

Attractive technological-enhanced playground artefacts

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Children's outdoor playground and play equipment have been increasingly innovative in design and interaction in recent years. Multiple studies attempt to use technologies in playgrounds to refresh play and activity experiences. The thesis focuses on an IoT playground project about technology-enhanced artefacts installed and located in Linköping, Sweden, and how they actively attract, engage and invite children and sustain their attention. Research through design is used to study the behaviour of participants. Previous observation data are used to give an initial idea of playground structure and play activities. After the analysis, field observation is conducted in the Magistratshagen playground. A visual and audio-based scenario design is created to gather more data on attracting attention. The result showed that audio and visual elements have a significant advantage on attracting participants' attention. However, the visual and audio effect in the design fails to keep participants' attention. The concept of social interaction should be considered during the design of attracting and engaging interaction for playground artefact.

Additional Keywords and Phrases: Human Computer Interaction, IoT Playground, attraction

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1 INTRODUCTION

1.1 Magistratshagen IoT Playground



Figure 1: Technological artefacts in Magistratshagen (hut on the left, two eggs on the right)

This thesis project is based on an ongoing technology-enhanced playground project inaugurated in Magistratshagen (see Figure 1), Linköping, in fall 2020. The playground in this project is a leisure space for children mainly built for play and have social interaction. Magistratshagen is designed unlike urban household playground. This playground combines the woods as part of the playground. The traditional playground props are located next to the wood, while the technology-enhanced artefacts extend the playground to the woods. The installation in the open-air park is built by the PlayIT project and Linköpings kommun. The project aims to combine IoT technology, playground structures, and nature to explore ideas for outdoor play with IoT activities. This IoT playground can promote IoT technology and the critical role of outdoor play in children's physical health and social development.

There are multiple traditional playground props within Magistratshagen playground. Swings, slides, climbing webs and sandpits are decorated with animal themes. Bees, elephants themed slides, spider themed climbing webs and multiple animals statues are in the centre of the playground. In other words, this technology-enhanced playground provides space for free play and allows children to have social space. Apart from the traditional playground structure, there are three programmable interactive artefacts, two interactive eggs, and a storytelling hut. They are installed with controllers, sensors, speakers and lights for diverse interactions and games. Several games and interactive storytelling are pre-programmed and uploaded to the server that controls artefacts within the playground. The lights allow the eggs to show vary options of colours while the controllers will control how the speakers and the lights operate in different play scenarios. Two egg-shaped interactive design and the interactive storytelling hut offer different play styles and experiences such as music and memory games. The eggs and hut will activate when the sensors are triggered; Then, the play scenario start. The scenario stops when they are idle for a while, be reset and ready for the next player to interact with them.

The activities the outdoor playground provide entertainment and challenge children's physical and social ability. Children playing in an outdoor playground see it as an entertaining and voluntary activity. The selection of activities relies on the relationship between children and the playground. Social factors such as their playing partners' choices are also affecting the flow of play. Traditional playground equipment such as tunnel, climbing

structures, ropes and swings are waiting to be played. With the help of IoT artefacts, we can make the artefact interact with the children in the playground by attracting their attention.

This study was undertaken to perform interaction and attraction-centre exploration between artefacts that are already inaugurated in the technology-enhanced playground and the children. The participants in this study are primarily children in kindergarten or primary school, around 3-10 years old. Children who played in that playground are usually accompanying and playing with their parents or their friends. Since Magistratshagen is a park open to the public, and not a playground within a school, people of all ages can play with the playground props. Even though the playground is open to everyone, children and parents are the most largest group in the playground. Therefore, participants of all age and gender are considered in this study. Observing the engagement and playing with their friends and parents is essential to explore interactions between participants and artefacts. This study is set out to focus on modifying the existing established artefacts. In the design process, I aimed to expand the original design of the technology embedded artefacts in an interaction centred direction to make the artefacts more engaging and active in interaction. Using temporary installation and re-programming scenarios to explore the following question:

How do the technology-enhanced artefacts actively attract and engage children in the playground?

2 BACKGROUND

2.1 Playground development

The outdoor children's playground has been an essential part of urban planning and development since the last century. A playing area can be a space between houses, woods, parks or spaces defined in the city's development [22]. Some of the playgrounds may also be attached to schools and kindergartens. However, a city's high developing speed narrows natural and public areas that allow children to play safely. Outdoor children playground in household communities becomes a necessity when the government plans to build playground close residential areas. These playgrounds increase cohesion between communities and improve children's physical health [10]. The space, structure and theme of a playground highly depend on the culture of the community in the living habitation [30].

The playground provides space for physical and social activities. Children who engage in play activities strengthen their physical skill and emotional development [14]. General physical activities and sports like football and skipping rope are popular activities in a park that do not require any playground structures. However, playground structures are introduced to community households playground to provide more options for social activities and physical challenges [5]. Household children playground in the modern day are more creative in designing playground structures shape. Some of the playgrounds may have a theme to encourage activities related to the theme. For example, Magistratshagen has an animals theme and the slides are decorated with bees and elephants. Decoration themes are essential in designing a playground since most playground props offer almost the same type of play. The theme can help each playground to be more recognisable in a children's mind. These playground props vary the style of plays and activities available in the playgrounds. Some children may prefer more free and open-ended play, but some may like a predefined games.

During the modern urban development, "smart" terms like "smart home" and "smart city" digital and IoT playground make the living environment connected to the internet. Digital devices and equipment are embedded into children's education and living environment, and they spend more time playing indoors instead of outdoors. 3d-printing, sensors, and IoT open up more possibilities for creating plays, social activities and educational experiences for children in an outdoor playground. Digital playing experiences, which are usually indoor activities, are brought to outdoor playground settings. Digital technology creates diverse play styles and encourage children to engage in more creative and physical activities [19]. The facility becomes more attractive and engaging, many technology-enhanced playgrounds are designed with attractive appearances and technological feedback through light, sound and tangible components. Before technology-enhanced artefacts are introduced to the playground, play styles offered by the equipment is very limited. It could become boring if the children have been living around the playground for a long time. Sensors and feedback components in the equipment provide opportunities for game and interaction designers to re-program the interaction and increased playgrounds' affordance so that the playground can elicit always new and fresh play experiences for children.

