer measuring movement of the balls and several LEDs reacting with different colors of light, giving a sense of living creatures being inside the balls (see Figure 5). Wobble is intended for children in the ages of 4-6 years old. Children can interact with the light in the balls individually or together. Wobble aims to trigger children's curiosity and stimulate them to develop their own imaginary worlds while engaged in fantasy play. The play scenario in Figure 5 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.

Interaction Scenario

The interaction scenario of Wobble is as follows (see Figure 6). 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.

User Study

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
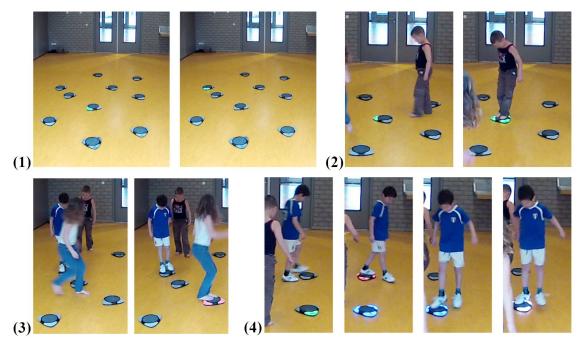

(1)   **(2)**

(3)   **(4)**

Figure 4. Interaction scenario "Catch".

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.

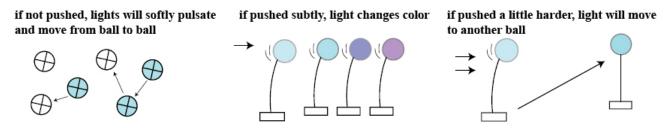**Figure 5. Children playing with Wobble** (left) **and the play scenario** (right)**.**

Figure 6. Interaction behavior of Wobble: not pushed, pushed subtly and pushed a little harder.

play session of 15-20 minutes. Some groups were same-gender. Others were mixed-gender. The teacher formed 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.

Analysis Design Cases

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.

Our analysis of the data consisted of multiple phases (see Figure 7). In the first phase, each design case was analyzed separately through a process of open coding (Strauss & Corbin, 1990). This step was performed asynchronously and by different researchers (respectively the first author of this paper for GlowSteps and the Master Student who also developed the design for Wobble). For both cases, the analysis consisted of three steps, each with a different focus for categorizing observational notes. In
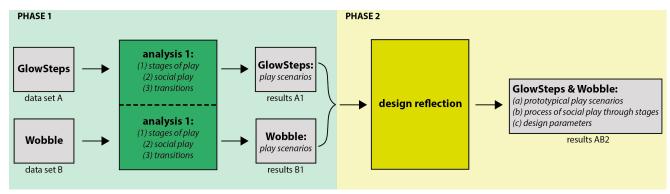

Figure 7. Process of analysis.

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 these 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 reflected on the two design cases by comparing the play scenarios from GlowSteps and Wobble to arrive at more general results from a holistic perspective. This reflection focused on the social perspective, which was our main interest. 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)) were used to direct our attention while reflecting on the play scenarios. This reflection led to a number of prototypical play scenarios describing the predominant types of social play and interaction in each stage. Comparing the 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.

Results

This section discusses the results from our analysis of both design cases per stage, starting each stage with a short anecdote from the GlowSteps study. The analysis led to a better understanding of the Stages of Play model on a general level and more specifically how these stages support social interaction. We discuss both sets of insights below.

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.

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.

In respect of *social interaction*, the invitation stage is characterized by individual interactions. Each child approached one of the play objects by themselves. Even when children seemed
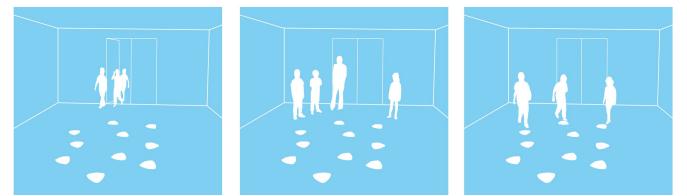

Figure 8. Invitation stage: entering the room, listening to the moderator and approaching the design.

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.

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. 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?*"

In respect of *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, for example, in interacting 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, in the exploration stage, children were mostly involved in Parallel play (Parten, 1932; Rubin 2001) and Associative play (Parten, 1932; Broadhead, 2004). 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).
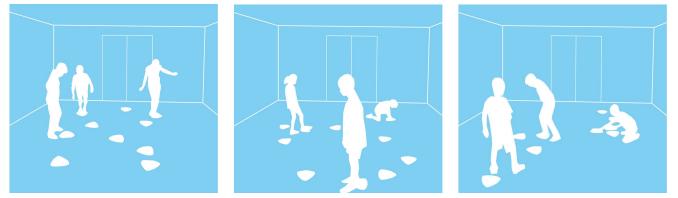

Figure 9. Exploration stage: stepping on tiles, trying out various interactions and moving tiles around.

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.

