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A toolkit for designing playful interactions: The four lenses of play

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Abstract. The development of ambient play environments provides an opportunity to develop tangible play solutions to stimulate social and physical play by embedding responsiveness tailored and adjusted to player behaviour in the environment. This paper gives an overview of different perspectives on play and translates this theoretical knowledge from different disciplines to design relevant knowledge. The design relevant knowledge is presented in the form of a design toolkit, called the lenses of play, including the perspectives of forms of play, open-ended play, stages of play and playful experiences. Application of the design toolkit is illustrated in relation to two interactive play design cases to emphasize the design relevance of the knowledge in the design process. Furthermore, it shows how the lenses can inform different types of design decisions, such as early scoping of the design space by focusing on a form of play and making more detailed design decisions later when considering different stages of play.

Keywords: Design for children, playful experiences, forms of play, open-ended play, stages of play

1. Introduction

Ambient intelligence play environments incorporate properties of ambient intelligence [e.g. 1], the technology is embedded in the environment, it can sense who is present and can anticipate actions, it can be tailored to a user's needs and can change in response to a user's actions. By embedding technology in the environment such play locations allow children to move around freely, without being stuck to a computer screen and explore the outside world [29]. This provides new opportunities that seduce children to be physically and socially active in an appealing environment that combines the qualities of traditional game and play solutions and the interactivity of computer and video games.

We have examined different aspects of play to support the development of a design approach for designing for playful interactions. Play has been the topic of research in various different domains, including child development, learning, ethnography and game design [7,10,16]. These different domains provide insights about what are important properties of play.

Designing intelligent play environments as compared to designing traditional play environments, can provide new opportunities for children to develop and practice diverse skills and have a fun experience at the same time.

The interactive and responsive nature also makes ambient intelligent play environments extremely suitable to elicit various forms of play, such as physical, social, and fantasy play. For example, an intelligent playground supports physical play when children take on different physical challenges that might be tailored to their skills by changing timing behaviours, or they can incorporate interactive behaviour in shared fantasy play in which they imagine that activating colours of lights in different play objects means that they are rescuing animals from an evil wizard.

Interactive properties of these environments can be related to different play properties. The knowledge from the various disciplines mentioned before can

provide complementary perspectives when making design decisions. Considering how to create appealing and successful play solutions requires considering many different aspects, such as properties of the play context and environment, how the interaction behaviour should adjust if the number of players changes and how the behaviour may be adjusted if the number and types of objects incorporated in the play activity changes.

Even though a wide range of theoretical knowledge about play is available; this knowledge is not easily accessible to designers of interactive products. Thus providing a toolkit that incorporates such design knowledge would be a good support for design practitioners.

In this paper we will present a new design toolkit called the *lenses of play* that can support designers in taking diverse play perspectives into account when developing intelligent play solutions for children.

We will first provide a rationale for developing the toolkit. Then we will give some examples of play perspectives described in the literature on designs of play solutions. Subsequently, we will provide an overview of play theories and their relevance for interaction design and translate these concepts into the lenses of play. Then we will illustrate the use of the lenses of play in more detail by describing two design cases, in which Industrial Design (Master and PhD) students developed diverse play solutions for children.

2. Developing a toolkit for the design of playful interactions

In our work on designing playful interactions we have found that it is beneficial to shift between different perspectives or approaches to develop rich play solutions. This view is very similar to the view presented by Thomas Erickson in his paper on the five lenses for Interaction Design [9]. He argues that taking different perspectives and frequently shifting between perspectives during interaction design is necessary to integrate different aspects in a design. He uses an example of an outdoor location where multiple games of chess are played to illustrate how the perspectives taken for analysis and design can shift. One example of his lenses is looking at the mind angle, which includes the perception, cognition and action angle of how people learn to play chess, of cognitive psychologists. Another example is the

social angle of the social rules of playing chess and waiting your turn to take on the winner of social psychology, sociology and anthropology. The other three lenses include the proxemics, artifacts and the ecological angle. Erickson argues that different perspectives can include various theoretical constructs that can help designers consider different aspects of a particular situation.

The purpose of the lenses is to support design, and to be able to shift between perspectives when exploring different design directions and decisions. Just like a sculptor who uses a lens to look at a detail of his statue, and then looks at the overall picture again, the lens helps to temporarily focus on a specific detail, without losing sight of the broader picture.

2.1. Toolkits for design

Why do we present the knowledge in the form of lenses? A wide diversity of toolkits has been developed to support design. Without being able to give a complete overview of such a wide topic, we like to draw attention to a few factors, including the purpose of the toolkits, the form of the toolkit and the type of knowledge provided.

The metaphor of lenses as a toolkit indicates that the toolkit addresses fairly high level perspectives in providing guidance to a designer.

The idea of using different perspectives or lenses is similar to the thinking hats proposed by de Bono [6]. He proposed that by using the six hats (blue process hat, white facts hat, red feelings hat, black cautions hat, yellow benefits hat and green creativity hat), different issues can be targeted in thinking processes, including factual, emotional, positive and weakness thinking. The hats themselves provide high level perspectives, whereas questions related to the hats provide more detailed design guidance.

Another example of a design toolkit that provides both more global and more detailed design guidance is the Design with Intent Toolkit [8]. It consists of eight (high level) lenses, with a total of 101 cards that describe more detailed design knowledge about designing for behaviour change [8,18]. The eight lenses globally structure the knowledge based on disciplinary areas of research, whereas the cards can be seen more as pattern-like descriptions of provocations for thinking about design [8].

