Chapter 27

Designing Interactive Tangible Games for Diverse Forms of Play

Tilde Bekker, Ben Schouten, and Mark de Graaf

Eindhoven University of Technology, Eindhoven, The Netherlands

27.1 INTRODUCTION

Digital games have been described in taxonomies and genres from different perspectives, depending on the angle of categorization. Games are often defined as systems that have certain properties, like having rules, or providing information or presenting a conflict. On the other hand, games are described as emerging qualities centered around the experience of play and for the player, such as pleasure or challenge [1, 2].

A well-known model of digital game design is the mechanics, dynamics, and aesthetics (MDA) model [3]. It is a formal approach to understanding games which attempts to bridge the gap between game design and development, game criticism, and technical game research.

Assume that we more or less understand what digital games are and how to design them. Then how can examining properties and qualities of play provide ideas for designing novel digital game and play opportunities? Moreover, as games are more and more social instruments of collaboration, for example, *World of Warcraft* (Blizzard, 2004) and *FarmVille* (Zynga, 2009), and play in its digitized forms can be more open-ended in the sense that players can interpret the interactive behavior to create diverse games and rules, the experience of the game player becomes more and more important.

Furthermore, development in the technical domain has also influenced the opportunities for designing for play and games in the sense that miniaturization of

Handbook of Digital Games, First Edition. Edited by Marios C. Angelides and Harry Agius.

components now allows interactivity to be embedded in mobile and tangible play objects, instead of needing to stay fixed to a computer to play a game.

The design for play and games needs a more user-centered approach (based on target groups) and a better understanding of the different forms of play according to user experience, cognitive skills, and involvement or context. To put it differently, play can be described from a more social perspective emphasizing whether people play alone or together and the extent to which they have shared goals and actions. Other types of play include physical play and play and games with rules.

This chapter will examine how various properties of play have inspired and can inspire new design directions for digital games and intelligent play objects. Play theories from a child development perspective will be described and will be related to concepts from game design, such as game mechanics and dynamics. Furthermore, a discussion will be provided of how different properties of play relate to children practicing social, emotional, physical, and cognitive skills in a playful and fun context. An adapted version of the MDA model will be presented as a tool that supports considering the richness of play design opportunities when creating dynamics, mechanics, and aesthetics for diverse forms of play from a designer and a player's perspective. The exploration will be extended by describing four design case studies of tangible intelligent play concepts for different contexts of use related to different properties of play. The design cases include an interactive storytelling mat for young children, an intelligent ball pit for young children, a system that supports children sharing the use of bikes during school play time, and intelligent play objects for a trading game with a design intention of supporting social interaction. The case study descriptions will illustrate how different play properties were related to (interaction) design decisions.

27.2 OUR APPROACH TO DIGITAL GAMES AND PLAY DESIGN

In the Department of Industrial Design we have been working on designing and evaluating innovative game play concepts for the past 10 years. In the course of these years we have developed a particular approach to designing intelligent play solutions. This approach is grounded in theories about child and life-span development, psychology, and sociology and game design. We have also explored how play and game concepts can play a role in persuading people to healthier lifestyles, for example, by designing for social and physical activity [4–7]. Out of this work a set of design values has grown to support designing for social and physical play of a range of use groups, which so far has been applied mostly to children. These values, based on the *context of play*, include designing for open-ended play, providing motivating feedback, and designing for a variety of social interaction patterns and cultural background [6, 8]. In open-ended play, no (game) rules are predefined; instead, the meaning of the objects and interactions are defined while they are being used. Players can negotiate game goals and rules as they are playing. Providing motivating feedback to physical activity can make playing physical games more rewarding. Finally,

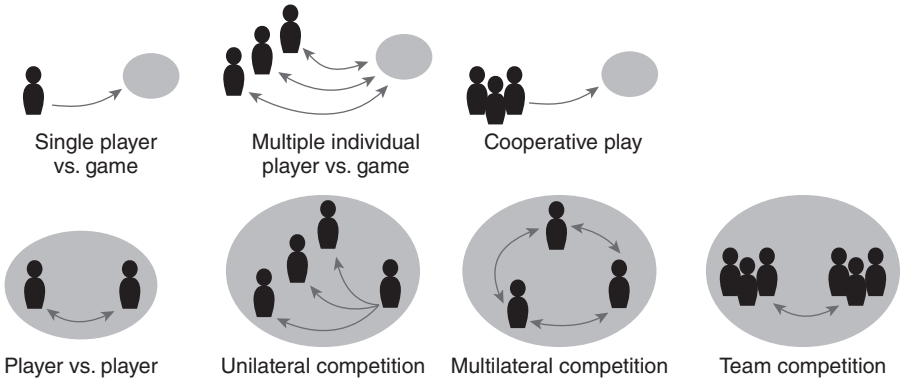


Figure 27.1 Player interaction patterns (after [9]).

designing with different social interaction patterns in mind can influence the diverse manners in which players can play a game together (see Figure 27.1). Social interaction patterns vary in number of players, whether they collaborate or compete, and whether the opponent is another player or the system [9]. For example, object shapes and properties can influence whether players see these as personal or shared objects, and the open-endedness of a design can allow players to change between different social interaction patterns (e.g., from competition to cooperation).

The chapter is organized as follows. In the next section we will describe different forms of play in combination with the skills that children practice during play. Then we elaborate upon the state of the art of the design for games and play. We will propose an enriched model for digital game design, adding the role of forms of play to an existing model (MDA) for digital game design. Then we will describe four design cases to illustrate how combining considerations about forms of play and aspects of game mechanics, dynamics, and aesthetics can lead to promising play solutions.