2.2 Game and Play

Outdoor physical play topics were explored from various angles and approaches. Researchers' investigation focused on activities and game-centre playful design [2, 23]. They tend to use digital technologies to create programmable hardware for a playground that encouraged children to have more physical, collaborative and social activities in an outdoor area [20]. These physical activities could benefit in developing children's mental cognition and cognitive performance when they play [11, 17]. Nonetheless, pre-programmed artefacts require children to learn the rules of playing before interacting with the artefacts and other children. If the game is too complex for them to learn, the artefact may fail the objective of bringing more playful interaction to the playground [24]. Physical landscapes, architectures and environments led researchers to construct an active outdoor technology-enhanced playground. Technology-enhanced structures widens and enhances social and play activities through tangible, sound and light feedback [1].

Apart from the game activities, the surrounding environment, nature, and players can affect a playground's qualities [12]. Playground artefacts and environment allow children to engage and have social interaction through physical activities. Physical games that children play challenge their physical, social and cognitive skills to overcome individually or in a group in return for achievement and enjoyment. Those are massive motivations for players' engagement during plays [9]. Playstyles in an outdoor playground are usually physical, social and embodied regarding the equipment and structures. They are also highly dependent on the culture in their country and neighbourhood. A technologically enhanced playground structure can expand the scope of playstyles in the outdoor play environment.

The spectrum of play is a broad family, including engagement, social interaction and structure of plays. Boon et al. [3] explore Free, Bodily and Dispersed play design strategies by observing how kids play with two different natures prototypes, plastic branches and a remote-controlled ball. Their research showed that technology and nature, creativity and embodiment can be found when kids interact with two very different objects. The creations of play rules are not limited by the physical and technological characteristics of artefacts.

The observations and findings on playstyles are valuable in creating engaging artefacts, understanding interactions and observing playing patterns in an outdoor setting. Seitingner [26] took an ecological approach in designing props for children to play in the outdoor environment. Her research developed an outdoor playing prop with a wheel-like explorer prototype. That "Space explorer" prototype built with personality characteristics. Interactions changes when children play with the prototype. The movement and behaviour of the computational props create and alter the relationship when children lead the play.

2.3 Attention

Cognitive science has been used in HCI to provide a supporting a conceptual ground to cognitive research when evaluating system and cognitive behaviours. Studying attention, perception and information processes is common in interface and interaction design. Many researchers use sensors to measure attention level to predict and lead the user's attention in digital interfaces. However, research in physical interfaces do not have enough attention in this field. According to Sohlberg and Mateer [28], a person's attention can be divided into focused, sustained, selective, alternating and divided attention. To shift people's attention, we can create an environment that stimulate selective attention to distract them from the current task. Visual, verbal, sound and tangible cues are possible distractions in the environment.

An attentive interface can be physically or digitally embedded in our daily lives. These interfaces take advantage of our attention system with sensational based interaction to attract our eyes and trigger our attention system to react [21]. Attention interfaces can be implicit or explicit according to their purpose. The most common attention interface is the traffic control system. The blinking and the colour keep us alert when we cross the street or are driving. Traffic light continuously interrupt our attention system to alert us of possible dangers on the road. Colour, sound and animation are useful in simulating and relaxing attention [27]. If we can stimulate in the right moment, we can give out positive signals to help people focus or draw their attention from occupied activities. Objects, structures and signs designed with saturated and salient warm colours are relatively effective in attracting our visual attention [29]. These design tactics can draw people's short-term attention to change their selection and priority of tasks [8].

3 METHODOLOGY

Research through design (RtD) [25] is used in this study. This paper will not try to generalise finding into theories; instead, this approach gives us the capacity to analyse and study children's and their parents' behaviour and the design; instead of creating a perfect solution to solve the research question. Wood et al. [23] used workshops and different playing themes to explore play activities with materials and bits. The observation tests and evaluates the design artefacts and environment while workshops explore the design inspirations and interaction surrounding the selected themes with the participants. The role of an artefact in RtD is used for data collection and analysis, and not object to create a final product that optimises the user experience [15].

Observations and research design are tools for this study to understand children behaviours and activities in the playground. This research takes a more explorative approach and use design iteration to explore this topic. This study focuses on children's and their parents' actions, activities, and interactions with the artefact and playground. Having initial research about the park landscape helps this research investigate how children navigate the park and select the playground equipment during activities. The park's basic specification like the landscape of the park, including the installation and space, are target information collected as assisting information in the observation, analysis, and design process.

The research is conducted under the COVID-19 pandemic and outdoor group activities are not recommended. Multiple safety measures are considered to protect the researchers and the participants. Therefore, this research uses previously collected data from the PlayIT project. After the design is implemented, co-located on-field observations are conducted. The reason of this decision is to minimise co-location with the participants and decrease the risk of spreading the virus.

To understand how children are motivated by the design in the playground, it is necessary to observe children's activities in the playground. The participants are informed prior to the observations. Observers used their mobile device to take notes and to record activities when children and their parents are playing in the playground. The reason for choosing mobile devices over professional recording tools is that mobile phones are less obstructing to the activities in the playground. If we had a setup of cameras and tripods in the playground, it could distract or disturbed their actions or make them feel insecure in the playground.

During the implementation stage of the design, some of the public observations are performed in the park. The difference between an ordinary observation and a public observation is that the public observation did not involve any photo documentation and video recording. All the public observation are written materials. The reason for doing public observation is that some of the observation duration was too short. When I performed public observations, none of the personal information, video and audio is recorded. Only written notes is used to record the observation. Observations with permission were done when the participants are staying and playing for more than ten minutes. In public observations, many participants pass by and only play for a few minutes before they move on to their destinations [2]. Asking consent from pass by participants, in this case, is not feasible when they do not have enough time to look through the detail in the consent form [18].