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 often occurred 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. They came up with new games and rules. This initiative could shift between children. When proposing new games, children explicitly mentioned the name of the game (e.g., Twister) or the goal (e.g., catch the green light) to 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.

In respect of *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 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 such 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. In respect of 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 11 illustrates the possible interactions between players and objects in the Stages of Play. The colored arrows indicate how most children go through the different stages. The green arrows show the process from
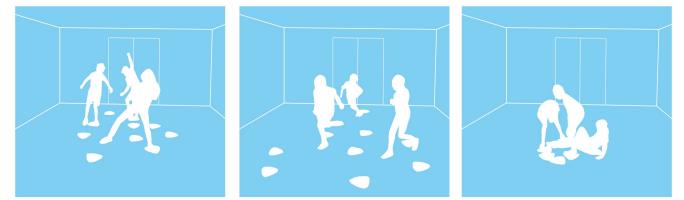

Figure 10. Immersion stage: Stepping game, Catching the light, and Twister.

invitation (individual) to exploration (first parallel, then together) and then to immersion. The pink arrows illustrate the process of going back and forth between immersion and exploration. The orange arrows 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

This paper focuses on how designers can apply the Stages of Play model as a design tool with the aim to design for social interaction. As a first step in achieving this, the previous section discusses the results of our observations on how social interaction changes over time 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 supported the different stages and influenced 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. The analysis of the design cases described in this paper 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 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, that is, various interaction opportunities and increasing challenges can positively influence the game play and players' experience.
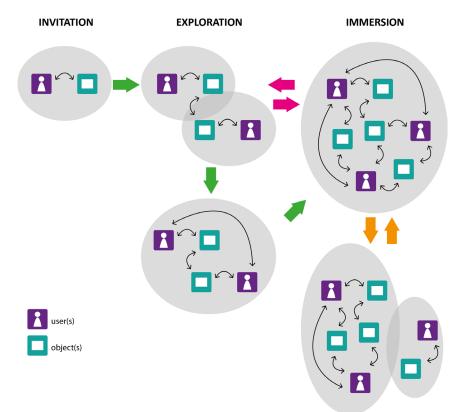

Figure 11. Interaction behavior between players and objects in the three stages of play.

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

Conclusion & Discussion

In this paper, we describe how social interaction occurs in the process of three Stages of Play when interacting with an open-ended play environment. We reflect on two design cases presenting novel interactive, open-ended design prototypes (GlowSteps and Wobble). Both prototypes were evaluated with children. The analysis of children's play behavior resulted in an improved understanding of how social interaction changes 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 on them and improve them to create rich and engaging play solutions. Together with the Stages of Play model, this set of results can serve as comprehensive design advice. In our view, the combination of interaction over time and social interaction offers a new perspective on designing for play in a social context. Although we believe these results 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. As another next step, we are also 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. 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. Then, the attribute of relaters (Edmonds et al., 2006) also becomes more important.

In this paper, we focus on open-ended play, but we believe our work also has value in the areas of interactive, open-ended systems in general. Analyzing two cases (GlowSteps and Wobble) has already provided us with some insights concerning the generalizability of our results. Designers of interactive systems should be aware of 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. We are looking into verifying and reflecting on our insights by analyzing other existing designs or by applying the insights explicitly as guiding principles in the design process.

Acknowledgments

References

1. Acuff, D. S., & Reiher, R. H. (1997). *What kids buy and why: The psychology of marketing to kids.* New York: Free Press.

2. Battarbee, K. (2003). Defining co-experience. In *Proceedings of the 3rd International Conference on Designing Pleasurable Products and Interfaces* (pp. 109-113). New York, NY: ACM.

3. Bekker, T., Sturm, J., & Barakova, E. (2010). Designing for social interaction through physical play in diverse contexts of use. *Personal and Ubiquitous Computing, 14*(5), 381- 383.

4. Berk, L. E. (2006). *Development through the lifespan (4th ed.).* Boston, MA: Allyn and Bacon.

5. van Beukering, A., de Valk, L., Bekker, T. (2014). Wobble: Supporting social play through an open-ended play environment. In J. P. van Leeuwen, P. J. Stappers, M. H. Lamers, & M. J. M. R. Thissen (Eds.), *Proceedings of the Chi Sparks Conference* (pp. 91-99). The Hague, The Netherlands: The Hague University of Applied Sciences.

6. Broadhead, P. (2004). *Early years play and learning: Developing social skills and cooperation.* New York, NY: RoutledgeFalmer.

7. Creighton, E. (2010). Jogo: An explorative design for free play. In N. Parés & M. Oliver (Eds.), *Proceedings of the 9th International Conference on Interaction Design and Children* (pp. 178-181). New York, NY: ACM.

8. Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety: Experiencing flow in work and play.* San Francisco, CA: Jossey-Bass.