27.3 PLAY AND CHILD DEVELOPMENT

Examining different forms and properties of play and how these may differ depending on the abilities and interests of the children/players can be inspiring from a game and play design perspective. The focus of play and child development theories is diverse and has shifted over time [10]. To give some examples, play has been examined in terms of its role in social competence and peer group affiliation [11], cognitive development [12], emotional development [13], and literacy and language learning [14]. In some theories the child is assumed to learn by interacting with the world almost without facilitation [12], whereas in other theories the role of peers, parents [15], or even more complex contextual factors are assumed to be of influence [16].

Play can be described based on many different dimensions, including social, emotional, motor, and cognitive dimensions, but also based on play contexts and structural properties of play behavior [17]. Different forms of play include

Table 27.1 Summary of play

Forms of Play	Description	Examples of Skill Development	Example Games and Toys	Age Range (year)
Constructive play [20]	Creating and constructing something from objects	Problem solving, mathematical thinking, scientific reasoning	Construction play sets, weaving looms, clay, photography, warhammer.	3-6 and up
Pretend (or socio dramatic) play [19]	Acting out roles, often using toys and props	Perspective taking, emotion expression and regulation, identity development, self-esteem	Costumes, swords, Punch-and-Judy, interactive talking dolls, miniature objects, dungeons and dragons, role-playing games	2–6 (solitary) 8–12 (in a group)
Physical play (or active play) [20, 21] (sports angle)	Sensori motor play with moving objects; physical play in preschool years involving rough-and-tumble play; older children engage in play with more vigorous component to test strengths and skills	Fine and gross-motor skills, endurance, balance, negotiation	Bikes, gym equipment, sports, exergames	3–8
Games with rules [18] (sports angle)	Playing games in social groups with fixed predetermined rules	Emotion regulation	Mental games, languages games soccer, Wii-sports	5 and up
Games with invented rules [18]	Playing games with modified or rule sets invented by themselves	Abstract thinking	Tag, hide and seek	5–8

construction play, pretend play, physical play, and games with rules (see Table 27.1). A play episode often combines multiple play forms. For example, a child playing with a construction set such as Lego may be constructing a village from the building blocks and pretend that it is under attack by an enemy army. When playing with another child, they may have rules about how the enemy may attack.

How children play changes as they grow older. On the one hand children develop skills when playing [22], and on the other hand new opportunities open up for play and games as certain skills have developed further. For example, as children's skills as problem solving and abstract thinking increase, more difficult games become

appealing. What is known about play development can be used as a source of inspiration when designing new games and play opportunities.

These different forms of play provide opportunities for children to practice certain skills. Table 27.1 provides an overview of different forms of play and how these relate to the skills that are applied, example toys, and age range where this form of play is most prominent. The following section will provide short descriptions of the different forms of play.

27.3.1 Different Forms of Play

Constructive Play Scenario
A group of children are playing at the water table. They are playing with cups, water hoses, and plastic bottles. One child has stuck the hose in the bottle and is trying to fill it. He still has some trouble getting the water in the hose. A girl is having fun squirting water using the bottle. She imagines it being a fish and later on changes her play activity to try to fill a cup with water by squirting.

Constructive play is a form of play in which children interact with objects and create different kinds of constructions. It can include playing in a sandpit, water play, and playing with (wooden) construction kits. The manner in which they do this and the kind of play this is incorporated in change as they grow older [20].

Constructive play can help children understand spatial relationships and geometry. They use and combine different shapes to create different constructions. They develop problem-solving skills and explore different solutions while creating 3D patterns. They also practice socioemotional skills when they collaborate in their construction activities, such as turn taking, negotiation, and sharing.

Preschoolers enjoy simple matching and sorting of objects. Five- and six-year-olds show higher levels of social interaction during constructive play. Older children use more complex classification criteria and often use multiple criteria in combination. They use materials with more complex interlocking pieces. They also become more interested in creating more detailed and realistic final products [18]. Furthermore, when children are older, they combine construction play more often with dramatic play [17].

Playing with construction kits and with water and sand supports logical mathematical reasoning and *cognitive* problem solving [23].

Pretend Play Scenario
Susanne is walking through the corridor, twirling her umbrella above her head, a shopping bag on her arm. All of sudden, Rob jumps from behind a box and pulls her bag out of her hands and quickly runs away. “Help, I am being robbed!” shouts Susanne. Fortunately, her older brother quickly comes through the kitchen door and, as a policeman, asks her what has happened, seriously taking notes on an empty envelope.

Pretend and dramatic play peaks around the ages of five and six years. As children grow older their pretend play shifts from solitary play to group pretend play. They can use abstract and concrete objects in their play episodes. As they become older, the pretend play episodes become more elaborated, with a larger component of directing their play in the form of skit.

Pretend play encourages diverse social skills [24], such as conversational skills, turn taking and perspective taking [25], and social problem solving [26].

The ability to engage in sociodramatic and pretend play requires the ability for abstract and representational thinking [14].

Physical Play Scenario

John and Emma are shooting marbles on the school playground. They have small marbles and bigger ones, and they try to hit the bigger marbles by shooting with small marbles. After playing for a while, one of Emma's marbles ends up in a puddle. This gives her an idea for another game. She splashes with both her feet in the puddle, and soon they are both running from one puddle to the next, trying to be the first to reach the next puddle. Right before John reaches the last puddle, Emma gives him a shove from the side, beating him into it.

Children incorporate small-motor skills, such as picking up small objects, and gross-motor skills, such as kicking a ball and balancing on the edge of the pavement, in all sorts of play activities. Different kinds of physical and active play include playing with playdough, ball games, jumping rope, tag, and hide-and-seek [21]. When children become older, physical play becomes incorporated in informal or formal sport activities, such as soccer and martial arts, in which formal rules play a bigger role.

