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The Interactive Trampoline – Safety and Enjoyment

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***Abstract* - This paper addresses the use of technology as a supplement to traditional and well-known dynamics of play. By examining the use of the Interactive Trampoline in the development process of play activities, this paper seeks to emphasise the relationship between physical activity, safety, enjoyment and sociality as factors that will be important to future development of interactive play design for play. The findings show us that, in order to design fun play activities that sustain children's interest over a prolonged period, we need to consider children´s play practices within their communities of play, and as part of the solution for a safer environment.**

1. Introduction

In recent years, children's play and everyday lives have undergone major changes and digital technology plays an increasingly significant role in this transformation. Technology is becoming more integral to toys and games, in museums and in children's communication with each other.

Supplementing the well-known dynamics of play and games with technology has also embraced outdoor play equipment [20,21,30] in products such as ICON created by Kompan, the Spieder from PlayAlive or Digiplay from Lappset. In the research field of play, interest in the combination of physical activity and technology has increased [17,18,20,11,31]. Digital playgrounds increasingly use computer games as an attraction and a motivating factor to engage children in outdoor activity in order to promote physical activity and new forms of learning [19].

This paper describes the development of a piece of practical and physical digital playground equipment called the Interactive Trampoline. It aims to reveal some of the challenges that appear in a design process whose aim is to develop the technology for a familiar and popular dynamic of play. The project was part of a larger, Danish industrial innovation project called 'Play and Learning – Kids n' Tweens Lifestyle', funded by the EU. Its aim was to bring companies and researchers together to create products for children aged 3-12. First, we outline the background for the research and development. This is followed by a presentation of the Interactive Trampoline, together with the design and development process and the tests carried out during this process. In conclusion, the article reflects on the activities developed for the trampoline, addressing the safety implications.

2. Background

The starting point for the development project was the popularity of the trampoline. In Denmark, the trampoline is the most popular unorganised, physical leisure activity among children aged 6-12 [27]. The question arises as to how it is possible to maintain and strengthen trampoline-based play activities. The central question behind our project is whether technology can contribute additional play value to this popular play equipment. The idea was, in other words, to create a trampoline version 2.0 so to speak.

Another important consideration that forms the basis for further development relates to the risks of injury in using the trampoline. In the past 10 years, we have seen a 100-fold increase in the number of visits to A&E as a result of trampoline play. Roughly 65% of the injuries occur on the trampoline and 35% occur from falling off it onto the ground or other nearby objects. When two or three children jump simultaneously, the risk of injury is doubled, while the youngest child is 13 times more likely to get injured than the older children [24,31]. As a consequence, adults now establish the external rules of the game by, for example, acquiring trampolines with safety nets and monitoring children's physical play.

When adults take over all responsibility for safety by eliminating danger, numerous problems can arise. One issue is that there is no guarantee that the physical play becomes safer. In many cases, children refrain from engaging in physical play to comply with the adults' need for a safer environment. Over time, one consequence can be that, when the children face future physical challenges, they will be ill-informed and inexperienced regarding bodily know-how. Their physical incompetence can actually make their play activity even more dangerous [1,29].

In infancy, when children begin to walk, learning to fall has great importance for their motor development [17]. Repeatedly falling allows them to practise the techniques of balancing, falling and managing their physical safety. If adults prevent them from falling, children remain physically ignorant in future situations where knowing how to fall safely will be essential. If unable to fall appropriately, the risk of injury in the form of broken bones and concussion increases. In the design process, considerations of risk and safety therefore played a significant role in decisions to develop activities and practices: in order to reduce risk (and

increase safety), only one person was to jump at a time [2,3,4,19,23]. It was, however, also important to underline that the responsibility for safety should first and foremost be rooted in competent practice, i.e., responsibility should be in the hands of the children and not the adults, who did not do the jumping.