A toolkit example providing very detailed design knowledge from the area of game design is the book by Jesse Schell [27] that covers 100 different

perspectives or lenses. Examples of lenses are: fun, surprise, goals, rules, challenge, competition, technology and client. Each lens card includes a short description of the meaning of the lens and some related design questions. In this context the lenses provide fairly detailed design knowledge. In this sense it differs from Erickson's and our interpretation of the term lens, which includes that you still look at the complete scene, and not to only a very detailed aspect of the scene.

While there is value in providing detailed design knowledge, the scope of the lenses of play focuses on providing a limited set of lenses that allow designers to easily shift perspective in design without losing track of the overall design goal. In this manner the toolkit balances providing support for easily shifting between lenses, and to provide more detailed depth within each lens. Furthermore, each lens contains design questions to provide starting points for the designer's knowledge.

2.2. Iterative design process of the toolkit

The toolkit described in the paper is the outcome of an ongoing iterative user centred design process. Over the last eight years we have been developing our design approach for designing interactive play solutions for children for different age groups, different play contexts (indoors, outdoors) and different clients (toy companies, playground companies and healthcare providers). We have examined different theoretical perspectives related to play as inspiration for design. These explorations have led to the development of different design perspectives, different lenses, related to open-ended play [3,29,32], stages of playful interactions [31], forms of play [4] and playful experiences [4,25,31].

The knowledge has been applied in multiple design projects both by ourselves and students within our Industrial Design department. The content of the toolkit was developed based on reflections by the students and their supervisors on the design process, and on realisations that knowledge that might first be applied implicitly, could be considered more effectively when made explicit in a new lens. Table 1 shows a list of some of the design projects over time, and the perspectives that were explicitly taken on board during the design process.

As in any user centred design process the quality of the design of the toolkit has been improved by examining whether the content was found to be

Table 1

Example student projects involving one or more lenses

Project, year project was run	Lenses
ColorFlare [3], 2009	Open-ended play
MultiModalMixer [3], 2009	Open-ended play
Shuffle [4], 2010	Forms of play, Playful experiences
BaBaBa [4], 2010	Forms of play, Playful experiences
FlowSteps [31,32], 2012	Playful experiences, Open-ended play, Stages of play
ZooMor [19], 2013	Open-ended play, Stages of play
Toinggg [13], 2013	Forms of play, Open-ended play, Stages of play, Playful experiences

Fig. 1. Children playing outdoors.

useful for the users, in this case in supporting the design process of the students.

2.3. Framing the lenses of play within the toolkit

In a similar manner as Erikson described in relation to interaction design we have found that we need to shift between different perspectives in designing rich playful interactions. In previous papers we have presented different perspectives on designing intelligent play solutions for children separately. In this paper we translate these perspectives into an integrated design toolkit: the four lenses of play.

Figure 1 shows a group of children playing outdoors. This scene represents an example of an

interaction design opportunity for ambient play solutions for children. By shifting between different perspectives, we can provide an analysis of how to design rich and appealing play solutions.

In line with the approach taken by Erickson [9] we can examine this scenario (see Scenario 1) from various play perspectives, examining a situation with constructs from different disciplines.

We can examine what *different forms of play* children engage in, and borrow constructs from child development and different forms of play perspective. For example, children want to express themselves and practice activities through pretend play activities.

From game design and ethnography constructs can be gathered that are related to the *open-endedness of play* activities. For example, children like to improvise and interpret abstract objects in different ways to suit their play activities.

Borrowing constructs from interactive art and play theories we can examine how children go through different *stages in their play* activity. For example, how do they initiate play activities, how do they explore a novel object and how they stay engaged in their play activity.

From a psychological perspective we can borrow constructs resulting in *player's experiences* in interacting with a play context. For example, we can examine how curiosity towards play opportunities contributes to how a play activity enfolds. Shifting between these different perspectives in design can support creating a rich solution that supports these different aspects in an ambient play environment.

Scenario 1

Some basic properties of play and play contexts, described by focusing on different perspectives in the lower part

Imagine…. Mark, Susie and John are playing in the garden. Mark is playing with a truck, and is making engine sounds to get the attention of Susie, who is also playing in the sandbox. John and Susie have created a mountain with tracks for marbles to roll down. Mark is feeling like changing to a different kind of game, after playing in the sandpit for 10 minutes. He wants to play hide and seek now.

* * * *

John and Susie are engaged in **free play** activities (*unstructured activity*). They have come up with their own play activities, inspired by some of the objects and environmental properties. They like building things (*creative play form*), and creating challenges for themselves (*experiences*). They like playing together and they negotiate different play goals and what rules are acceptable (*social interaction*).

3. The design of ambient interactive play solutions

In this section, we will give a non-exhaustive overview of ambient interactive playful solutions. So far, a wide range of ambient play solutions have been created. Technological opportunities have been embedded in the design to create rich play solutions. The technology can be embedded in the environment in different ways. It can be embedded in the complete environment, in the floor or in the walls. Another approach is that solutions incorporate tangible objects in the overall concept. This provides children the opportunity to explore the world by interacting with physical objects and enhancing this experience by providing feedback using digital technology [21].