As children grow older, they can perform more precise and more complex physical activities, requiring more complex motor skills. For example, young children can kick a stationary ball, while older children can kick a moving ball while running toward it. Various forms of physical play allow children to practice a variety of skills. Rough-and-tumble play allows children to practice social and *emotional* self-regulation [27]. Engaging in activities in a playground helps children practice balancing skills, endurance, and muscle tone.

Play with Rules Scenario

Tycho is sitting on the floor with his plastic knights set up in front of him. His brother Mark has raided a board game for wooden blocks to create the battlefield. They negotiate how many knights each is allowed to buy using their paper money and what the powers of the different knights are. After having agreed on the initial rules, they start the battle. Tycho throws the dice to determine how many knights can attack Mark's castle. He still thinks it is unfair that Mark got the only shoebox as his home territory. Sometime in the game, Mark agrees that an extra rule is needed to even the odds a bit more.

From around the age of four children can start incorporating rules in their play activities, called games with rules. Younger children have not yet acquired the skill of abstract thinking, which makes understanding rules difficult. Preschool children can play games such as matching pictures or simple board games moving pawns on a board. When children become older, they enjoy games with more complex rules [19]. Games with rules can incorporate collaboration or competition, allowing children to practice emotion expression and regulation. These can be card games and board games but also sport like activities with rules, such as soccer and hockey. This form of play can also be combined with dramatic play, when the games are set in fantasy or adventure themes, such as using a variety of figures to fight wars in a fantasy world.

27.4 DESIGN PRACTICE OF DIGITAL GAMES AND PLAY

In defining *play*, Rubin, Fein, and Vandenberg [28] include aspects such as that it is intrinsically motivated, controlled by the players, concerned with process rather than with the product, free of externally imposed rules, and characterized by the active engagement of the players. Different types of play include sensory play, dramatic play, construction play, physical play, pretend play, games with rules, and games with invented rules (see Table 27.1).

Salen and Zimmerman [29] define games as an artificial conflict, based on rules, with a quantifiable outcome. According to Salen and Zimmerman, games are a subset of play, but the other way around, play can be defined as a part of gaming (we then like to call it game play). In other words play brings in more dimensions of "freedom" (relating to the qualities of the player) than (digital) games.

Taken from the perspective of different forms of play, considering the (short) evolution of digital games, categorizations of computer games are based on the different playing *skills*. The first digital games were called arcade games as they were played in arcade halls and mainly based upon the skills as quick reaction and dexterity. As (early) games evolve from text-based to more graphical instances, new skills are introduced such as *navigation* [e.g., *Super Mario Bros.* (Nintendo, 1985) and other platformers] and *accuracy* (e.g., in first-person shooters e.g.) and more advanced genres evolve such as adventure games, *role-playing games*, and massively multiplayer online role-playing games (MMORPG), which emphasize more collaborative and "social" skills and also increase the influence and complexity of *rules* in the game play. This is one of the reasons why taxonomies of digital play are in many cases incomplete (with respect to the play literature) or not consistent. According to Veugen, who lists a large number of different taxonomies in her thesis [30], most game theorists agree that game genres should better be subdivided to a more complete list of game play skills or types of interactivity. This inconsistency is also reflected in the different definitions of digital games, which we will discuss below.

According to Juul [31], games can be seen as systems that have certain properties, such as rule based, having a variable outcome, and affected by the effort of the

player. On the other hand, digital games can be described as having more emerging qualities (centered around the experience of play for the player) such as social expression or pleasure [2]. Salen are Zimmerman structure the contents of their book *Rules of Play* [1] first into units that describe games as systems of information, emergence, and conflicts and second as qualities of play such as experience, pleasure, or meaning.

These definitions suggest that games are about rigid (unchangeable) rules, challenge, and artificial (i.e., not real) experiences. Also Caillois [32] places forms of play on a continuum from Ludus, structured activities with explicit rules (games), to Paida, unstructured and spontaneous activities (playfulness). In general, there is a tendency to turn Paida into Ludus. In our opinion, however, games should no longer be considered as "formal systems that provide informal experiences" [31], as their rules are no longer fixed. *Little Big Planet* (Sony, 2008), the modding community, MMORPGs, social games, and the advance of user-generated content show that the mechanics of today's games do change and, by doing so, gaming can become more playful and open [33]. But, more important, it requires a completely different role of the designer, not being the sole "author" of the game but designing opportunities for play in open (intelligent) systems of interaction between players. The boundaries between (digital) game and play design will eventually blur and rules will emerge instead of being preprogrammed.

27.5 DESIGN PRACTICE OF GAMES

A well-known model of digital game design is the MDA model, developed and taught as part of the Game Design and Tuning Workshop at GDV, San Jose, 2001–2004 [3]. It is a formal approach to understanding games which attempts to bridge the gap between game design and development, game criticism, and technical game research. Games are created by designers and developers and "consumed" by players (see Figure 27.2). The MDA model formalizes the interaction within games by breaking them into their distinct components. Let's quote Hunicke [3, p. 2]:

> *Mechanics* describes the particular components of the game, at the level of data representation and algorithms.
>
> *Dynamics* describes the run-time behavior of the mechanics acting on player inputs and each others'outputs over time.
>
> *Aesthetics* describes the desirable emotional responses evoked in the player, when he/she interacts with the game system.

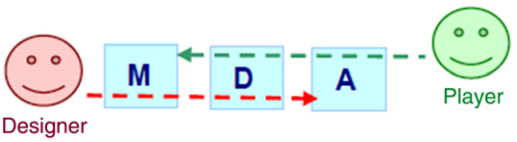


Figure 27.2 Original MDA model in which designer and player each have dfferent perpectives (from [3]).