The triad of knowledge – about interactive play equipment, use of the trampoline and about theories of play – together contributed to the development of interactive activities for the trampoline. The technology involved is often added on as a supplement to traditional play equipment, such as swings, slides or climbing gear, or is seen as the motivating factor in the development of entirely new types of interactive play equipment [22]. In the last decade, this trend has developed from research and development projects into finished products. In what follows, we include a number of selected examples from both development projects and finished alloy products, where full body movement is in focus.

Impressive work in the field has been achieved by the PLAYWARE project in Denmark. Based on robotics, homogeneous interactive tiles were developed that were built into different surfaces and programmed with different games. The technology used in the tiles was based on distributed intelligence and simultaneous communication between them. The tiles have a pressure-sensitive area and actuators show different colours. In later versions, sound has also been embedded. 'Play hopscotch', 'Ping Pong' (table tennis) and 'Color Race' have been developed, among a number of other activities, with intelligent solutions in the form of adaptability in the software. The long-term goal in developing the tiles is to build them into playgrounds [10,16,17,18].

At the Interactive Institute in Piteå in Sweden, they have developed Digiwall. The climbing wall has built interactivity into the climbing grips by sensors that detect where the climber grasps and communication via light and sound actuators in the climbing wall. The sensors and actuators in the climbing grips create a space for game design on the wall. The idea was to remove the user from the screen in communication with the 'computer' [25].

A number of companies, such as the Danish company Kompan, have developed commercial products. Kompan's ICON equipment comprises games and activities based on mini-screens and touch sensors mounted onto playground equipment. In modified versions, the equipment is similar to familiar playground equipment, climbing frames, carousels and balance and Turk coach [10].

Lappset developed their Digiplay series, based on SmartUs technology, where learning, play and physical activity are combined in interactive playground installations. The user needs an identification card to be led around on the play and learning paths. Users are also linked up online and can therefore compete with others playing on similar installations around the world. Lappset have also developed a product called Sona for outdoor dance games and the Suto interactive wall for ball games [11].

Play Dale has developed the i.play system, which involves a stainless steel tripod with push, pull and rotational interfaces as well as light and sound feedback. The i.play system creates a space for reaction play and physical play [9].

Playneos has developed three concepts: Wall, 360 and Call. Pressure sensitive sensors are used, with feedback from light and sound actuators. The play equipment is designed for reaction and memory games [12].

PlayAlive has developed a climbing frame called Spider, based on a touch interface with light and sound actuators which they call a 'satellite'. Using the satellite as the interface, they developed movement and memory games around the climbing frame [13]. The satellites are also used in the ground and landscape-based playing surfaces of a product called Playtop Street [13].

These interactive play concepts generally consist of interfaces with sound, light and touch, and there is usually an attempt to eliminate screen-based activities [10,12,24]. The screen that once restricted the user of the computer to standing or sedentary activity is eliminated in most movement-generating playground products. The majority of the concepts, however, are based on movements within a relatively limited spatial area. In most of the projects, an important part of the philosophy seems to be that the installations must be able to work as play equipment even when the technology is not activated. For some projects, adaptivity of the software plays an important role, in the sense that the system acknowledges the needs of the users and adapts to those needs. Finally, the play activities and games developed for the different kinds of equipment seem only to last for a relatively short duration.

All together, the number listed number of critical aspects sets limitation to how physical challenging the activities can be in the interactive playground equipment [8,17,26]. With these considerations in mind, we came up with a framework for the design process of the interactive trampoline. One of the interesting questions in this framework was: To what extent is it possible to incorporate these considerations in a design for an Interactive Trampoline?

3. The Interactive Trampoline

The Interactive Trampoline is a large, round, king-size trampoline. Four satellites are placed along the outer edge of the trampoline. The satellite unit has a contact center that can display 16 LED lights in seven different standard colours and in 64 colours combinations. In addition, the device has a speaker where specific sounds for each game or play activity can be uploaded. The satellite also has built-in motion sensors, which relate to five zones: one near each satellite and one in the center of the trampoline. Movement data from the satellites is used to conduct games and play activities for the trampoline.