Apart from embedding technology into the environment in different ways, ambient play solutions have been created for different forms of play including physical play, social play and communication, music creation, creativity and storytelling.

Interactive play environments, including floors, walls and spaces have been developed both by companies and by researchers. For example the Nebula interactive wall by NYOYN is an interactive wall on which children can play diverse games [20]. An example of an interactive floor is the IGamefloor by Grønbæk and colleagues [11], which supports social interaction and gaming with multiple players. An example of an interactive environment is Funky Forest, which was developed by Theodore Watson and Emily Gobeille [34], allows children to become aware of their actions on a forest-like ecosystem through bodily actions.

Another type of pervasive play solutions is called head up games. Head up games are based on interactive, tangible objects where the players can keep 'their heads up' without looking at a screen when moving around in the real world. For example, Soute et al. [28] developed head up games to support social and physical forms of play such as HeartBeat, in which an attacking team and a defending team fight over a virtual treasure using small portable devices and heart rate sensors.

Rosales and colleagues [22] have developed solutions for physical and social play that can be carried around 'on the body'. An example design is interactive shoes for children that provide light feedback during free play activities. Children can incorporate the feedback in diverse physical and social games of their own making.

An example of tangible play objects for social and physical play are Morels [15], which are cylindrical objects that can detect whether other Morels are close by using wireless technology. They provide auditory feedback and launch themselves after having been squeezed.

Digital play objects can also be incorporated in creative activities. An example is the I/O Brush [25], which is an interactive brush that can record colours and textures and can then be used to paint new creations. Another example is Video Bubbles [24], which consists of tangible objects that support children in creating expressive video art displayed on a screen.

These examples of ambient play solutions illustrate the diversity of play solutions created with different types of technologies for diverse forms of play. Overall, the design intentions in the perspective of forms of play of the examples above vary: e.g. social or physical play.

The examples described are often presented from a *form of play* perspective, and subsequently describe interaction scenarios including the perspective of *playful experiences*. It seems less attention is paid to the perspective of the *stages of play*. Of course, this may have been considered during the design process, without it being mentioned in the publications about the design. Because in many cases the design process is not described in detail, it is unclear how designers have shifted between perspectives over time.

The contribution of this paper is an overview of four lenses with some theoretical grounding. Subsequently, we will show how the lenses can be applied during a design process.

4. The lenses of play

In this section, we will describe each of the four lenses that together form the design toolkit. These lenses describe on a fairly high level four different perspectives that designers can focus on when developing playful solutions. We will illustrate how each lens can inform design decisions by relating lens-related issues to a specific design case. For this purpose we have selected the design of an interactive device that was designed to support open-ended play and social play called the Shuffle. It was developed in 2010 by (then) Industrial Design Master student Koen Verbruggen as a design research project of about 12 weeks of work.

Table 2

Properties of games and play [32]

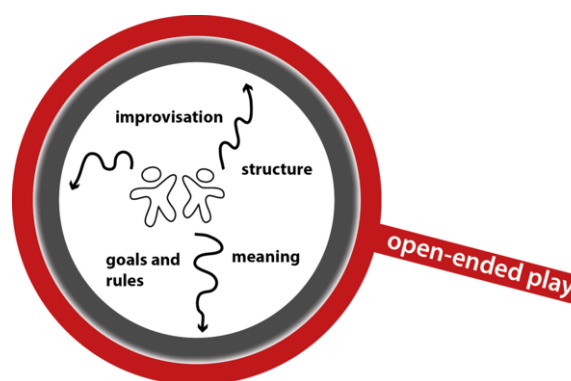| Games (ludus)	Free play (paidia)
Structure	Chaotic
Finite, with (end) goals	Infinite, no logical ending point
Fixed (game) rules	Improvisation, spontaneity
Predefined	Own construction of meaning
Challenge, competition	Sensation of play, Expression

Fig. 2. Play lens 1: Open-ended play.

4.1. Play lens 1: Open-ended play

What are some of the properties of play that influence a play activity? The following properties of play are mentioned in literature [e.g. 7,11,26]: the amount of structure provided in or for a play activity, whether (end) goals have been defined, whether the rules are fixed or not and what the main experiences of the play activities are (see Table 2). This lens combines these properties within a child development perspective as open-ended play designs aim at actively encouraging a child's imagination and creativity as well as social negotiation skills.

In a previous paper [32] we described a detailed literature study that resulted in a better definition of what we mean with levels of open-ended play. Open-ended play can be positioned somewhere between free play and games with rules. It can provide some structure, some opportunities for rules, and it can provide opportunities for different play experiences. It can move towards games, or ludus [7], when players come up with rules and goals, or towards free play, or paidia [7], when players are mainly playing for the sensation of it.
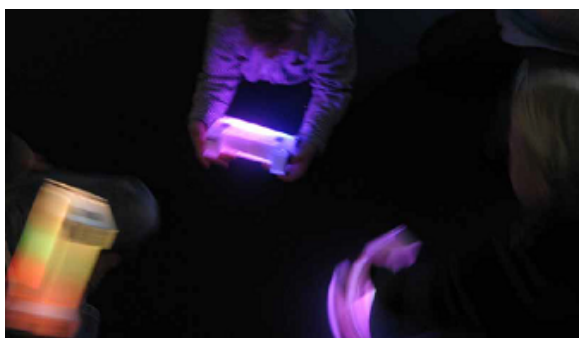
Fig. 3. Children playing with Shuffle.