Hunicke et al. present the model as a "lens" of a game and subdivides the components of aesthetics into qualities that are very useful for our framework and relate to the work of Korhonen [34]: sensation, fantasy, narrative, challenge, fellowship, discovery, expression, and submission. Furthermore they describe the relationship between games as systems and games as player experience [3, p. 2]: "From the designers perspective, the mechanics give rise to dynamic system behavior, which in turn leads to particular aesthetic experiences. From the player's perspective, aesthetics set the tone, which is born out in observable dynamics and eventually, operable mechanics." In general one can say that the mechanics generate dynamics which generate aesthetics. This relationship poses a challenge for the game designer as he is only able to influence the mechanics and only through them can he produce meaningful dynamics and aesthetics for the player. It also allows us to bridge the gap between games as (formal) systems and games which have emerging qualities (centered around the experience of play for the player).

So, to come to a conclusion, there are several reasons to adjust the MDA model:

1. Player experiences: Dynamics is something a system (game) can have, but dynamics is also something which partially "happens" in our brain, (e.g., a child in a cardboard box doing "broom, broom" imagines himself as the greatest formula 1 driver ever). Dynamics is only partially programmable, but still there is an understandable relationship between mechanics and dynamics which can be designed. As such dynamics can be predicted and designed for; a shift from mechanics to dynamics as the leading principle in the practice of the design of play and games is beneficiary and necessary.
2. In open-ended play, dynamics and aesthetics can lead to new mechanics, which on its turn can lead to new aesthetics. It requires a new form of open system and iterative design.
3. Interaction design for play and games is highly contextual, which differs from the original interaction (of usability), which means that cultural and social background is an essential part of the design process.

As a result of the above criteria we have redrawn the picture for the MDA model; see Figure 27.3. In Section 27.7 we will elaborate on several design cases of our department which use this revised model for play and game design.

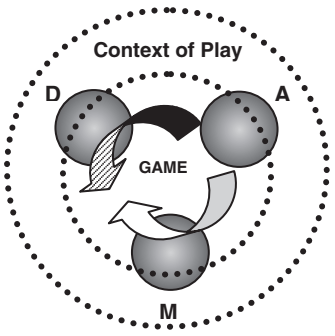


Figure 27.3 Adapted MDA model showing influence of combining designer (bottom arrow) and player's perspective (top arrow) and taking context into account.

27.6 RELATED WORK ON DIGITAL PLAY SOLUTIONS

A wide range of digital play solutions have been created without using screens as part of the design. These solutions often incorporate tangible objects in the overall concept. Embedding interactivity in play objects combines the opportunity for children to explore the world by interacting with a physical object and enhancing this by providing feedback using digital technology [35]. Tangible play solutions have been created for different forms of play, including physical play, social play and communication, music creation, creativity, and storytelling.

Interactive playgrounds have been developed both by companies and by researchers. For example, the SmartUs playground by Lappset provides an interactive installation where children take part in a "live" computer game and help determine the course of the game through the technology. Soler-Adillon and Parés [36] developed an interactive slide to make children's physical play more engaging by projecting game elements on a large slide.

Another type of tangible play solution is called a head-up game, a mobile game where the players do not need to keep watching a screen but can keep "their heads up" when moving around in the real world. Soute et al. [37] developed head-up games, or pervasive games to support social play. These games often incorporate interactive tangible objects that support social interaction and physical play.

Other types of play solutions have been created that can be carried around "on the body." Rosales and colleagues [38] have developed a prototype with interactive light feedback in shoes for children that encourage social interaction during free play activities. Children can incorporate the feedback in diverse physical and social games of their own making.

Iguche and Inagake [39] developed Morels, which are interactive play objects that stimulate social and physical play. Morels are cylindrical objects that can detect whether other Morels are close by using wireless technology. They can provide auditory feedback and launch themselves after having been squeezed. Children can create various games incorporating social and physical play activities.

Creative activities can also be supported by digital play objects. The I/O Brush [40] is an interactive brush that can record colors and textures and can then be used to paint new creations. Video Bubbles [41] are tangible objects that support children creating expressive video art displayed on a screen.

Tangible solutions have also been created to support children in creating music. For example, Jogo [42] is a music generator consisting of a round tabletop and colored ping-pong balls. By placing the ping-pong balls in the different slots, children can create different musical compositions. Examples of digital play solutions that support storytelling and fantasy play are StoryMat by Cassell and Ryokia [43], an interactive mat with stuffed toys that records and plays back stories created by children, and TellTable, a table-top platform to support children in engaging in fantasy play using virtual objects and drawings [44].

These examples of interactive play objects show the diversity of tangible play solutions created for diverse forms of play. In the next section we will conduct a design analysis of designs created in our own department to illustrate how the adjusted MDA model can inform design decisions and reflections.

27.7 EXPLORING RELATIONSHIP BETWEEN PLAY AND DESIGN THROUGH DESIGN CASES

To explore how the different forms of play can be combined with the concepts presented in the MDA model (see Figure 27.3), we describe four design cases of industrial design master's students covering digital play solutions for the different forms of play: pretend play, social, physical play, and games with rules. We describe the main concept, a small scenario to describe a possible play episode and an explanation of the design in terms of the game MDA. We also provide a small reflection on the play quality of the concepts.

27.7.1 Design Case 1: Pretend Play and "Wondrous Imagination"

This case study was designed by Gijs Houdijk during his final master's project over a period of 10 weeks (Figure 27.4).

Figure 27.4 Children playing with Wondrous Imagination mat using interactive objects and stuffed animals.