3.1 Ethics

In the data collection stages, previous observation resources include written reports, videos, and pictures from the PlayIT project used in the data analysing process. Since those materials involves children in the observation and design stages, there are multiple ethical considerations taken to minimise the impact on children as participants. Protecting children's and other participants' identities is an essential criteria in the study. Therefore, consent is essential when it is necessary to take photo and record video. The material used in the published paper will be anonymous and should not leave any traces that could lead back to the participants. Consent is necessary to be acquired from accompanied parents or adults if the children are not alone. Project details and observation are kept secret and should not be shown to any people without the right to access and who is not a project member.

3.2 Observation

This research used recordings and written observation data by the PlayIT project members during the installation between 2019 and 2021. Two written observation reports and five videos are used in the analysis. Most of the participants in the observation involved children from 1-6 years old. The participants went to the park with their parents and friends. The observers took field notes about the activities and sometimes communicated with the participants as well as their parents. All the observation took place in the winter. Therefore, most of them were

taken while the playground was covered in snow. However, the snow in the playground and the thick clothing did not affect the participants' playfulness. The primary aim of gathering videos and other materials is to explore the activities and interactions when the children engage in play. In the initial qualitative analysing process, thematic analysis is used to observe meaningful notions, themes and patterns from both videos and written materials [4].

4 THEMATIC ANALYSIS

This study looked for how and what drew the children's attention and how they interacted with the artefacts. It is also essential to study what type of feedback can help players engage in games in the playground. An online tool, Padlet, builds an affinity diagram for the thematic analysis during the analysis process. The affinity diagram and thematic analysis are used to categorise the theme of the dataset, but it also helps create a brainstorming platform for the innovative designing process. During the coding process, I tried to code all interesting finding from the written script and videos. After a few coding cycles, the coding process is complete when there are no more new codes from the materials. After the codes are extracted from the data, they are divided into five themes (Social Interaction, Confusion and Play Activity, Attraction and Interest). Social interaction include all interesting social interaction. They may include conversation and play activities that involved social interaction. Play activity contains the interaction between children, parents and the artefacts. Those play activities showed how players played and reacted with the artefact. The attraction category provides the idea of how participants were attracted or distracted by the environment. In the final category, children in some observations express their feeling and interest about the interaction with those artefacts and the things they like about the playground.

4.1 Social Interaction

Children had built a strong relationship with this playground. Children and their parents reveal in the conversations that they keep coming back and play in this playground and on the same artefacts. Since the children playing in this playground are too young to come and play alone, most of the participants come and play with their friends and parents. Their parents would demonstrate or help them understand how to play games with the artefacts when they did not understand the rules. However, parents usually would not leave their children to play alone. They will also play along with their children if there are no other children involved in the play. Cooperative and competitive play can be seen in the playground. Children helped others to complete in games such as changing the whole egg to an exact colour by smashing lights on the egg. Aside from cooperative and competitive play, the observation showed that children could play together without a common goal or objective to finish the games. A girl and a boy play together on the same egg by hitting the egg and making sound patterns. The boy yelled and laughed while the girl was also trying to hit the sensor and complete the game.

4.2 Confusion



Figure 2: interact with artefact with knees

Most of the children figure out how to play with the eggs, and the hut but not all of them knew how to play or activate the eggs and the hut in the playground. In the video recordings, a girl first peeked into the birdhouse through the window. She spotted the light and listened to the story recording inside the birdhouse. She ran around the shed quickly but stopped in front of the hut to watch the light inside. She paid attention to the light and the sound recording and talked back to the recording. However, she did not know how to start the scenario in the hut and shouted "What" in Swedish. After a few seconds, when the recording began to play, she noticed that she could press the sensor on the wooden chair to activate the hut's music. The light on the wooden chair started to blink, and she learned that she could press the sensor on the chairs to make different to the sound effects and music. She did not try to sit on the wooden chair with a sensor until the lady walked into the hut to dance and show her how the wooden chair worked.

On the other hand, children did not face many problems when they began to play with the eggs. When the children could not figure out how the eggs worked or how to complete the game, they would play with the physical characteristics of the structure, such as using the egg's shape as a slide and kick the sensors with their knees (see Figure 2). Children who played with the artefacts often feel confused with the game rules, and the accompanied adults or other children will help and work together to complete the game. In one of the written observations, a father and his child were confused by the game rules, so they asked the observer about the details of the game. The parents tried to press the sensors and play combinations of keys to draw their children's attention with the piano sound effect. Nonetheless, the children was not following the pattern but played with his own rhythms and songs.

4.3 Play Activity



Figure 3: chasing light around the egg

The observation also showed that a girl slowly understood the game rules by touching the sensors. She observed the changes in the coloured light of the egg and chasing around it (see Figure 3). Children react different from their parents when they encounter activities and interactions. When they listened to the stories, they were dancing and playing along with the music, but some of them listened patiently on the chair. However, the kids could not focus on the same attraction for more than a few minutes. They will move on to another game and artefacts to begin another activity. The longer the kids stay on the same interaction and artefact, the easier they lose attention to the activities or interactions.

The embodiment was among the physical activities and interactions within the playground. Adults mainly used their hands to activate and interact with the egg, while children use the whole body to play. Kicking, jumping and hitting the eggs are common actions when kids interact with them. Since the egg is taller than some of the younger children, sometimes they had to jump or get help from their parent to hit the top section of the sensors.

4.4 Attraction

During the observations, the children only focus on one activity until they are distracted by something else or move on to another interaction. Sound effects from the eggs can attract surrounding attention. Music and sound are stronger than the light effects on attracting people. The children's attention will also move according to other players near them. For example, a girl played with the egg next to her until a lady activated the other egg. The girl's attention quickly moves to the lady's interaction with the other egg. She then ran toward the other egg and played with the lady on the same artefact.

The observation shows that the sounds and the lights are the strengths of the artefacts. Both light and sound are visible and attractive in the playground. Children who are playing with the slide and web can notice the technology-enhanced artefacts next to the traditional playground. However, if the artefacts are not activated by anyone, they will not give any signal to the children in the playground. The egg only became noticeable if someone activated it. The game instantly turns into cooperative or social play when players from other artefacts join the one who activated it. Nevertheless, the data in videos and notes didn't show how participants are attracted when the play activities start.