Fig. 1: The satellite

4. Design of the play activities

As a starting point, we conducted observations and informal conversations with five children who were involved in jumping on the trampoline in a back yard. The idea was to get a broad view of trampoline-based play activities, both in terms of performances and the children's experiences.

The development of the games and play activities subsequently took place in a design process that was based on a practice perspective [20,21]. It also employed four generic profiles of children, developed by the Danish company PlayAlive and Petersen's five play practices [26] (see below). Furthermore, we divided activities into different game/play typologies. The diversity and complexity in the design of the games ensured that a variety of activities would appeal to a range of different children [6,8,21].

PlayAlive has created four generic profiles of children that can be useful in designing play activities:

Action: Andy and Amy: They love speed, excitement and competition. They are the rebellious kinds, who prefer to play outside in the open, where there is room for wild play. Action Andy and Amy like catching, ball games and hiding games.

Mind: Max and Macy: They are motivated by intellectual challenges. Max and Macy like competition, but mostly at the tactical and strategic level. They prefer board games and construction toys.

Fantasy: Fiona and Felix: They love role-playing and fantasy games where they can fully live out their own fictional world and can tell stories. Competition is not something they are very fond of.

Creative: Carla and Chris: Carla and Chris are creative and prefer games where they can create without coming up against all sorts of limitations. They love to draw, paint and sing and for them competition destroys the activities they love.

Fig. 2: The interactive trampoline

Inspired by Huizinga [14] and Caillois [6], Petersen [26] distinguished between five different play practices, which we also employed as a basis for the design of games and play activities:

Fantasy play is all about pretending and telling a story; poetry and role-play are also important here.

In *construction play* creating something and using creativity play an important role.

In *high activity play*, speed, strength, agility and the influence of the vestibular system and of kinesthetic senses are central.

In *moving play*, it is all about physical interaction between bodies, and there are rules for this interaction.

In *rough-and-tumble play*, several elements of competition, risk or fighting are included.

5. The play activities

With the four profiles of children and the five types of play practices, we developed four play activities for the trampoline. The first, called *Energizer*, encourages children to jump as much as they can. The *Action Andy and Amy* profile provided the primary basis for this game. In *CircusPlate*, they jump and put as much energy into the satellites as they can. When they jump into a zone, the energy in that zone is filled up and leaves the zones they have left. They have to make sure that there is always a little energy left in all zones. *ZoneJump* is about how many zones they are able to jump in within 45 seconds. In the design process, we created the jump at the centre of the trampoline to make sure that children did not jump across the trampoline, which would pose a significant risk. As a reward for winning, the children experience sound and light displays. *Mind Max and Macy* was the primary influence behind both CircusPlate and ZoneJump.

The final game is *Gardenband*, where each zone represents an instrument, thereby allowing the children to compose their own music. They can also change the loops in the music by pushing the satellites. When they jump into the central zone of the trampoline, the music is stored and they are able to play it again and again. Gardenband derives

from *Creative Carla and Chris* and to a lesser degree from *Fantasy Fiona and Felix*. Of the five play practices; high activity play was the main inspiration for Energizer, CircusPlate and ZoneJump and to some extent also for GardenBand. Due to considerations of safety mentioned earlier, neither moving play nor rough-and-tumble play were employed.

After finishing the design of our four games, we tested them among our users. In the following, we will sum up the methodological considerations of our tests and describe what we subsequently learned in relation to design and testing methods.

6. Methodological considerations

The basis for our data production and collection was a triangulation of participant observation, observation using video as well as informal interviews with children [5,7,28]. The triangulation was meant to create different perspectives on the data, where the observations/participant observations were intended to provide an idea of how the children generally used the test sites and the trampoline. The intention of the interviews was to obtain impressions of children's experiences and thoughts about their trampoline use and also their thoughts about the activities. Finally, video monitoring was to give us a clearer idea of how the games and play activities worked, for how long children were motivated to be active and of their general strategies in using them [21,22].

The purpose of the testing was to create data from which we could generate an understanding of the activities on the trampoline, in order to get a better idea of how they functioned and to design and develop new types of activities.