Scenario of Use	MDA
Three children are playing on the interactive mat. The child care provider has just read and shown a picture book about a magician going on a journey. The mat includes shapes of a mountain, roads, and a lake. The children pick up differently shaped objects with colored Led lights. Mark picks up the magical doll and says, "Look it's taking to rocket to go on his trip!" Denise is happy that the light changes color: Now she has put the monkey on the orange object. "I like the lamps," she says. "It makes my monkey happy."	Aesthetics: expression, discovery, fellowship Mechanics: objects, the mat, the stuffed toys, storybook Dynamics: interactive behavior of the objects, fairly abstract input and output properties, story lines that children create

27.7.1.1 Context of Use

The interactive story mat (see Figure 27.4) is intended for child care locations, where the caregiver can start the play activities by reading a picture book for the children (two- to five-year-olds). The intention is to evoke pretend and fantasy play, giving children the freedom to do this in an open-ended play setting. They can *negotiate* the story that is created and *take* a different *perspective* when talking about the actions of the character objects. The design provides some structure, both through adult participation and by combining its use with picture books.

Informal user tests in a daycare center showed that too much freedom with only abstract shapes was too difficult for this age group. This has led to changes in the design, such as making the visuals on the carpet more concrete and adding stuffed toys and a picture book link for the support of storytelling. Further user explorations showed that the open-endedness worked: Children allocated different meanings to the objects and the interactive behaviors.

The *dynamics* are set within a *pretend play* setting, embedding the opportunities for interaction in relation to storytelling. In some cases children create stories on their own, *discovering* opportunities for different story directions. In other cases children can create stories together and experience a sense of *fellowship* while playing. The *mechanics* given the play form and the user group provide tangible triggers for storytelling. However, the interactive behavior adds an extra dimension to diverse opportunities in story directions. Children can practice perspective taking by telling a story from the perspective of another character, can negotiate story lines, and practice their language skills in creating or retelling stories. Depending on the amount of objects, some aspects of *construction play* may also play a role in this design.

27.7.1.2 Reflection about Play Qualities

The visuals on the mat and the interactive objects are concrete enough to help children create a story. The object forms are abstract enough to allow for diverse interpretations, like a rocket, a tower, a lamp, or a mushroom. The interactive behavior of the intelligent objects is abstract enough, so they can be incorporated in different stories. A fine balance is struck between getting children started with telling a story and providing changing behaviors in the interactive objects that can provide new impulses to the story.

27.7.2 Design Case 2: Pretend and Physical Play and "BABABA"

This case study was designed by Gijs Houdijk and Chris Gruyters as second-year master's students during a three-week learning activity. See Figure 27.5.

27.7.2.1 Context of Use

BABABA can be used in a childcare facility but also in shopping malls, where children (between ages two and five years) are playing during shopping break. The

Figure 27.5 Children playing with Bababa and listening whether they have found an interactive ball.

Scenario of Use	MDA
Six children are playing in the ball pit. Sophie is standing on the side and jumps in the pit. She hears three funny sounds. "Shsss," she says to the boy next to her, putting her finger to her mouth. Then they all start searching for the sounds. They put different balls next to their ears, until Sophie shouts, "it's a monkey!"	Aesthetics: challenge, discovery, and fellowship Mechanics: interactive ball with speaker, boundaries of ball pit, number and color of balls Dynamics: The ball makes a sound when shaken or moved. Children create diverse games when jumping in the ball pit or wading through the balls. Children start cooperating to be more effective.

intention is to make the ball pit more appealing by providing extra cues for moving about in the ball pit. Children have to listen carefully to find the limited number of interactive balls between the large amounts of normal balls. The balls only make a sound when they are moving or shaken. They have to *negotiate* to sometimes be quiet to be able to discover the balls. They can come up with different games, either searching together for all the balls or trying to find more balls than the other children. They wade through the ball pit to cover the whole area and manipulate individual balls to determine whether they make a sound. Observations of children in a daycare center showed a variety of play behaviors, including trying to find as many of the interactive balls as possible and searching for the sounds by switching between being quiet and moving to elicit the sounds.

The **dynamics** provide diverse opportunities for games. Some are *challenge* related, when children want to find a ball first or the most balls. Some are more *discovery* based, trying to find where a ball is and discovering what sound it makes. It is set in a "**physical play**" context and a "**pretend play**" context when children jump in the ball pit and create stories around the sounds of the ball.

27.7.2.2 Reflection about Play Quality

The strength of the design is based on having a limited number of interactive balls that only make a sound when it moves. Children have to search for the balls in

between all the other noninteractive balls. They have to alternate phases of high activity—to cause the balls to make sound—with phases of focused listening—to hear and find the balls. Furthermore, because the appearance of a ball is similar to the noninteractive balls, children have to listen carefully to find an interactive ball. This adds to the *challenge* and the need for *discovery* as well as a need to cooperate (*fellowship)*.

27.7.3 Design Case 3: Social and Physical Play and "Coplay Bikes"

This case study was designed by first-year master's student Martijn Kors during a 10-week design project. See Figure 27.6.

Figure 27.6 Children playing with ShareBikes and holding colored tags close to display.

Scenario of Use	MDA
A group of children are on the playground with two bikes. Every day children negotiate heavily to get their time on the bikes. The ShareBikes only run when two children have added "fuel" to the bike by holding the right color token to the display. This time one of the bikes shows a yellow and a red light. Elise is happy, because she has a red token today. "Who has yellow?" she shouts. Fortunately, her friend Amy helps her in finding somebody with the right color. "Yes," says Dennis, "I will go with you." They start biking on the playground until they are halfway through their biking time. "OK, time to change," says Elise and lets Dennis take over the steering position, while taking the back position. She likes steering better, but pushing is fun as well.	Aesthetics: fellowship, collaboration Mechanics: tokens, display for required colors, and fuel-level indication Dynamics: combining two tokens, negotiating getting the two tokens, finding somebody with the right token, keeping track of the fuel level

27.7.3.1 Context of Use

The Coplay Bikes are used in the school playground with many children vying for a chance to use them. Often the caregivers do not facilitate this process, unless real problems occur, and children cannot solve the disagreements themselves. The children (between 5 and 8 years old) have a limited time during recess, and the use of the bikes is limited to the playground of the school.