4.5 Interest

Theme design in a playground is very important to help children build up loyalty and relation. The animal theme is embedded in the structure design and animal statues in the Magistratshagen playground, such as the bee slide and the spider climbing web. Children who played in the playground loved the animal theme, and they could not stop talking about it. Stories in the hut bring up the animal topics and encourage them to look for animal statues around the playground. In the interviews, children replied that the stories and the music were the most fun part of interacting with the artefacts.

5 DESIGN PROCESS

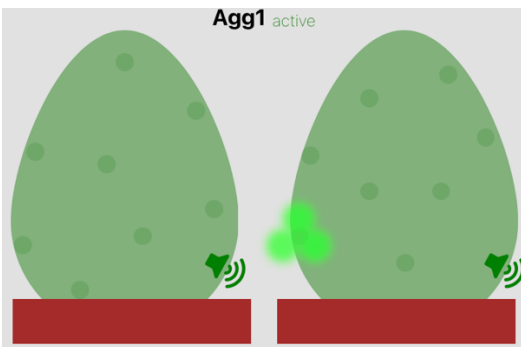


Figure 4: Light start to glow one-by-one around the egg

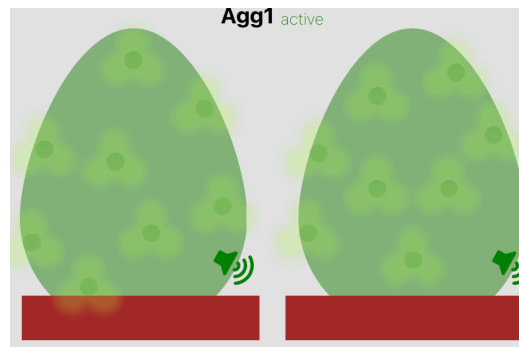


Figure 5: All light glow with heartbeat sound effect

After analysing the previous observation data, initial design work was done using block-based programming editor, Google Blockly. After the initial programming design was done, PlayIT project members reviewed the coding design to ensure that the design did not affect other normal playground activities and original scenarios. Then it is implemented into the artefact temporally only for the follow-up observation and data collection. The implementation process will change the configuration and implement the scenarios into the working artefacts with the help of the PlayIT project members. In this design stage, only one scenario for the egg is created due to time constraint. Field observations were held to acquire the data about how the new scenario design attract attention and interrupt activities. The second objective of the design is to investigate on how to make artefact design more attractive and engaging by stimulating attention with perceptual signals.

Breathing Egg is a new scenario design that trigger when the egg is in idle mode. When no one is playing the egg for a short time, the eggs will turn into idle mode and wait for the next player to activate it. This scenario is a design idea that uses the animal theme, light and sound to create attention allocation and attract children's

attention to the idled egg artefacts. This idea uses light and sound to create an interface metaphor of an animal egg with a heartbeat sound and an animal voice to match the egg's theme. Breathing Egg consist of two main component that target different type of attention. The bird sound effect is the invitation that initiate activity. It can draw children's attention or distract them when they are playing in the playground. The other component is the light show and breathing sound. After the bird sound drew attention, a light show go on to keep their attention on the egg.

At the beginning of the scenario, an animal sound comes out from the egg speaker and follows with glowing lights from various spots around the egg (see Figure 4). The scenario will finally end with a heartbeat sound (see Figure 5). Children are supposed to approach the egg and touch the sensors to start the game. The games are originally programmed to play when they triggered the sensors in the egg. However, these games are not part of the design in this research. This scenario offers an attractive light show with shifting colours in event rotation. The design can capture children's perception and curiosity to explore the artefact. Since the egg can be spotted from almost anywhere in the playground, the light and animals sound effect can draw children's attention from the slide, the hut, the swing and the climbing web. Therefore the children can notice the change of the artefacts and know that the eggs are working, waiting to be activated.

During the analysis of the previous observations, children are keen on running around the egg and chasing the glowing lights. Therefore, during the design process, we want to see if this activity with embodiment can sustain their attention throughout the scenario. The growing light around the egg (see Figure 4) will encourages them to explore the egg by chasing the light and keeping them attracted before starting a new scenario by touching the sensors. In this scenario, the routine will take a break every minute. The idea of adding a time gaps is that the design would not become annoying that continuously interrupts other interactions in the playground.

6 FINDING

In the design implementation, two consented observation and public observations are conducted physically in the Magistratshagen. The public observations were done when participants were passing by and playing. Therefore, only written reports were completed during the observations. When the families stayed in the playground a bit longer, we could observe a more immersive activities and interactions. During the observation days, the weather was cloudy, rainy and even snowy. The weather had a significant impact on the activities in the playground and the participants' playing habits. The eggs could be easily and accidentally activate by the rain and snow. The water puddle surrounding the eggs stop children from touching them and interact with them closely. Rainy and snowy weather also fragmentise the play activities into concise interactions. They made the technological artefacts hard to spot and reach for the children playing in the traditional playground. The light and sound from the artefacts were highly disturbed by the noise from rain and snowflakes. Therefore, there were more passing by play with the traditional playground structure than usual social and play activities during the observation. Traditional playground structure lying next to the main road had a significant geographical advantage when a passing by player had little time to choose what they wanted to play. The design concept of the Breathing Eggs did not perform well under lousy weather, but it still reveals the strength of light and sound when it comes to attracting attention. The sound was the most effective way to draw children's attention. During the observation, children who were and were not playing in the playground were attracted by the bird sounds. They looked into the woods to find the source of the sound.

In the first observation, three kids with two parents appear in the playground on a rainy afternoon. Two kids and their mother ran to play with the swing while the last kid played with the slide. The sound drew attention from the kid who was on the slide for a few seconds. He investigated the egg while the light was blinking and said "ägg!". However, his attention did stay on the egg for longer or approach the egg. Instead, his father approached the egg and started to hit the sensor on the egg. The kid stood and saw his father interacting with the egg, but he did not play with his father. The other two kids kept following their mother around the swing, and the father and kid who were playing with the egg reunion and pass on to other playground structure.