The trampoline was tested at two locations in Vejle (Denmark) and at one location in Odense (Denmark).

The first test of our four games took place in the town of Vejle at a local children's activity centre called *Legelandet.dk* (Figures 1 and 2), where it was placed among other play equipment and tested over two days. The centre consists of, among others things, an indoor play area with inflatable, foam-covered climbing castles and slot machines. The trampoline was also tested for three days in the school holidays at a venue called *Spinderihallerne*. *Spinderihallerne* is a reconstructed factory that is used for a variety of cultural activities. During the school holidays, the venue is reserved for various cultural activities for children, including chess, painting and creativity-based courses. The trampoline was the only physical activity. Finally, the GardenBand activity was also tested by a group of physiotherapists at the annual seminar for children's physiotherapy at Dalum Landbrugsskole, Odense in February 2011.

The final test was carried out in Odense, where the trampoline was placed in a garden close to a local authority housing complex (Fig. 3). Around 20 different children visited the trampoline during a three-week period, some of them for several hours every day [8].

Fig. 3: The trampoline in the yard.

7. Discussion: test findings

Energizer: The activity is the simplest design for the interactive trampoline. The game was not used very much but often just played once, and then the children would find something else more interesting to do. Just jumping up and down is not, in the long run, very motivating, and we assume that is the reason why the children quickly chose a different activity. Also, *Energizer* was difficult to play with more than one person. The children clearly preferred playing together using the other activities that were better accommodated to multiple players, even though they were originally designed as a single player activity and not for multiple players [1,8,29].

CircusPlate: The activity aims to generate high intensity activity, and it also encourages the children to play tactically. We can suppose that the children found an advantage in playing with others, rather than playing on their own. When playing CircusPlate, having four children at the trampoline made it possible for the children to operate one satellite each. The setup made it possible to perform even better. As one boy said in the interviews:

Boy: Yes, it is really hard.
I: Isn't it hard work playing on the trampoline back home?
Boy: Well, I just jump a few times and then do some somersaults. When you are engaged with the game activities you have to use your brain and more energy to move quickly. This is a very good game, and I would like to buy it if I could.

ZoneJump: ZoneJump proved to be the most popular of the four activities. As with CircusPlate, the level of intensity was also high.

One major goal of the activities was to encourage physical activity on the trampoline, but as with many of the existing products on the market, children's interest in the

games is short-lived. Once the children had tried the interactive activities a few times, they reverted to using the trampoline as they were used to doing at home [8]. The activities generate higher levels of intensity, but the desire to repeat the games is limited. If the activities included more sophisticated adaptability, would this have prolonged the children's interest? This seems to be the unanswered question.

GardenBand: *GardenBand* was different from the other play activities. It is about creating music, about feeling the rhythm and being physical at the same time. There is no limit to the activity. One major problem with the activity was the volume of sound, as it was difficult for the children to hear the changes in the loops and the differences in the number of instruments. The low volume made all the sounds very alike, and soon it just becomes noise, without any structure or meaning. This was very clear from the videos, and the children simply started pushing the satellites again and again, trying to make some sense out of the game but without really succeeding. Few of the play activities that were started by the children were completed. After repairing the volume, we tested the play activity again with some physiotherapists. By switching between the satellite interfaces, the physiotherapists were able to compose their own melody and simultaneously adjust the pace of the melody to the jumping rhythm in the trampoline. In that sense the adaptive potential of the technology was exploited to a certain extent.

8. Security considerations

Our knowledge of, and concern for, safety played a major role in the design of the interactive activities for the trampoline.

One of the elements in the design process was that the children should only jump one at the time. As shown in the above, the children preferred to jump together and take part in the playing activities jointly. The only time they played the game one at a time was when adults on site managed the play situation around the trampoline. It is worth mentioning, however, that both CircusPlate and ZoneJump encouraged the children to be placed in different zones of the trampoline, as they were responsible for their own areas. In that sense, the playing activities constituted a lower risk of physical impact than if the technology had not been present.