The interactive behavior of the ShareBikes facilitates a number of social interactions. It is positioned in a *physical play* context of the playground and facilitates *social play* aspects. A Coplay Bike can be used only when two tags with different colors shown on the display have been held close to the tag reader. Children each receive a colored tag. The system can recognize and display six different colors. Furthermore, the display shows that the "fuel level" of each bike where two tokens are required to use start the bike (see Figure 27.5). Children negotiate who can use the bikes, and they have to find the right partner. The system also keeps track of when they have to reverse roles. However, a certain flexibility is still present in the system, because children can exchange tokens, or ignore that it is time to change roles, if they want to. The system facilitates social interaction but does not regulate it completely. It makes certain social interactions more explicit. User tests with the system showed that children were inclined to help each other find the right colored token even if they did not have it themselves (*collaboration*).

The *dynamics* support children in using the Coplay Bikes together. They facilitate keeping track of the turn-taking procedures. Because of the different colors of the tokens and needing two different colors to be able to ride the bike, children have to match the right token to the right bike. They can help each other in finding the right colored partner supporting a sense of fellowship. The amount of time that a child can bike based on showing their token influences how fair the system is in creating enough opportunities for children to use the bikes. The *mechanics* is mostly defined by the tokens and the interactive systems on the bikes and the ratio between the number of bikes and the number of children on the playground with tokens.

27.7.3.2 Reflection about Play Quality

A very important factor for the success of the system is related to the game **dynamics** in terms of the amount of time children receive for biking based on presenting the token to the system. When it is too short, children will be dissatisfied with already having to relinquish the bike. When it takes too long, they may become too impatient with the system and try and circumvent the system.

27.7.4 Design Case 4: Social Play and Games with Rules Incorporated in Shuffle

This case study was designed by first-year master's student Koen Verbruggen during a 10-week design project. See Figure 27.7.

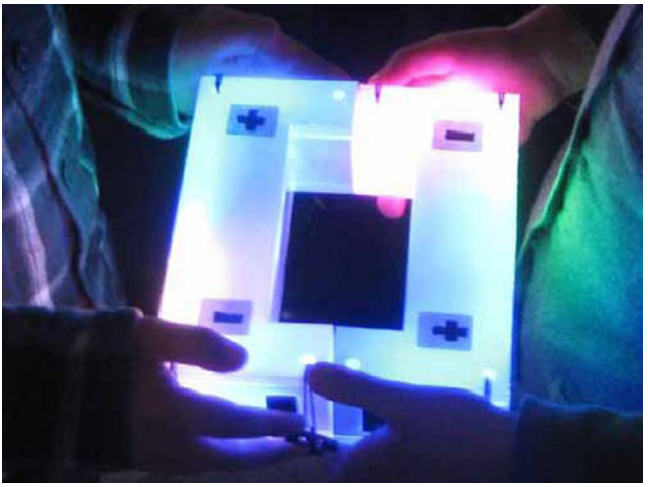


Figure 27.7 The Shuffle game.

Scenario of Use	MDA
Four children are playing with their Shuffle devices. They are trading colors by holding the shuffle devices to each other in turns. Jan looks at the different devices and sees that Jessy has some colors at the end of her object that he is still missing. "Do you want the secret, or the open option?" he asks. Jessy likes a bit of a gamble and chooses the secret option. After Jan has hidden the color of the outer lights they put their devices together. The Shuffles light up and Jan is sad to see he got the wrong color light. Well, he will just have to try again with somebody else.	Aesthetics: discovery, challenge, curiosity, and fellowship Mechanics: shuffle object, with five lights, and "secret" option for two outer lights Dynamics: Children can decide to help each other or not, use the mystery button or not, and collect the same colors or according to another rule of their own.

27.7.4.1 Context of Use

The Shuffle can be used any place: on the playground, at school, or at home. No facilitation by adults is required. Children can decide who they want to trade with and have to negotiate the turn-taking protocol themselves. Children can set their own goals when playing with the Shuffle (see Figure 27.7). There is no official scoring system, or official collecting protocol, such as in football picture collection books. They can decide to collect as many different colors as possible, a particular pattern of colors, or only one color. The Shuffle provides a sense of unpredictability by choosing at random whether to shift the colors in a clockwise or counterclockwise manner. Furthermore, the secret button can be used to hide the colors that will be traded.

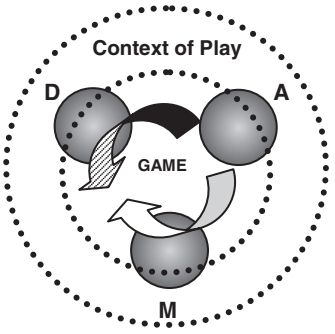
The *dynamics* are related to diverse social interaction choices. It is positioned in a *social play*, with "*games with invented rules*" context. These influence what the resulting emotions are: *fellowship* and sharing or *challenge* and hindering. Children apply and practice a wide diversity of skills in the various play scenarios: For example, they have to interpret the other players' emotions (emotion understanding), and managing to help others or reaching their own goals can contribute to a sense of self-esteem.

27.7.4.2 Reflection on Play Qualities

The secret option adds a lot to the appreciation of the Shuffle. It adds a dimension for negotiation in the interaction (**dynamics**). Because children can decide on their own goals in the open-ended play context, they can decide to be competitive or collaborate in their game play.