Open-ended play implies that rules and goals are not predefined by the designers but become meaningful during play, during interaction. Players are in control and can create their own play. Designers offer interaction possibilities that players can attach meaning to and constructs games with. Designers can decide on what side of the continuum between games and free play they position their design, depending on the overall aim of the design.

Questions designers can ask themselves: What does the design leave to the interpretation of the players? How can players improvise with the design? What is the balance between providing structure and spontaneity in the design? Can players interact in diverse ways with the design?

4.1.1. Applying the open-ended play lens

Shuffle is an example of an interactive, open-ended play design. It is a U-shaped design (see Fig. 3) with a range of different colours that encourages children to exchange colours with other children by positioning their Shuffles against each other. Children might decide they want to collect all different colours (game rule). They can also come up with other games, for example using the Shuffles as building blocks to make a fortress.

4.2. Play lens 2: Forms of play

This lens takes the child development perspective as it focuses on how various developmental factors are encouraged. Different forms of play support children in practicing different cognitive, social, emotional and physical skills and abilities [4,5,10,16].

Children engage in different forms of play (see Table 3), such as pretend play or constructive play. Furthermore, play episodes often include multiple forms of play.

Scenario 2

Play forms and play objects and environments

Rosie and Tamara are building a little village using wooden blocks and some of their plastic figurines. They create both big and smaller buildings and also some garden structures that are delineated by wooden blocks. In the mean time they create a story about two families that live in the village. One girl has just moved to the village and meets children from the second village for the first time.

Table 3

Forms of play (adapted from [4], in press)

Forms of play	Description	Example games and toys
Constructive or creative play	Creating and constructing something from objects	Construction play sets, weaving looms, clay, photography, warhammer
Pretend or socio-dramatic play	Acting out roles, often using toys and props	Costumes, punch-and-judy, interactive talking dolls, miniature objects, role-playing games
Physical or active play	Sensori-motor play with objects. In pre-school years this may involve rough-and-tumble play. Older children engage in play with a more vigorous component to test strengths and skills	Bikes, Gym equipment, Sports, Exergames
Games with rules	Playing games in social groups with fixed predetermined rules	Mental games, languages games Soccer, Wii-sports Tag, hide and seek
Games with invented rules	Playing games with modified or rule sets invented by themselves	

The children described in Scenario 2 engage in different forms of play: they build different houses and a little village in a form of *creative or constructive play*, they build their own story in a form of *pretend play*.

Using this lens means making design decisions to support specific forms of play (see Fig. 4) and analyse user data related to these forms of play. Within the choice for a form of play, there is still room for much diversity. For instance, within constructive play one can decide to focus on building physical shapes or creating drawings or music.

Questions related to this lens are: Which form(s) of play does the design support? Which design decisions are related to this (e.g. type of feedback modality, shape of object)? Does the design support multiple forms of play?
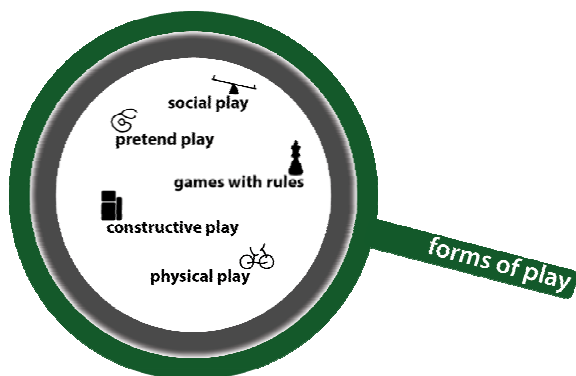
Fig. 4. Play lens 2: Forms of play.

4.2.1. Applying the forms of play lens

This lens was also used when designing Shuffle. This design was particularly aimed at supporting social play. As the designer observed society to become less social nowadays, he wanted to stimulate social behaviour. The shape of the Shuffle underlines this as it encourages children to position their Shuffles against each other. Also, children need to negotiate with each other to get the desired colour or help another with achieving this.

4.3. Play lens 3: Stages of playful interactions

Play episodes can go through different phases. What are the starting and finishing points, and do play episodes also show different play properties?

Let's look at the start of a play episode. Children start a play episode, possibly triggered by objects or other play partners. This is the *invitation stage* of play [31]. Some properties or affordances need to support the play activity to start. Of course, children can play all by themselves, starting with a little story. In that case, the trigger may be a thought in their minds. Examining how a play episode develops, the child can explore how to incorporate different objects, players or abstract concepts in their play. This phase is the *exploration stage* [31].

Players start interacting with the objects and explore the rules and boundaries. Boundaries can be defined by the child still searching for a play focus and structure. Finally, in the *immersion stage* [31] some basic play properties have been chosen, and the player or players engage in a play activity within these boundaries. More complex relations between players and the objects arise in this stage. Within the selected objects, global play frame and global play rules, children engage in a shared play 'world'.

Children can shift back and forth between these different stages. A child that has just arrived can be invited into the play world, frame of play. Triggers of new objects, players or rules can support a shift from the immersion stage to the exploration stage.