The second observation had similar activities as the first one. The girl kept playing around the playground repetitively from the slide next to the playground to the zip-line structure about fifty meters away from the slide and the eggs. The girl stood and observed from the distance. Her father approached the egg and pressed on the sensors but she did not respond to the light and sound from the egg. Then they went into the hut and listened to the stories while sitting on the wooden chair patiently. Although the light and sound could attract children from the

playground, their attention did not stay on the egg. Their parents always tried to start the interaction by touching and activated the egg.

7 DISCUSSION

The objective of this study was to investigate the attraction and engagement of the IoT playground artefacts. During the analysis of the previous observation data, we found an opportunity to capitalise on animal sounds and spinning light effects to attract children's attention. The finding of this paper highlights the effectiveness of visual and audio when it comes to the outdoor playground environment. The observation in the design stage pointed out that the scenario only attracts the children's short-term engagement. We saw that most of the participants were attracted by the bird sound effects from the speakers while playing with other playground structures, but they did not approach or engage further in any interaction with them. The engagement created by the design is weak, while sound is effective in drawing participant's attention.

The sound effect is the most effective invitation to draw children's attention in the playground. It successfully attracts the gaze of children and their parents. The bird sound from the egg attracted children who walked past the playgrounds; it also distracted children playing with the traditional structures. Sound has an advantage in drawing short-term attention because it can distract children even when engaged in an activity. Their curiosity will lead them from their play to explore the origin of the sound. The light effect around the egg was supposed to attract the children to run around the egg. However, during the observation, children who played and passed turn out to be uninterested in chasing the light, instead, they stand and listen to the bird sound effects. After the kids were attracted, they didn't engage in play activities or interactions. Sound can be heard around the playground but when the children focusing on their play activities, sometimes it took a few trials to attract children's gaze.

Another significant result from the design observation is that social interaction is crucial to sustain their attention on the artefact. Children's attention seldom stays on a play activity or interaction alone. They always follow their parents. Whenever they found themselves playing alone, they will leave the activities and look for company to start a new play activity. It shows that social interaction is a critical element in young children's notion of play, which matches most of the physical play concept in literature. The "honeypot effect" [1] also found on the eggs artefacts. When the parents were attracted by the egg and interact with it, the interaction become a attractor to help children engage. Social dynamics and the role of parents in outdoor plays should be concerned in designing attractive interaction between parents, children and artefacts [3]. Therefore, the lack of social interaction in the design results in weak engagement between parents, play partners, and children.

7.1 Limitation

Limited data and participants during the pandemic are limitations of this study. The data collecting process is the most affected stage since the initial observation was originally planned to be held physically at the Magistratshagen playground. Outdoor group activities and co-located observation with our participant could risk the participant's and researcher's health.

Therefore, not much participant had played in the playground in the observation. Under the situation, participants come in groups are difficult to see during observation session. Comparing to the observation done by PlayIT project members, activities in the design observation were more fragmentise and short play activities. The observation is also affected by the bad weather. The rain made all playground equipment wet and created a small pond that made some of the artefact difficult to reach by young children. As a result, most of the play activities during that day didn't last for more than 5 mins.

7.2 Recommendation of future work

The design in this research exposes opportunities to expand the study about engaging interaction between artefacts and the player. Future studies are recommended to continue on the same topic of this research. When social and playground activities are less affected by the current pandemic, more data can be collected from the participant in the playground. Repeating the research process and conduct more data and observation could revise the result and find here. Further testing and deeper analysis on the same topic with more data in the research can bring more

understanding of attracting attention in the playground. To expand on the topic of attention in physical playground, the following idea could be tested in the future study.

A new research direction could apply social interaction to the attraction scenario. As we talked about the finding from the design, the observation in this research suggested that children can easily be distracted by other activities happening around them. Joint attention could be helpful when their parents or their friends tried to share the experience and interaction with the children.

The second idea is expanding the design to all artefacts in the Magistratshagen playground. Due to some major delay by the pandemic situation, only one scenario design is done in this research. Moreover, there were accidents with the other egg artefact so that only one egg and one scenario worked during the observation. Future work could expand the current design to create multiple scenarios for the hut and the two eggs or even add more sensors and feedback components to extend the reachability of the technology-enhanced artefacts. Applying one attractive scenario involving all artefacts can create interactions between the artefact and the participants and between the artefacts themselves.

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Research Observation Consent Form

Hej,

I'm a master student from Uppsala University, and I'm working on my master thesis about the IoT artefacts in this playground (Magistratshagen). You are invited to participate in this research study about the user experience of playground artefacts implemented by the PlayIT project. We hope to use the observation data to analyse and study children's behaviours in this playground. Since this observation is voluntary, we will need your consent and authorisation to use the materials in this observation and study. The collection and processing of data require your authorisation. If you agree to sign this consent form, it will approve using those materials within the research. Please read the detail carefully before signing this consent form:

1. **Observation:** The observer will observe around the playground. The observer will approach when there are questions about activities. The observer will take notes and record videos for research purposes.
2. **Involvement:** You and your children are participants in this observation. The observation takes place in this playground. In this observation, the observer will not give instruction or interrupt the activities, so you and your children can just play as usual.
3. **Privacy:** Written material, videos and photos will be taken during the observation. Those materials might be used and mentioned in the research anonymously. You and your children's identities will be encoded and shown anonymously in the data. All the materials are all for research purposes and will only be disclosed to project member and others who have right to access.
4. **Participant Right:** According to the EU's General Data Protection Regulation, you have the right to access the collected data related to you and your children. The data and video will be kept for as long as needed in the research or at least ten years. If you want to take part in the information or interest in the research result, you can contact Jon Back (see contact information below).

Jon Back, Research Leader, Uppsala universitet, Institutionen för informatik och media

Telefon: 018 – 471 1525

e-post: jon.back@im.uu.se

To Kei Fung, Master student, Uppsala University

e-post: keifung.to.0237@student.uu.se

I agree that my children _____ (children name(s)) take part in the study and observation.

I agree and understand that the observation data will be treated as described above.

I agree that written, photo and video observation data are used for publication anonymously.