27.8 DISCUSSION AND CONCLUSION

In the previous sections we have examined how various properties of play can inspire new design directions for digital games and intelligent play objects. In our examples we showed how theories from child development can enrich the current practice of game design relating the theory of play forms to the existing MDA model for game designers. We practice a more iterative approach (see Figure 27.8) of the MDA model and combine it with an in-depth understanding of our target group(s). In contemporary games and play solutions, the dynamics provide an important design angle for linking to diverse forms or play, and different skills and abilities that focus on dynamics can present players with more diverse ways to play as this approach



- The context of play includes considering aspects such as forms of play and child characteristics in designing new interactive play solutions.
- A design process for tangible play solutions should combine the player's angle (top arrow) and the designer's angle (bottom arrow) in an iterative manner.
- The role of dynamics plays a more central role in creating play solutions incorporating tangible play objects.

Figure 27.8 Summary of relationship between adapted MDA model and its implications.

abdicates the authorship of play to the player. The above-mentioned cases show that this elicits emergent game play (play that was not envisioned by the designer) and more autonomous play. Moreover, the design-from-dynamics approach can help designers to create games that elicit creative (emergent) game play among players and help (serious game) designers to create a game in which players actually play with the intended learning content and change motivations to play (and learn) in positive ways.

We like to draw the following conclusions:

- *Combining play forms and skill and abilities with the MDA model* provides a richer framework for creating digital game and play objects for diverse players. Moreover, *an iterative process of the MDA model* is beneficial.
- New technologies such as sensors and actuators (e.g., incorporated in Wii and kinect) allow for enriched game play opportunities, which makes a shift from mechanics to dynamics in the design process inevitable.
- Play has a more open-ended character. In modern game design open-ended play becomes more and more important [33]. Examples are *Little Big Planet* and *Minecraft*. To design for modern games it would be beneficial to focus more on the dynamics. The aesthetics and emotions can be interpreted and elicited in the context of different play forms that have different properties. The play forms are often combined. Are we looking at a physical challenge or a social challenge or both? Are we supporting fellowship through helping each other with different kinds of play forms, for example, construction, co-creating a story?
- Designers can reason from a (set of) play forms and/or a set of skills to be incorporated in the game to explore game dynamics solutions, *which allows a shift in authorship from designer to player* [33].
- Thinking about forms of play will influence the type of game dynamics that is embedded in a design and as such what skills children or players can practice or develop.

REFERENCES

1. K. Salen and E. Zimmerman, *Rules of Play: Game Design Fundamentals*, MIT Press, Cambridge, MA, 2003.
2. E. Adams and A. Rollings, *Fundamentals of Game Design*, Prentice Hall, Upper Saddle River, NJ, 2007.
3. R. Hunicke, M. LeBlanc, and R. Zubek, "MDA: A formal approach to game design and game research," *Proc. AAAI Workshop on Challenges in Game*, AAAI Press, San Jose, CA, 2004.
4. M. M. Bekker, E. Hopma, and J. Sturm, "Creating opportunities for play: The influence of output modalities on children's play behaviour," *J. of Arts and Technology*, vol. 3, no. 4, pp. 325–340, 2010.
5. N. A. Romero, J. Sturm, M. M. Bekker, L. de Valk, and S. Kruitwagen, "Playful persuasion to support older adults' social and physical activities, Special Issue on Inclusive Design," *Interacting with Computers*, vol. 22, no. 6, pp. 485–495, 2010.
6. J. Sturm, R. Tieben, M. Deen, T. Bekker, and B. Schouten, "PlayFit: Designing playful activity interventions for teenagers," in *Conf. DIGRA 2011*, 2011.

7. B. A. M. Schouten, M. Deen, and M. M. Bekker, "Playful identity in game design and open-ended play," in J. Raessens, et al. (Eds.), *Homo Ludens Digitalis: Media, Play and Identity*, Amsterdam University Press, Amsterdam, 2011.
8. T. Bekker, J. Sturm, and J. Eggen, "Designing playful interactions for social interaction and physical play," *Personal and Ubiquitous Computing*, vol. 1, no. 5, pp. 285–296, 2010.
9. T. Fullerton, C. Swain, and S. Hoffman, *Game Design Workshop*, CMP Books, San Francisco, CA, 2004.
10. M. Kernan, "Play as a context for early learning and development," research paper to Aistear: The Early Childhood Curriculum Framework, Dublin, National Council for Curriculum and Assessment, available: www.ncca.ie/earlylearning, 2007.
11. M. Parten, "Social play among preschool children," *J. of Abnormal and Social Psych.*, vol. 28, pp. 136–147, 1933.
12. J. Piaget, *Play, Dreams and, Imitation in Childhood*, W.W. Norton, New York, 1962.
13. E. Erikson, *Childhood and Society*, Routledge, London, 1963.
14. K. Roskos and J. Christie, "Examining the play-literacy interface: A critical review and future directions," in E. F. Zigler, D. G. Singer, and S. J. Bishop-Josef (Eds.), *Children's Play: The Roots of Reading*, Zero to Three Press, Washington, DC, 2004, pp. 95–124.
15. L. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*, Harvard University Press, Cambridge, MA, 1978.
16. U. Bronfenbrenner and P. A. Morris, "The ecology of developmental processes," in W. Damon and R. M. Lerner (Eds.), *Handbook of Child Psychology, Vol. 1: Theoretical Models of Human Development*, J. Wiley, New York, 1998, pp. 993–1028.
17. J. E. Johnson, "Play development from ages four to eight," in D. P. Fromberg and D. Bergen. (Eds.), *Play from Birth to Twelve: Contexts, Perspectives and Meanings*, 2nd ed., Routledge, New York, 1998.
18. D. Bergen, "Stages of play development," in D. Bergen (Ed.), *Play as a Medium for Learning and Development*, Association for Childhood Education International, Olney, MD, 1998, pp. 71–93.
19. M. L. Manning, "Play development from ages eight to twelve," in D. Pronin Fromberg and D. Bergen (Eds.), *Play from Birth to Twelve: Contexts, Perspectives and Meanings*, 2nd ed., Routledge, New York, 2006, pp. 21–29.
20. J. Hewes, "The value of play in early learning: Towards a pedagogy," in T. Jambor and J. van Gils (Eds.), *Several Reflections on Children's Play*, 2007, pp. 119–132.
21. B. D. Goodson and M. Bronson, *Which Toy for Which Child: A Consumer's Guide for Selecting Suitable Toys: Ages Birth through Five*, U.S. Consumer Product Safety Commission, Washinston, DC, 1985.
22. D. Bergen, "Reconciling play and assessment standards: How to leave no child behind," in *Play from Birth to Twelve: Contexts, Perspectives and Meanings*, D. Pronin Fromberg and D. Bergen (Eds.), 2nd ed., Routledge, New York, 2006, pp. 233–240.
23. K. Sylva, J. S. Bruner, and P. Genova, "The role of play in the problem-solving of children 3–5 years old," in J. S. Bruner, A. Jolly, and Sylva, K. (Eds.), *Play: Its Role in Development and Evolution*, Basic Books, New York, 1976, pp. 244–261.
24. R. K. Sawyer, *Pretend Play as Improvisation: Conversation in the Preschool Classroom*, Lawrence Erlbaum Associates, Mahwah, NJ, 1997.
25. K. H. Rubin and N. Howe, "Social play and perspective-taking," in G. Fein and M. Rivkin (Eds.), *The Young Child at Play: Reviews of Research*, vol. 4, 1986, pp. 113–126.
26. K. H. Rubin, "Some 'good new' and some 'not so good news' about dramatic play," in D. Bergen (Ed.), *Play as a Medium for Learning and Development*, Association for Childhood Education International, Olney, MD, 1998, pp. 58–62.
27. N. Blurton-Jones, "Rough and tumble play among nursery school children," in J. S. Bruner, A. Jolly, and K. Sylva (Eds.), *Play: Its Role in Development and Evolution*, Basic Books, New York, 1976, pp. 352–363.
28. K. H. Rubin, G. G. Fein, and B. Vandenberg, "Play," in E. H. Hetherington (Ed.), *Handbook of Child Psychology*, 4th ed., Vol. 4, John Wiley, New York, 1983, pp. 694–774.