When designing for these three stages of play (see Fig. 6), one has to make conscious decisions on how to support the different stages with the design. This lens illustrates the interaction design perspective. Designers should take into account how people interact with the design and how this interaction can
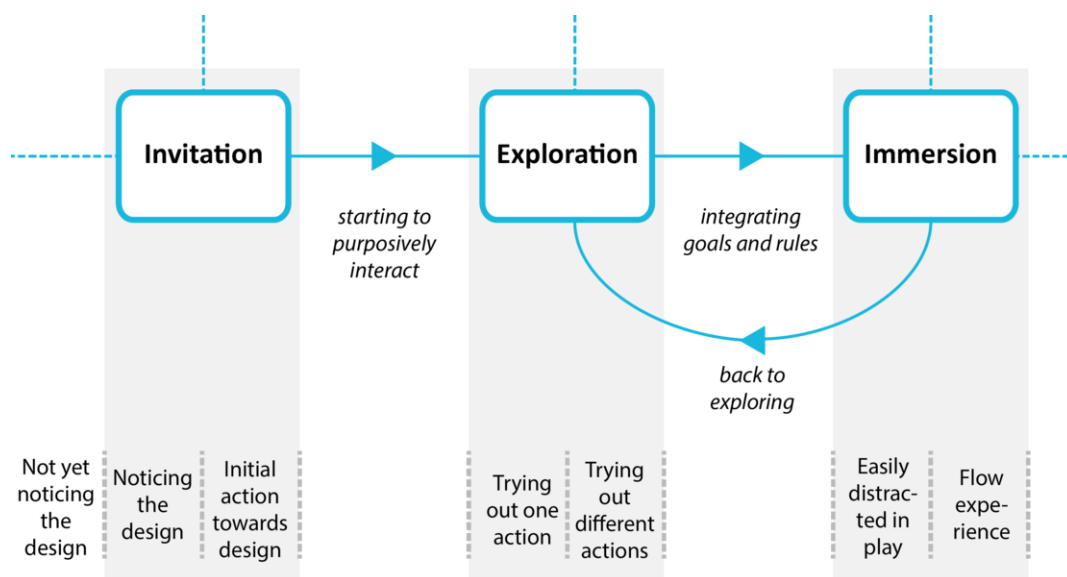

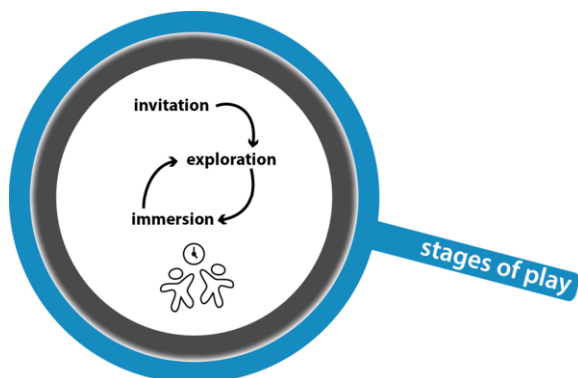Fig. 5. Stages of play in interaction with a playful design.

Fig. 6. Play lens 3: Stages of play.

develop over time. Somehow, the design should actively attract potential players at the start, then support easy exploration and the possibility to attach meaning to elements of the design in order to create reasonable rules and goals.

This lens raises *questions* as: How does the design support the three stages of play? What design decisions are related to this (e.g. interaction behaviour, feedback modalities)? Does the design emphasize a certain stage? How does the design support transitions between the stages?

4.3.1. Applying the stages of play lens

Shuffle attracts potential players in the invitation stage by the lights in the design that communicate its interactivity. Children can easily pick it up and hold an object in their hands to examine the different functionalities more closely in the exploration stage. As soon as they start interacting and negotiating with other players and start exploring social affordances such as exchanging colours, they move to the immersion stage. During interaction, different children can be in other stages at the same time.

4.4. Play lens 4: Playful experiences

People can have a wide range of experiences when engaging in play activities. This lens focuses on this perspective of user experience design: the experiences of people interacting with the design. This lens challenges designers to think about how to increase the likelihood of certain user experiences to happen when people are interacting with the design. A designer cannot design the user experience itself, but one can design *for* such an experience.

Various researchers have described the relationship between play and experience. We have been

Table 4

Overview of playful experiences (according to [17])

Category	Description
Captivation	Experience of forgetting one's surroundings
Challenge	Experience of having to develop and exercise skills in a challenging situation
Competition	Experience of victory-oriented competition against oneself, opponent or system
Completion	Experience of completion, finishing and closure, in relation to an earlier task or tension
Control	Experience power, mastery, control or virtuosity
Discovery	Experience of discovering a new solution, place or property
Eroticism	Experience of sexual pleasure or arousal
Exploration	Experience of exploring or investigating a world, affordance, puzzle or situation
Expression	Experience of creating something or expressing oneself in a creative fashion
Fantasy	Experience of make-believe involving fantastical narratives, worlds or characters
Fellowship	Experience of friendship, fellowship, communality or intimacy
Nurture	Experience of nurturing, grooming or caretaking
Relaxation	Experience of unwinding, relaxation or stress relief. Calmness during play
Sadism	Experience of destruction and exerting power over others
Sensation	Meaningful sensory experience
Simulation	Experience of perceiving a representation of everyday life
Subversion	Experience of breaking social roles, rules and norms
Suffering	Experience of frustration, anger, boredom and disappointment typical to playing
Sympathy	Experience of sharing emotional feelings
Thrill	Experience of thrill derived from an actual or perceived danger or risk

most inspired by the work of Korhonen and colleagues [17]. In their literature study to develop an overview of playful experiences [17] they include philosophical, psychological and game design perspectives. The *philosophical* perspectives of Karl Groos (see [17]) and Roger Callois [7], include an exploration to define play. *The psychological* perspective of Csikszentmihalyi and Maichel Apter (see [17]) include aspects of flow and immersion. The *game design* perspective of Pierre Carnau and Marc LeBlanc, Bartle and Yee (see [17]), include reasons and motivations why people play (computer games, multiplayer online games), plus Hunicke et al. [14] about pleasures.

