Design principles of interactive play systems for children's outdoor play

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Research paper

Design principles of interactive play systems for children's outdoor play: A designers' perspective

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ABSTRACT

In recent years, designers around the world have developed a number of interactive play systems to stimulate children's outdoor play. This paper provides a framework for the design principles used by designers of interactive play systems. In addition, the mechanisms by which these design principles could potentially contribute to stimulating children's outdoor play are discussed based on the COM-B model of behaviour change. The COM-B model is adopted to elaborate the design principles and their mechanisms of action. This model provides a basis for designing healthy behaviour change interventions. It defines behaviour as the result of an interaction between three components that generate behaviour: Capability, Opportunity, and Motivation. The contribution of this paper is to identify the design principles and link them to the underlying factors of children's outdoor play in terms of the components of the COM-B model. Clarifying this link elaborates the mechanisms of action of design principles to stimulate children's outdoor play. An in-depth interview approach is used to explore the designers' perspectives. The findings of this research contribute to the theory of behaviour change and are beneficial for practitioners, and in particular, interactive designers who develop systems that stimulate children's outdoor play.

1. Introduction

In today's digital age, technologies such as mobile apps and gaming are one of the key global factors and trends driving changes in children's outdoor play behaviour. Children increasingly prefer to spend more time indoors behind a screen than engaging in healthy behaviour like actively playing outside. Excessive screen media use and playing digital games have been associated with poor motor, cognitive, and social skills and increased physical inactivity in children (Felix et al., 2020; García-Hermoso, Hormazábal-Aguayo, Fernández-Vergara, Olivares, & Oriol-Granado, 2020; Turkle, 2011). However, in recent years, one idea that has been studied and operationalized to stimulate children's outdoor play involves taking advantage of technology to create technology-enhanced environments. Turning technology from a problem into a solution with "interactive play systems" (also called co-located augmented play spaces) is an example of a technology-enhanced environment that aims to stimulate children's developmentally relevant behaviour, including play behaviour.

These systems combine traditional play activities with gaming experiences by using advanced technologies such as sensors and actuators to engage children in physical, social, and cognitive play activities (Bekker, Sturm, & Eggen, 2010; van Delden, Gerritsen, Heylen, & Reidsma, 2018; Moriya et al., 2022; Tetteroo, Reidsma, van Dijk, & Nijholt, 2014). Several studies also indicate that some interactive play systems even have the potential to stimulate "children's outdoor play" behaviour (Back et al., 2016; Back, Turmo Vidal, Waern, Paget, & Sallnäs Pysander, 2018; Cumbo, Jacobs, Leong, & Kanstrup, 2014; Khalilollahi, Kasraian, Kemperman, & van Wesemael, 2022). A variety of interactive play systems for children's outdoor play have been implemented in the last decade; however, little is known about how designers of implemented interactive play systems (heretofore referred to as

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interactive play systems) intend to stimulate children's outdoor play by these systems. This question can be addressed by understanding *which* "design principles" are used by the designers of the interactive play systems, and *how* these design principles can potentially contribute to stimulating children's outdoor play.

Design principles are heuristic, and value statements indicate the purposes of a good intervention design or its procedural aspects (Hulshof, Pemberton, & Griffiths, 2013). Design principles provide researchers and designers with a guide to effectively design interventions by pointing out the goals and the process of achieving these goals (Arzate Cruz & Igarashi, 2020; Chiasson & Gutwin, 2005; Hulshof et al., 2013). The process of designing interventions to promote healthy behaviour usually begins by considering which underlying factors of the behaviour need to change or be influenced, and which actions need to be taken (Michie, van Stralen, & West, 2011). In this study, intervention actions are articulated as design principles. Thus, the first step to identifying the design principles used to create interactive play systems is to understand the underlying factors that are purposefully targeted in the design of children's outdoor play. The underlying factors of behaviour refer to the individual and environmental factors that influence that behaviour (e.g., independent ability, greenery environment).