As mentioned in the methodological considerations, this project was based on research about fun and safety in play on trampolines. Some of the major findings in this research were that, in order to stay safe and have fun at the same time, it is important to have a "sense of the rhythm in both play practices", "rhythm of the trampoline" and "rhythm of bodily movements". It is also important, especially in terms of maintaining the fun levels, to know when and how to break these rhythms [8]. The children used the games; they automatically had a role in their strategies towards keeping the play both fun and safe at the same time [8].

The Energizer game proved the most popular in the garden setting during the three-week holiday. Typically, the children wanted to score full points in the game. In order to achieve this, they needed to work together by jumping fast and going in a synchronised circular motion around the trampoline. The activity remained safe, even though there were high energy levels and a lot of children involved. The target of getting full points and the rules of the game kept the jumping rhythm within a range that the children could manage. Going in a circular motion also ensured that the rhythms of bodily movements were coordinated among the children.

Energizer also became the game you could play whenever the play practice became boring, and some new action was needed [21]. As mentioned earlier, this meant breaking the rhythms, and thereby increasing the risk of accidents. However, because the rhythms of the play were restricted by the rules of the game, there was less chance that the children would disagree on what to do. This meant that the rhythms were more predictable and manageable, and this created a relatively safe play experience.

CircusPlate and ZoneJump had some of the same effects on the children's ability to stay safe and have fun at the same time. The preset rules of the games helped the children to know in advance what the games were about and therefore the rhythm of play practice was not to any great extent up for discussion. This did not mean that the rhythm in play practice did not change over time; rather that the interactive games gave the children a starting point [17].

GardenBand did not in itself encourage dangerous play. On the contrary, the music in GardenBand provided an audible rhythm that apparently helped the children to both maintain control and reacquire any lost rhythm in bodily movements. For example, this could be examined when establishing appropriate trampoline rhythms for making a somersault. The music could then be used as an underlying basis for both trampoline and bodily rhythms and movements.

The findings in this project showed that the interactive games had a positive effect on the children's ability to have fun and stay safe at the same time. This was also the case when there were a number of children on the trampoline at once. The aim of the design process was that the interactive games should appeal to solitary playing, and therefore safer playing.

That play is a social phenomenon was confirmed by the tests carried out at three of the sites (Spinderihallerne, Legelandet.dk and in Odense). The reality showed that whenever more than one child was around the trampoline, they would jump on it together. The explanation for this could lie in the fact that many games – not just the interactive games – require more energy to be exerted in order to make it fun than one child can produce on their own [8,21]. When the design process allows for play equipment to function without interactivity, familiar play practices can still be employed. In the case of trampoline play, this usually involves more than one child at a time on the trampoline.

Even though the interactive games did not stimulate solitary trampoline play, they nevertheless facilitated the strategies needed for the children to have fun and stay safe at the same time. This was not because of any inherent physical safety features, but because the games helped the children to maintain the sense of the rhythms of play practices, rhythms of the trampoline and rhythms of bodily movements through the set rules and possibilities of the games.

In the future, it might be relevant to further examine how the technology and interactivity is capable of enhancing the children's own abilities to create fun and safe playing. This seems to be where the challenge lies. We need to shift the emphasis from building safety into the designed activities, and instead start to support the child's own competence with regard to risk management behaviour [8,29,31].

9. Conclusion

The article has presented some of the challenges we experienced in developing the Interactive Trampoline. From the beginning, physical activity, safety and technology were central themes, but the relationship between them created some insights that should be borne in mind in future development of interactive play activities. Our observations showed us, not surprisingly, that children prefer playing together on the trampoline, but that, despite this, the interactivity seemed to work as a promoter of both fun and safe playing. On the other hand, it seemed that, because of the social act of playing together, the children were more active than when playing alone. The relationship between challenge, physical activity, safety and sociality must therefore be considered paramount in future design and research. Lastly, while the development of the design demonstrated the value of enhancing the use of technology in existing play equipment, it also highlighted the importance of ensuring that the equipment also can be used without the technology.

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