Based on his literature study and empirical analysis Korhonen and colleagues present a list of 20 playful experiences including expression, fellowship, challenge and fantasy (see Table 4 for the list of playful experiences).

Fig. 7. Play lens 4: Playful experiences.

Fig. 8. GlowSteps prototype.

Different play experiences can occur during a play episode with multiple forms of play. For example, children can experience *challenge* during a game of tag, where they *explore* different ways to pick out somebody they can tag, and where they *express* themselves by combining the game of tag, with a *fantasy* related framing of play, such as in the 'world' of Harry Potter.

While this list is developed largely in the context of designing games and interactive installations, it can also be a useful tool for exploring different experiences in designing various playful interactions and contexts.

A designer can choose to design for several playful experiences and make design decisions based on that. During analysis, one can judge if these experiences are indeed present and what was the cause of this.

Questions for designers include: What kind of experiences does the design support? How can the players switch between different experiences? Which design decisions are related to this (e.g. timing of challenges, personal or shared objects, flexibility of objects)?

This lens is related to lens 2: Forms of play, as certain experiences are more likely to arise with certain forms of play. For instance, when designing for physical play, the experience of challenge is likely to be present, while designing for social play encourages fellowship or competition. Moreover, this lens also relates to lens 3: Stages of play, as a variety of playful experiences can be supported in the different stages of play. For example, fellowship might be of importance in the exploration stage to encourage discovering the possibilities of the design together, while competition might be involved in the immersion stage, when players play games in which they compete with each other.

4.4.1. Applying the playful experiences lens

Shuffle was designed, as mentioned before, with a focus on encouraging social play. This relates to the experiences of competition and fellowship. Furthermore, Shuffle offers players the experience of challenge, as players can try to become better at collecting colours or can try to beat other players. The experience of competition is also part of the design, as players can deliberately try to sabotage other players by exchanging the wrong colours with them.

5. Creating play solutions with the lenses of play

We will now illustrate how the lenses of play were applied in two design cases. The first design case is an ongoing design case related to a PhD design research project involving the second author. This design has gone through roughly three iterations over the period of one year. The second design case is related to an Industrial Design project of Master student Alice van Beukering that lasted about 12 weeks full time. The designs have been made following a user centred design process, with frequent input from users to verify design decisions and improve the design. Also, both designs have been published about and the PhD design has been presented at several exhibitions.

5.1. Design case 1: GlowSteps

GlowSteps provides an open-ended, interactive play environment that exists of ten separate tiles that are placed unattached on the ground (see Fig. 8). Each tile contains a pressure sensor as input detection and three colours of light (red, green and blue) as

Scenario 3

Children playing with GlowSteps to catch a virtual animal

Janice and Ben are playing in the schoolyard with GlowSteps …. Janice points at the red light on one of the tiles and says 'let's catch that mouse'. Ben shakes his head; he would rather catch the blue cat. They challenge each other to catch the most animals. After a little while their friend Ellie joins in the play, and play shifts towards leading the mice to the left corner of the playground, so they can sit in the sun and be happy.

output modality. The tiles can be picked up and moved around. In this way, children can create play spaces. Similar interactive tiles exist, but GlowSteps is unique in offering interaction opportunities to children to let them come up with their own game rules and goals.

GlowSteps is developed to elicit mainly physical active play and social interaction. Children are encouraged to run around, step on the tiles and move the tiles closer or further away. They can play together in pairs or small groups, competing with each other or cooperating to achieve a mutual goal. See also Scenario 3.

5.1.1. Applying the lenses of play during the design process of GlowSteps

If we look back at the design process of Glow-Steps we can reflect on which design decisions were made during which design phase. GlowSteps is the second design iteration and follows up on the design FlowSteps [31] which consisted of only six tiles with simpler interaction rules and only two colours of light.

Globally we can distinguish three design phases: the *early design phase* in which we framed the scope of the play solution, the *middle design phase* in which we made initial design decisions about the play solution and the *later design phase* in which more detailed design decisions about interaction rules were made.

In the *early design phase* we applied mostly the lenses of forms of play (play lens 2) and of open-ended play (play lens 1), because they incorporated the main focus and value of the design solution: i.e. designing for social and physical play. The interactive rules in the tiles that only light up for a little while provide an opportunity to play physical games. However, if used differently, children can also engage in pretend or fantasy play. The abstract output modality of light allows children to interpret the interactive rules in different manners, suitable for

different forms of play. Open-ended play is encouraged as no game rules were predefined. The scenario above shows that children create their own game while playing with GlowSteps. They decide on some simple rules for catching the colours, and on a game goal of catching as many animals as possible. They improvise and change the rules as they play.