Date

Name of guardian

Signature of guardian

Appendix 2 – Observation Coding

<p>Observationer Magistratshagen 2020-12-17</p> <p>Datum: 2020-12-17 Tid: 13:00 Väder: 6 C. Vinstilla. Lerigt. Uppehåll men regnat mycket under dagen. Observerat av Jon Back, Karin Johansson Fältanteckningar: Karin Johansson Finns också Foton + Film Letter of consent påskrivet, genomgången och överlämnat.</p> <p>K = Karin J = Jon</p> <p>Observation 1 (Pojke med familj) Tid: 13:00-13:50</p> <p>Participant: B = the child. Children, boy, 5 years. Been to the playground 2 times (once the day before and so this day). German and lived in Germany but Swedish mother and spoke both German and Swedish.</p> <p>P = dad. Adult, man. The father of the boy. German. knew a little Swedish, otherwise German and English.</p> <p>M = grandma. Adult, woman. Elderly woman, grandmother of the boy. Spoke Swedish and lived in Sweden.</p> <p>How the observation was carried out: Studied at a distance. Asked questions to the child and the adults. Asked the boy to show and tell. Alternated questions with observations.</p> <p>Field notes: Page by page as they were noted (with some clarifications) B - (answers the question what is best at the playground). Listening to fairy tales is best. Eggs, it's best to play music. Best with the fairy tales that they are exciting. We have played hare and fox (pointing to dad). The best place in the hut is here (he points to the place at the far right of the hut).</p> <p>(the observer sits with the boy in the hut and listens). the boy sits very still and sometimes comments on the tale "Kana!" exclaims the boy (delighted / recognizing) when the hare in the fairy tale rides a canoe on the ice. The boy is sitting and listening. After a few minutes he stands up and stands up and listens. Still standing still and looking attentive.</p> <p>B – Looking for animals. P - looked for jays (on the phone). Did not know what they looked like B - yes the one who took the squirrel's lunch bag. B - where is the hare in the park? (not found it, the boy is referring to the animal sculptures) B - is it from Sagan? (the boy points to the big bumblebee in the play structure)</p> <p>Dad difficult to answer questions due to language.</p> <p>K - what's most fun about eggs? B - Play music</p> <p>The boy spends a lot of time jumping on the egg. It's possible with dad's help.</p> <p>M - says that grandfather is in the hospital and that they are waiting in the park B - "They should remove a lump"</p> <p>B says that they played fox and hare after they had been in the park the day before. The child tells that he was the hare and that the father was allowed to be the fox.</p> <p>When we just got to the park, Grandma came out when she heard that we (J + K) had started the eggs (perceived that it belonged to the hut and maybe disturbed a little).</p> <p>When the boy listens to the fairy tale: in the fairy tale: "The hare eats bark!" The boy - bläää!</p>	<p>The boy come to the playground with his parents</p> <p>Listening to tales and music from the egg is the best</p> <p>Attracted by tales Keep listening</p> <p>Interested in animals and animals theme play structure and sculptures</p> <p>Music most fun</p> <p>The boy return to play after a day</p>
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<p>13:00. We came. The playground looked empty when we arrived. 2 adults with dog walked by.</p> <p>As we got closer we saw a family sitting in the hut listening to a fairy tale. They sat still on each stump in the hut. They had set the table on the beam by the round window in the hut. They had an orange thermos and soft buns.</p> <p>We waited outside, they listened for about 10 minutes. Then they started picking together. At one point, Grandma looked out and saw us (this after we started sounding the eggs). We introduced ourselves. Told about the research. They told me that they had listened to the fairy tales in the hut and been here twice. That they liked the play environment.</p> <p>The boy said they had played fox and hare. The father was a fox (the boy points). The child looks happy when he tells this.</p> <p>K asked them to show what they played on the eggs. The baby plays with the eggs for about 15 minutes. A short break to go rollerblading (in the large play area) once. Then back to the eggs. Grandma deviates, says she will pick up grandpa at the hospital. Boy and dad stay. The boy jumps a lot towards the egg and tries to get on the egg.</p> <p>The boy runs around the egg to play music. The boy says that the egg can play music. He tries several times but does not succeed (Note: he tried to get it to play jingle bells, I perceived it as)</p> <p>Dad wonders how to choose play (on the eggs). The child tries to choose the music game but starts a different scenario. The boy plays with it a bit, he does not seem to see the other egg change. The boy says that he only played with one egg (the one closest to the playground).</p> <p>Then I (Karin) ask the boy how he did in the hut. Goes there he follows. He points out the best place (in the hut). I ask how to start. He sits down and starts listening intently. He comments on "kana!" and "bleed, eat bark". He sits very still for about 5 minutes. I sit next to him and take notes. He's not looking at me. After a while he stands up and listens. He stands still for a while (about 3 min). Then he goes out and back to the eggs, after about 10 minutes inside the hut. They play a little more with the eggs. The boy then asks the father: Can we go now? We thank each other and they leave. (ca 13:50).</p> <p>Other från observationen: The grandmother once said something along the lines of He (the boy) likes more calm games. He likes to sit and think.</p> <p>We told when we introduced ourselves that we were involved in developing the play environment (this may have affected their response)</p>	<p>Family join play with their kids</p> <p>Sound from the egg draw surrounding attention</p> <p>Try to play with the physical shape of the eggs</p> <p>Explore around the egg to play music</p> <p>Distance of two egg Playground as center</p>
<p>Måndag 4:e Januari 2021 kl 09:30-12:15. Ljust ute, mestadels uppehåll med stunder av lätt snöfall. Lite snö på marken, minus 1 grader.</p> <p>POJKE CA 3-5 ÅR Goes into the hut himself and sits on a stump, has to jump a little to get up, but it goes well. No one else is in the hut with him. The story begins to play and the candles are lit, he looks up at the ceiling, quiet and still. Sits completely still and quiet for about 20 seconds. Suddenly he jumps off the stump and runs out, he screams out in a happy way, and moves towards the eggs. No one else is playing with the eggs right now, they are empty. He throws himself at one of the eggs and strikes with both hands and his chest against the egg. The blue scenario starts. He touches the egg with both hands in circular motions and several candles are lit, he laughs out loud and runs around the egg with one male against him all the time. More candles are lit and he continues to touch the egg now also high and low. He continues for about 10 seconds before he tentatively runs on towards the swings where the rest of the family is.</p> <p>FLICKA CA 3-5 ÅR The father stands with the observer and reads consent and signs, meanwhile she walks towards Kojan herself. "Pappa koja" "Yes go to the hut you" She stands at the opening and looks carefully into the hut. The hut is empty, no one else is there. One hand against the frame, standing there for about 10 seconds. She enters and disappears from view where the observer and the father stand, after about 10 seconds from the time she enters, a fairy tale begins to play, but ends quickly. The papers are ready and the father goes up and looks in through the bird hole. The daughter</p>	<p>Play alone</p> <p>Embodiment</p> <p>Cannot wait to play even play alone</p> <p>Exploring the hut carefully</p>