It is helpful to use the lens of "behaviour change" theories and models as they provide a framework for understanding the underlying factors of behaviour and the process by which an intervention action influences these underlying factors (Darnton, 2008). The Capability, Opportunity, Motivation, Behaviour (COM-B) model developed by Michie et al. (2011) explains the "components" that generate behaviour. This model theorizes behaviour as the result of an interaction between three main components: "Capability", "Opportunity", and "Motivation". These components can be used to categorize the individual and environmental underlying factors of children's outdoor play behaviours *(e.g., independent ability and walkability of the area)*. In addition, this model provides a basis for understanding how an intervention action can contribute to a healthy behaviour change (Michie et al., 2011). The process through which an intervention action affects behaviour is called "the mechanisms of action". Based on the COM-B model, the mechanisms of action of intervention are explained by understanding which components of the COM-B model are targeted by intervention actions.

The use of the COM-B model enables us to identify: i) which underlying factors of children's outdoor play are addressed by designers, and (ii) which design principles they use to do so. Then, by finding the links between design principles and the COM-B model components, we explain how design principles could potentially stimulate children's outdoor play. Subsequently, this article addresses three research questions: 1) Which underlying factors of children's outdoor play behaviour do the designers of interactive play systems target in their designs? 2) How (by which design principles) do designers of interactive play systems target the underlying factors of children's outdoor play? 3) How can we explain the mechanisms of action of design principles of interactive play systems that are used to stimulate children's outdoor play based on the COM-B model?

These questions are answered by a series of in-depth interviews with designers of interactive play systems for children's outdoor play, along with the development a conceptual framework by mapping the design principles onto the COM-B model. This will contribute to the theoretical underpinning of the design principles of interactive play systems and the mechanisms of action of interactive play systems based on a behaviour change theory. The theoretical underpinning of design principles and their mechanisms of action based on the COM-B model guide designers and researchers in designing effective intervention principles. This framework is helpful as it explains which design principle could potentially be useful in stimulating children's outdoor play and how to begin that process. For instance, a design principle is likely to be effective in stimulating children's outdoor play as it targets children's motivation.

Fig. 1 presents the conceptual framework of this study by explaining the mechanisms of the action of design principles of interactive play systems to stimulate children's outdoor play. This conceptual framework is built upon the COM-B model. Here, the design principles of interactive play systems contribute to stimulating children's outdoor play through addressing the individual and environmental underlying factors of children's outdoor play in terms of capability, opportunity and motivation. These constructs and the links between them are furthermore explained in the findings and discussion sections. The rest of this paper is organized as follows: Section 2 elaborates on the background of the study. Section 3 discusses the methodology. Section 4 presents the results of the analysis of the interviews. Section 5 and 6 provide the discussion and conclusion of the research.

2. Background

2.1. Children's outdoor play

This study focuses on children's outdoor play as having the opportunity for outdoor play is a basic prerequisite, not only for the health and well-being of current generations of children, but also for subsequent generations. Many studies have found a positive relationship between children's outdoor play behaviour and the development of social, psychosocial, physical, and cognitive skills (Ansari, Pettit, & Gershoff, 2015; Hikihara, Watanabe, Kawakatsu, & Ishii, 2018; Hinkley, Brown, Carson, & Teychenne, 2018; Razak et al., 2018). Children's outdoor play includes a wide range of activities, including exploratory, creative, imaginary, problem-solving, and physical/social activities (Clements, 2004; Cooper Marcus & Sarkissian, 1986). A new genre of games named "pervasive games" has emerged that augments traditional, real-world playing activities with digital and virtual gaming (Soute, Markopoulos, & Magielse, 2010). This new type of game can provide children with opportunities to explore, create and be involved in social activities (like engaging with other children or parents) through meaningful interactions with a combination of traditional play activities and digital gaming (Cumbo et al., 2014; Moyse, 2019). They can also be used to assist children in (nonformal) environmental education programs (Crawford, Holder, & O'Connor, 2017). Traditional outdoor play activities and pervasive games greatly benefit the healthy development of children. Therefore, the elements of both types should be combined when designing interventions to support children's outdoor play.