In the *middle design phase*, we started exploring what playful experiences (play lens 4) would be appealing in combination with supporting social and physical play. Children can set themselves challenges, or they might be more interested in exploration and expression when they engage in fantasy play. Furthermore, we examined how play might develop from initial use to different variations of emergent play (play lens 3). The interactive tiles invite children to play, by having a shifting coloured pattern in the invitation stage. Once a child steps on a tile, different interactive rules are triggered that support the exploration stage. They can set goals (as catching the mouse in the scenario) and create game rules that should be obeyed in the immersion stage.

In the *later design phase*, we tried out different interaction rules, to optimise the flexibility of play opportunities, in the sense that children could engage in different forms of play, with different play experiences over time (play lenses 1, 2, 3 and 4).

Reflecting on using the lenses in this particular design process, we can clearly identify how the lenses supported the designers. The lenses gave direction in the project and helped to determine a focus quicker. As the designers were experienced in designing for open-ended play and using the three stages of play, these lenses could be easily and quickly applied. The lenses were helpful in making conscious design decisions. For example, play lens 1 forced the designers to purposively decide upon what to design (e.g. the form of the tiles, the light output) and what to leave open for the interpretation of the players (e.g. potentials game rules and goals). In the end, the development of the designs with the lenses in mind led to a rich and interesting result.

Considering the play qualities of GlowSteps, the design itself has demonstrated its value and potential as a playful solution. In several user evaluations, children played enthusiastically with the design. GlowSteps supported a nice balance between providing structure and boundaries on the one hand and leaving room for spontaneous user improvisation on the other hand. The frame of the design (e.g. the physical shape of the tiles) guides children into the

direction of physical and social play. In this direction, children can come up with a physical game of catching the light or more expressive play in which the tiles are used as an performance stage. The light feedback is open and abstract enough to support diverse game play. Interaction is simple but therefore understandable and usable for children.

5.2. Design case 2: Wobble

Wobble is a decentralized, interactive play design consisting of multiple standalone objects with their own set of fixed rules. The play objects are able to communicate with each other. Children can play with a minimum of three play objects and can easily extend the environment by adding more objects.

Wobble consists of multiple balls on a flexible stem. The balls can move around flexibly affording to be pushed and touched. The light of a couple of balls in the system (for example 50%) will softly pulsate and sometimes jump to another ball to trigger the curiosity and fascination of children. The play objects are sensitive for the actions of the children and respond with light and sound adding a sense of "living creatures" inside the balls. When a child touches an enlightened ball the child can change the colour of the light, whereby the ball will play local sounds of an abstract creature that lives inside the ball. When a child softly moves an enlightened ball the light jumps to another (randomly assigned) ball, hereby the ball will play local sounds of an abstract creature that flies or jumps away.

Together, the play objects form a magical layer in the outdoor environment of children. The play objects seduce children to become curious and fascinated about what can happen. When exploring the play objects children wonder and will be amazed about what can happen. In this way, children are actively stimulated to develop their own world of fantasy and pretend play while engaged in physical and social play. It aims at children in the ages 4–6 years.

Scenario 4

Children playing with Wobble

Mary and Emily are playing a catch-the-firefly game with Wobble. Mary sees a turquoise ball on her right. She gives a small shake to the ball. Straight away the firefly flies away to a ball further away. She challenges Emily to quickly catch the firefly. However before Emily reached the ball, it turns to purple. They both think it is a pity that the firefly disappeared before they could catch it.

Fig. 9. Children playing with Wobble.

Fig. 10. Adding some concrete objects to Wobble.

5.2.1. Applying the lenses of play during the design process of Wobble

In the *early design phase* the designer decided to focus on pretend and fantasy play (forms of play), and on the playful experiences of magic, surprise and fellowship (playful experiences). She decided to provide open-ended play opportunities through balls with light feedback and sounds (open-ended play).

In the *middle design phase* design explorations were made around different interaction scenarios. The overall focus on the forms of play stayed the same: fantasy play. To support improvisation in open-ended play, some concrete objects, e.g. lady bugs and butterflies, were added to Wobble (see Fig. 10). The evaluations in the early phase showed Wobble was too abstract for children to start coming
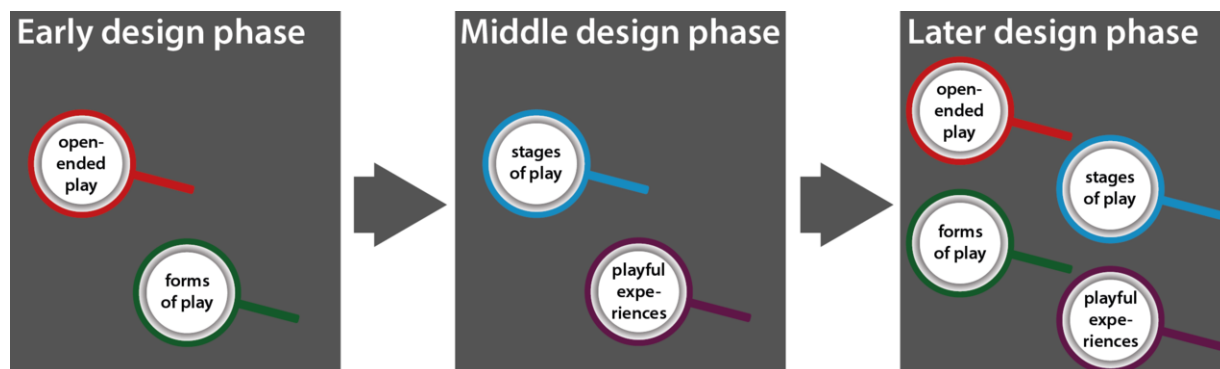
Fig. 11. Design process with the four lenses of play.

up with some game ideas. The interaction rules were also varied to explore how to enhance the playful experiences of exploration and curiosity.