walks between the stumps and touches the sensors with her hand and holds for 1-2 seconds. She continues about 10 times before she starts shouting the colours as she puts her hand against the stump. "Pink" moves to the next "Purple". She starts running between the stumps now, the game goes faster. Still shouts most colours, but not all, but always pink and purple, so possibly she shouts the colours she can. The story does not seem to affect her at all, she does not stop to listen and makes no comments about the story. Continuing for about a couple of minutes, the father repeats the candles she calls out, then she interrupts and goes to the father at the bird hole. She hangs out a little through the hole and looks down at the eggs. Other children play there. Instead, she goes to the exit of the hut and looks out with only her head, she has her body left in the hut and stays in the door frame. The father comes around, the daughter goes out and holds the father in his pants.

"Shall we go down to the swings?"

"Mmm"

They go down to the analog playground, but the children who played by the egg towards the park have gone to the other egg and the daughter stays by the egg and so does the father.

The daughter puts her hand against the egg and pulls along the egg while she walks around. The red scenario jumps off. A green dot lights up on the other side of her. She continues to walk around the egg with her hand towards, then she comes and sees the green light spot. She touches it, not very fast or stressed, but calmly and gently. It goes out, she removes her hand and stops, looking where the light was previously loose. The new bright spot has been lit close to the first one, she sees it and touches it. It goes out and she already seems to understand what's going on. She walks around the egg and sees the next point of light, touches it and continues about 10 more times, all the time calmly and carefully. There is no verbal communication between her and her father in the meantime, but he is very close to her. Finally she stops, looks at the other children at the other egg playing with the green scenario, they are more fast-paced. She grabs Dad's legs again and they slowly move on towards the swings.

FLICKA 5-7 ÅR POJKE 4-5 ÅR

I do not see how the game is started, but the boy and the girl stand by the egg with mother and friend of mother. The blue scenario is on, they quickly light up most of the bright spots and the children hit the egg hard. The boy makes a lot of sound effects while hitting the egg, the girl starts to imitate him, but is not as outgoing. All four remain in about the same place all the time and turn on the different colours, it continues for about 10 seconds, then the boy backs up a bit, picks up speed and jumps towards the egg, he shouts "Baaaam!" And deliberately falls dramatically to the ground, he lies on the ground and shouts "baam!" Again. The girl looks at the boy and laughs while she continues to hit the egg with her left hand. The boy gets up and returns to knocking on the egg. It is difficult to determine if there is a pattern or goal with the beating from either the children or the adults. There is no specific colour they stay on or any particular bright spot they turn on but it is beaten fresh on the egg. It never looks away from the other egg, but is fully focused on the egg they have in front of them. At the other egg stands a father with a small son and a daughter, the colours of their eggs change all the time considering the activity at the other egg, I can not observe them closely, but the father holds the son who can barely stand himself, the son holds his hands against the egg and the daughter stands together and touches a point of light far down on the egg and causes it to change colour.

Back to the active egg. The girl suddenly says "who can hit the most?" The boy shouts "jaaaaag", everyone starts pounding the egg even more feverishly. The boy makes sporadic exclamations and after less than half a minute they reduce the frequency. The boy ends abruptly and then the girl also ends. The girl seems to say something to the boy that I do not understand and they run on towards the slides. They will not return to the eggs anymore.

PAPPA MED SON (CA 1 ÅR) OCH DOTTER 2-4 ÅR

The father goes with the daughter and son from the eggs up to the hut, there is no one in the hut right now. The father stands with the son in his arms and tinkers with a bag just outside and the daughter says "Come dad, into the hut". Dad answers "who do you think this is about today?" And she answers "Maybe the fox!". Dad is writing on paper so I ask her if she has listened to the fairy tales before, she gets a little shy and stands by her dad but smiles and nods. I ask what she likes most, The rabbit shouts she shouts immediately and gets a little shy right after. Dad gets ready with the paper. She does not enter by herself, but it is only when the father sits on the stump that the daughter jumps up opposite. When she gets in place she says "nothing happens to me" and is silent for a while, then she says "Orange only today!" says the daughter and looks up and is silent for a while then and listens then she says "And the kurran!" Happy and laughing. She sits still and listens, sometimes she says something about the story and the father answers happily. It is a very calm and quiet environment, but both the father and the daughter are very happy, the son just hangs out. In the end, the story is over and it becomes a ping and the next story begins. They sit still even through this. After the ping, the daughter asks to change places so it changes to each other's places. "Haha Dagge !!!" She exclaims, "And purple, my favorite colour." They sit through this saga too, still. After it is over, the father asks if they should change places and then the daughter asks to go rocking instead so they move on.

Follow the rhythm of game

Listen patiently and quietly

Notice there are other children playing in the PG

Interact/touch around the egg. Not on single spot

Colour teach the girl how to play the game.