2.2. Interactive play systems

This study focuses on interactive play systems as interventions that have been developed in recent years to stimulate children's outdoor play. To encourage and support children's outdoor play, in recent decades, designers, policymakers, and activists of children's rights have proposed many programs and interventions, such as "Play Streets[1]", "Playbourhood[2]", "Playful City[3]", "Active Living Research[4]" and "Child-Friendly Cities[5]". However,

1 https://londonplaystreets.org.uk/
2 https://playborhood.com/
3 https://www.aplayfulcity.com/
4 https://activelivingresearch.org/
5 https://childfriendlycities.org/

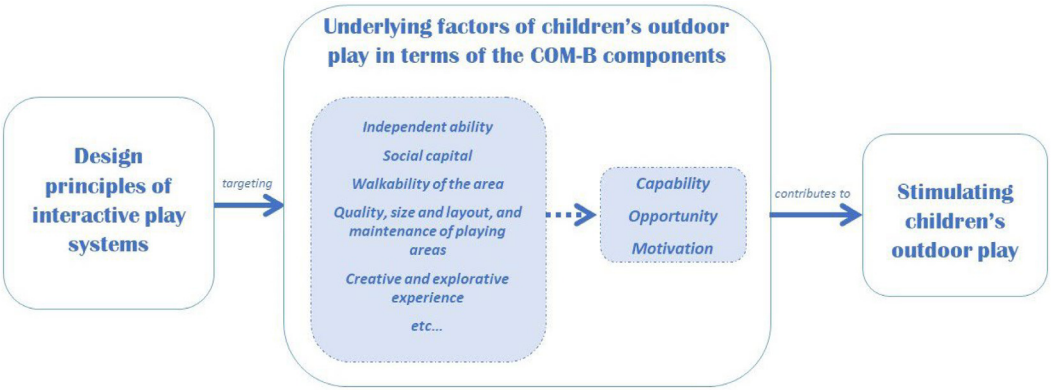

Fig. 1. The conceptual framework of the mechanisms of action of design principles of the interactive play system to stimulate children's outdoor play.

none of these programs support the changing desires of children from exclusive traditional outdoor play activities to the inclusion of technology-advanced gaming. The change in children's play behaviour requires built-environment professionals to explore innovative and creative approaches to developing playable spaces (Anon, 2017). Interactive play systems are initiatives that combine the benefits of traditional playgrounds with advances in technology such as sensors and actuators (Soute et al., 2010; Sturm, Bekker, Groenendaal, Wesselink, & Eggen, 2008). Well-designed interactive play systems could stimulate physically active behaviour, sports skills, and social interactions to improve children's cognitive development and provide them with joyful experiences (van Delden et al., 2018).

There are two main types of interactive play systems: interactive playgrounds, and geo-location-based games. Interactive playgrounds use additional sensors or additional means of providing feedback, while geo-location-based games mostly rely on sensors in the environment. Geo-location-based games use electronic devices (mostly smartphones and tablets) with location-based technologies such as GPS and QR codes. In other words, the screen of a smartphone or tablet becomes a window into the 2D and 3D virtual environment that augments the physical environment (van Delden et al., 2018; Poppe, van Delden, Moreno, & Reidsma, 2014; Tetteroo et al., 2014). Designers of both types of interactive play systems are included in this study to understand how each type can contribute to stimulating children's outdoor play.

2.3. Design principles

This study focuses on exploring the design principles of the interactive play systems to stimulate children's outdoor play. Researchers and designers can use these design principles to develop effective interventions. The purposes and actions used by designers to design a product or system are usually presented as design principles. Some researchers have tried to describe the purposes of a good interactive play system for children's outdoor play. For instance, Sturm et al. (2008) define the key issues for the successful design of interactive playgrounds for children's outdoor play in concepts such as simplicity, social interaction, challenge, goals, and feedback (Sturm et al., 2008). Poppe et al. (2014) describe the general goals of interactive playgrounds in terms of engagement and fun, physical activity, behaviour change, education and learning, and diagnosis (Poppe et al., 2014). These purposes and goals of interactive play systems are too global to be used as design principles. Specific and operative design principles are needed to be operationalized into more detailed requirements to achieve an effective intervention.