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

10. Edwards, C., Gandini, L., & Forman, G. (2011). *The hundred languages of children: The Reggio Emilia experiences in transformation (3rd ed.).* Santa Barbara, CA: ABC-CLIO.

11. 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.

12. 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* (pp. 2589-2598). New York, NY: ACM.

13. 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* (pp.1-9). New York, NY: ACM.

14. Forlizzi, J., & Battarbee, K. (2004). Understanding experience in interactive systems. In *Proceedings of 5th Conference on Designing Interactive Systems* (pp. 261-268). New York, NY: ACM.

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

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

17. 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.

18. Huizinga, J. (1955). *Homo ludens: A study of the play element in culture.* Boston, MA: Beacon Press.

19. Hutt, C. (1985). Exploration and play in children. In B. Sutton-Smith & R. E. Herron (Eds.), *Child's play* (pp.231-250). Florida, FL: Robert E. Krieger.

20. Iguchi, K., & Inakage, M. (2006). Morel: Remotely launchable outdoor playthings. In *Proceedings of the SIGCHI International Conference on Advances in Computer Entertainment Technology (No.35).* New York, NY: ACM.

21. Korhonen, H., Montola, M., & Arrasvuori, J. (2009). Understanding playful experiences through digital games. In *Proceedings of the 4th International Conference on Designing Pleasurable Products and Interface* (pp. 274-285). New York, NY: ACM.

22. Ludvigsen, M. (2005). Designing for social use in public places – A conceptual framework of social interaction. In *Proceedings of Designing Pleasurable Products and Interfaces* (pp. 398-408). New York, NY: ACM.

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

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

25. Petersen, M. G., & Krogh, P. G. (2008). Collective interaction – Let's join forces. In *Proceedings of 8th International Conference on the Design of Cooperative Systems* (pp. 193-204). Institut d'Etudes Politiques d'Aix-en-Provence.

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

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

28. Rosales, A., Arroyo, E., & Blat, J. (2011). FeetUp: A playful accessory to practice social skills through free-play experiences. In P. Campos, N. Graham, J. Jorge, N. Nunes, P. Palanque & M. Winckler (Eds.), *Proceedings of 13th IFIP Conference on Human-Computer Interaction* (pp. 37-44). Berlin, Germany: Springer.

29. Rubin, K. H. (2001). T*he play observation scale (POS).* Retrieved February 24, 2015, from http://www.rubin-lab. umd.edu/CodingSchemes.

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

31. Strauss, A. L., & Corbin, J. M. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Thousand Oaks, CA: Sage.

32. Sturm, J., Bekker, T., Groenendaal, B., Wesselink, R., & Eggen, B. (2008). Key issues for the successful design of an intelligent interactive playground. In J. Cassell (Ed.), *Proceedings of 7th International Conference on Interaction Design and Children* (pp. 258-265). New York, NY: ACM.

33. Suchman, L. A. (1987). *Plans and situated actions.* Cambridge, UK: Cambridge University Press.

34. Tentori, M., & Hayes, G. R. (2010). Designing for interaction immediacy to enhance social skills of children with autism. In J. E. Bardram, M. Langheinrich, K. N. Truong, & P. Nixon (Eds.), *Proceedings of the 12th ACM International Conference on Ubiquitous Computing* (pp. 51-60). New York, NY: ACM.

35. Tieben, R., Bekker, T., & Schouten, B. (2011). Curiosity and interaction: Making people curious through interactive systems. In L. Little & L. Coventry (Eds.), *Proceedings of the 25th BCS Conference on Human-Computer Interaction* (pp. 361-370). Swinton, UK: British Computer Society.

36. de Valk, L., Rijnbout, P., Bekker, T., Eggen, B., de Graaf, M., & Schouten, B. (2012). Designing for playful experiences in open-ended intelligent play environments. In K. Blashki (Ed.), *Proceedings of the 5th IADIS International Conference on Game and Entertainment Technologies* (pp. 3-10). IADIS digital library.

37. de Valk, L., Bekker, T., & Eggen, B. (2013a). Leaving room for improvisation: Towards a design approach for open-ended play. In J. P. Hourcade, N. Sawhney, & E. Reardon (Eds.), *Proceedings of 12th International Conference on Interaction Design and Children* (pp. 92-110). New York, NY: ACM.

38. de Valk, L., Rijnbout, P., de Graaf, M., Bekker, T., Schouten, B., & Eggen, B. (2013b). GlowSteps – A decentralized interactive play environment for open-ended play. In D. Reidsma, H. Katayose, & A. Nijholt (Eds.), *Proceedings of 10th International Conference on Advances in Computer Entertainment Technology (*pp. 528-531). Berlin, Germany: Springer.

39. Vermeulen, J., Luyten, K., van den Hoven, E., & Coninx, K. (2013). Crossing the bridge over Norman's gulf of execution: Revealing feedforward's true identity. In W. E. Mackay, S. Brewster, & S. Bødker (Eds.), *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1931-1940). New York, NY: ACM.

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