In the *later design phase* a decision was made to provide more handles for fantasy play in open-ended play context: e.g. provide graphical help on the balls because young children need more concrete pointers for fantasy play, and more clear rules for stages of play. Furthermore, a new interaction rule was added about the balls changing colour if not touched for a while providing new opportunities for open-ended play.

The designer used the four lenses during her design process. Again, they supported her in determining a focus for her design. For instance, play lens 2 led to focusing on fantasy play. Play lens 1 was examined through all phases in exploring how to facilitate open-ended play for young children, using different implementations of feed forward and feedback modalities (e.g. colour and sound). The designer was not experienced in designing for open-ended play and indicated that this lens was very important for her to keep in mind during the entire design process. Play lens 3 was taken into account in all iterations in thinking about how to facilitate the stages. This was also a new lens for the designer and she needed to get acquainted with its function and the various elements. Therefore, in later phases, this was examined in more detail. Play lens 4 also played a role in all iterations.

Reflecting on the play qualities of Wobble, children who played with Wobble expressed their fun and engagement with the design and the magical play space it created. Observations showed various examples of pretend play, especially after concrete objects (e.g. flowers and bugs) were attached to the balls. The process involved focused design iterations to make the design less abstract but still open. In this way, children were supported to get started but also to develop the play further themselves.

5.3. How lenses are applied in the design process

If we examine how the play lenses were used during our own design process and by one of our Master students, we have seen that the lenses of play can inform different kind of design decisions. At the start of the design process (the early design phase), play lenses 1 and 2 are most important. These lenses help in framing the design space. For instance, choosing a form of play (play lens 2) gives a design project some direction as choosing to support storytelling (pretend play) and influences initial design decisions as developing multiple objects (social play) or objects that are spatially divided (physical play).

Play lenses 3 and 4 become relevant later on in the process when more detailed design decisions and interaction scenarios are being developed. For instance, the stages of play (play lens 3) motivates designers to think about the total experience of interaction, making detailed design decisions for each stage.

In the later design phase, zooming out is essential to understand the overall design rationale, and all four lenses are important in this step.

Figure 11 on the next page illustrates how the lenses play a role in the design process.

6. Conclusions

We have presented the four lenses of play. We have illustrated how they can be applied during a design process to inform design decision making in different phases of a design process.

Often ambient play environments are designed to support children's physical and social play. However, different forms of play can often be combined (play lens 2). Play lens 1, about open-ended play, gives a starting point for creating opportunities for social interaction, for example by having play objects communicate with each other. Furthermore, considering different playful experiences (lens 4) for different stages of play (lens 3) can help designers create rich play solutions that can be engaging for a longer period of time. For example, by having the interactive behaviour change over time, depending on the player's behaviour.

The toolkit provides a variety of ways to design ambient play properties, such as incorporating personalisation and adaptation based on different behaviours that can be sensed in the play environment.

The toolkit can help designers to reflect on the aim of the play designs they create, to frame the design space and to develop rich play solutions to support children in engaging in diverse play activities.

7. Discussion

At present, the toolkit contains four lenses of play. However, we imagine that there are other relevant lenses as well. Knowledge to support designers in making age appropriate design considerations [e.g. 2] should also be incorporated in the extended version of the lenses of play. In our work on decentralised play environments we are examining how to design for emergent play, using constructs as adaptation [23]. In the future we expect to add a lens about designing for emergent play, incorporating constructs from these disciplines to further enrich play experiences.

The question is whether the knowledge embedded in the toolkit is of an appropriate level for supporting designers in their process. Erickson [9] argues about different types of knowledge: e.g. an intermediate, i.e. not too small such as flow, affordance or breakdown, and higher level knowledge, such as activity theory and ethnography. While his paper provided a position statement without an application of how the lenses might be applied in practice by others, we have illustrated the use of the lenses of play to two design cases.

What is our initial impression of the level of knowledge provided in our toolkit? The overall lenses provide a global perspective for designers. Within the lenses some constructs are fairly small,

e.g. fairly unstructured activity (open-ended lens) and invitation and exploration stage (stages of play lens), because they should be applicable to a specific domain of play. As design toolkit we have found it to be useful to combine high level lenses, with medium level constructs such as challenge, and more concrete examples of how such a construct can be implemented, e.g. changing timing property to increase or decrease challenge level.

We have applied the lenses to specific design contexts. If we compare Erickson's examples of the chess scene to a play context, it does not necessarily mean that a designer has to take one particular scene as a starting point for applying the lenses. In framing the design space, and in making decisions the designer may examine different 'scenes' which may be imaginary or real in order to make design decisions in the different phases of the design process.

So far the toolkit has been used by us and our design students. A next step is to explore how the toolkit may be used by other design practitioners in the future. Future work includes developing the toolkit further, by extending the design questions to provide more useful pointers to making design decisions, and examining how to make the lenses easier to use.

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