Father and other kids didn't join the interaction but stand near the girl

Note: Green scenario is faster than red

No common goal to complete the game

Father aid his son to play with his daughter

Competition between kids

<p>Later, the father comes forward and asks how the toys by the eggs work. They have not been since the "new games" came and he wonders how they work and how to choose. "We did not really understand." "I think it's cool with this interactivity in play outside, Edith likes the fairy tales very much in particular" "We have never seen it before".</p> <p>POJKE 6-8 ÅR The family sits and has coffee at a table by the slides, the son runs off to the nearest egg quickly and hits it. The blue scenario starts and he lights most of the bright spots very quickly, then he runs from there again. It all takes no more than 10 seconds. Everything happens in silence and no one else is at any of the eggs.</p> <p>FLICKA 6-8 ÅR, FLICKA 4-6 ÅR I come up to the birdhouse when they are already sitting there, mother, grandmother and grandfather standing outside. The older girl is sitting on one of the outer stumps but with her face against the wall, the other girl is sitting opposite but with her face towards the hut. They sit quietly and listen to the story. The younger sister moves in silence. As she moves to the new stump, she constantly looks up at the ceiling. She sits down and they continue to listen. After about 15 seconds, the little sister gets up again and goes back to the place up towards the park. Suddenly a boy comes and sits on the stick by the bird hole, he sticks his head in the hut, both girls look at him, then he eels in through the hole and yells, after him comes his little sister who flies in after the hole. (Karl and Matilda). After the two new children have flown in, they hit the remaining stumps and shout. First, the younger sister of the children who was first in place gets up and goes out just outside the hut and shortly after, the big sister does the same. The two new children run between the stumps and turn them on, so it becomes a kind of light show. The sisters who went out remain standing and look at the roof for about 10 seconds, before going down to the eggs instead. The two active children remain and continue to run between the stumps. They look up at the ceiling to see when the colours change, but they say nothing to each other. They shout sometimes, but do not laugh. All of a sudden, the girl runs outside the hut and stops a few meters outside. The boy also comes out, then the girl starts running towards one stump and the boy runs after towards another stump, as if they were competing over who can light the candle first, but they have not said anything to each other. They run out again and do the same thing, but there is no ready-made walk or the like but the communication between them is wordless. The boy climbs up on the stump and jumps down, the sister takes after. The father appeals for them to take it easy from time to time, but the game remains unaffected. They run out and compete again, then without warning the sister runs out and shouts "towards the net!". The brother and father follow.</p> <p>When I look down at the eggs, the sisters are playing with the eggs. They have started the blue scenario and many candles are already lit. They touch the candles and the younger sister says "it should be pink", many of the candles are already pink, but grandma happens to change one of the pink candles to another colour "oh sorry" says grandma and looks at grandpa and they laugh. The children are happy and sometimes laugh and say little things to each other. The big sister says that she also thinks the pinks are nice and they print to change everyone to the same colour. They look away from the other egg as well, they say nothing out loud, but both children look away towards the other egg while they change the colours of the egg they have. The mother says that dad is ready with the car now, so they have to interrupt the game, but they do not seem to be sad about it but just walk away from the egg.</p> <p>POJKE 3-5 ÅR the boy looks away towards the other egg where there is a slightly older boy and plays with the other egg, he has the Christmas harp running. After a few seconds of looking, the boy turns his focus to the egg in front of him and touches it. The red scenario starts. A bright spot far up lights up. the boy touches the middle and lower part of the egg, but nothing happens. He looks away at the other boy again and then he touches the middle of the egg again. Dad asks "what happens if you touch the light?". the boy stretches and the light goes out. "It may not work," says the father. the boy touches the middle of the egg again and moves around and then he sees the light down that shines and touches it. It goes out and a candle almost lights up, he touches it too and he laughs, he continues to chase the candle at a steady pace 10-15 more presses before he looks at his father and they move on.</p>	<p>Stories, colour make them happy</p> <p>Confusion about how the eggs work</p> <p>Instantly engage but didn't continue</p> <p>Distracted but return to complete the game</p> <p>Father tried to lead the activity and teach children how to play</p> <p>The change of colour distract children from their conversations</p>
<p>2021-02-13 14.20.10 The girl peek inside the hut from the window. Observe the hut in front of the door. She did not understand the game, rules and listened to what the recording is saying. She is confuse about what to do in the hut until the light on the wooden chair start to blink. Keep asking "Va då?". Activated the story by pressing the sensor on the wood but still. Start dancing along the music until the music stop and she didn't get another round of music after she press again. The kid leave the hut for couple second and return.</p>	
<p>2021-02-13 14.12.48 chasing around the egg looking for light. Touching and kicking the egg with knee and foot</p>	
<p>2020-12-17 13.33.52</p>	

Try to play a sound in different combination with both hands. Play with his own rhythm/not following the game then he started to randomly hit the light with both hands rapidly.

2021-02-13 14.11.42
Leave the egg she is playing and play with the egg activated by other

2021-02-13 14.43.45
The girl keep chasing the adult on which egg the adult is playing with. The girl was attracted and playing on the egg close to her but quickly move her attention to the lady who is running to the other egg.

<p>Date: 11/04/21 Time: 2:00p.m. Weather: Rainy, snowy and windy Format: written notes Observer : To Kei Fung</p> <p>Observation 1 (3 children and 2 parents) Children shouted “ägg”. The boy raise his father attention on the egg when the sound play. Then his father approach and knock on the egg while the boy was standing but didn’t give any further response. The did not play with the egg after the boy ran away from the egg to the swing. The other two children following their mom and play at the sand pit. After a while all 3 children play with reunion and play with the swing together.</p> <p>Observation 2 (1 girl and father) They play everything in the playground. The girl play in the playground one-by-one. They played for more than 30 minutes even under rain and snow. Her father follow her in the back and talk to her continuously. The only structure the girl keep going back to play is the slides. The sound and light is difficult to spot in bad weather. His father was more interested in the technological artefacts. Her father press on the sensor and the girl stand by and watch. Then they ran into the hut together. They sat and listen to the story for 5 min then leave.</p> <p>Public observation Pass-by playing – most of the families just pass by the playground and only play for a few minutes, then they move on to their destinations. Egg sensor is sensitive to the rain and snow. Water paddle make children difficult to approach. More children play with slide but they did not play with the eggs nor the hut. Sound still work better than light effect in attracting children’s attention. Sound can attract their initial attention to the egg. The spinning light effect is effective to keep their eye on the eye when they are attracted by the sound.</p>	
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