29. K. Salen and E. Zimmerman, *The Game Design Reader: A Rules of Play Anthology*, MIT Press, Cambridge, MA, 2006.
30. C. Veugen, "Computer games as a narrative medium," Ph.D. Thesis, Vrije Universiteit, Amsterdam, 2009.
31. J. Juul, "The game, the player, the world: Looking for a heart of gameness," in M. Copier and J. Raessens (Eds.), *Level Up: Digital Games Research Conference Proceedings*, Utrecht University, Utrecht, 2003, pp. 30–45.
32. R. Caillois, *Man, Play and Games* (Reprint). University of Illinois Press, Urbana, 2001.
33. M. Deen, and B. A. M. Schouten, "Let's start playing games! How games can become more about playing and less about complying" in *Proc. Fun & Games*, Leuven University, Leuven, 2010.
34. H. Korhonen, M. Montola, and J. Arrasvuori, "Understanding playful experiences through digital games," *Proc. on Designing Pleasurable Products and Interface*, Compiègne, France, 2009, pp. 274–285.
35. G. Revelle, et al., "Tangible user interfaces for children," in *Proc. of CHI EA '05*, ACM Press, New York, 2005, pp. 2051–2052.
36. J. Soler-Adillon and N. Parés, "Interactive slide: An interactive playground to promote physical activity and socialization of children," in *Proc. CHI EA '09*, ACM Press, New York, 2009, pp. 2407–2416.
37. I. Soute, P. Markopoulos, and R. Magielse, "Head up games: Combining the best of both worlds by merging traditional and digital play," *Personal Ubiquitous Comput*, vol. 14, no. 5, pp. 435–444. 2010.
38. A. Rosales et al., "FeetUp: A playful accessory to practice social skills through free-play experiences," in *Proceedings of INTERACT'11*, Springer, Berlin, pp. 37–44, 2011.
39. K. Iguchi, M. Inakage, and M. Morel, "Remotely launchable outdoor playthings," in *Proc. on Advances in Computer Entertainment Technology*, ACM, New York, 2006.
40. K. Ryokai, S. Marti, and H. Ishii, "I/O brush: Drawing with everyday objects as ink, in *Proc. of CHI '04*, ACM Press, New York, 2004, pp. 303–310.
41. K. Ryokai, H. Raffle, H. Horii, and Y. Mann, "Tangible video bubbles," in *Proc. of CHI EA '10*, ACM Press, New York, 2010, pp. 2775–2784.
42. E. Creighton, "Jogo: An explorative design for free play," in *Proc. of Interaction Design and Children*, ACM, New York, 2010, pp. 178–181.
43. J. Cassell and K. Ryokai, "Making space for voice: Technologies to support children's fantasy and storytelling," *Personal Ubiquitous Comput*, vol. 5, no. 3, pp. 169–190. 2001.
44. X. Cao, S. E. Lindley, J. Helmes, and A. Sellen, "Telling the whole story: Anticipation, inspiration and reputation in a field deployment of TellTable," in *Proc. of Computer Supported Cooperative Work*, ACM Press, New York, pp. 251–260, 2010.

Game and Product References

Blizzard Entertainment, *World of Warcraft*, PC, 2004.
Lappset, *SmartUs interactive Playground*, Istation, 2006.
Nintendo, *Super Mario Bros*, several platforms, 1985.
Sony Computer Entertainment, *Little Big Planet*, Play Station, 2008.
Zynga, *FarmVille*, PC, 2009.