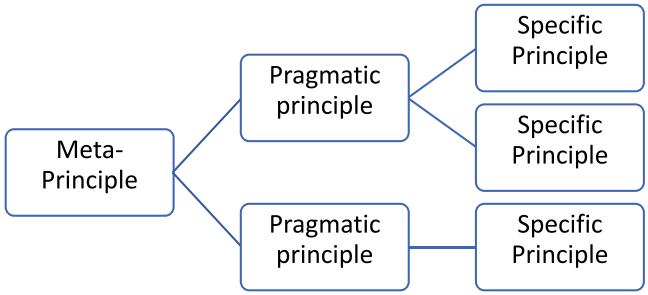

Fig. 2. A schematic representation of the multiple connections of three levels of design principles.

Design principles vary from general rules to specific opportunities. Bell et al. (2004) outline three levels of design principles of technology-enhanced environments in terms of their purposes: Specific Principles, Pragmatic Principles, and Meta-Principles. These three levels are hierarchical: A specific principle describes the rationale behind the design of a single feature; a pragmatic principle connects several specific principles (or several features); and a meta-principle captures abstract ideas represented in a cluster of pragmatic principles (Bell, Hoadley, & Linn, 2004). Fig. 2 schematically illustrates these multiple connections. Within this study, the three levels of design principles of interactive play systems are explored from the viewpoints of designers. This will contribute to obtaining a systematic understanding of general and site-specific design principles.

2.4. The COM-B model of behaviour change

In this study, we use the COM-B model as a framework for understanding the design principles of the interactive play systems and the process by which these design principles can potentially contribute to the stimulation of children's outdoor play. Behaviour change theories and models aim to explain why and how human behaviours change. There are many theories of behaviour change, like the "Fogg Behaviour Model" (Fogg, 2009) and the "Transtheoretical (Stages of Change) Model" (Prochaska & Velicer, 1997). Most behaviour change theories tend to emphasize individual capabilities and motivation, with limited reference to context such as social and environmental factors (Davis, Campbell, Hildon, Hobbs, & Michie, 2015). Moreover, most of these theories do not link behaviour change actions to the underlying factors of behaviour (Prestwich et al., 2014). The COM-B model of behaviour change provides a framework for understanding individual and environmental underlying factors of behaviour, as well as for designing behaviour change interventions. This model

Fig. 3. Interactive playground examples. Top left Yalp Sona,[6] Yalp Memo,[6] the Playnetic KineticWheel;[7] Bottom left: the Playdale i. Play,[8] Biba smart playground;[9] Top right: Kompan smart playground.[10]

was developed with reference to existing theories of behaviour and is applicable to all behaviours (Michie et al., 2011).

The COM-B model conceptualizes the underlying factors of behaviours in relation to three components: Capability, Opportunity, and Motivation. Capability refers to the individual physical and psychological capacity to engage in an activity. Opportunity refers to the factors afforded by the physical and social environment that lie outside the individual and make behaviour possible or prompt it. Motivation is a factor that energizes and directs behaviour. Motivation may be reflective, i.e., inspired by others or events (extrinsic motivation), or it may be automatic, i.e., originating from within the individual (intrinsic motivation). Khalilollahi et al. (2022) adapt the COM-B model to explain the underlying factors of children's outdoor play in neighbourhood and playground areas (e.g., children's independent ability, the walkability of the neighbourhood, etc.) (Khalilollahi et al., 2022).

The underlying factors identified by Khalilollahi et al. (2022) are used to understand which underlying factors of children's outdoor play are targeted by designers of interactive play systems. Moreover, the COM-B model is intended as a starting point to design interventions that are most likely to be effective through different intervention actions. In other words, intervention actions target a particular component of the COM-B model (Capability, Opportunity, Motivation) to bring a healthy behaviour change. In this paper, the intervention actions are articulated as meta, pragmatic, and specific design principles.

3. Methodology

The methodology used in this study involves two steps: conducting a semi-structured interview with designers of interactive play systems, and developing a conceptual framework. Table 1 presents how the research questions of this study are addressed by these steps. These steps are further explained in the 3.2 and 3.3 sub-sections.

3.1. Selection and participation

First, to find interview participants, an internet search for companies that design and develop interactive play systems was conducted. This consisted of performing a search for the following keywords and their variations in Google: children's interactive play, co-located augmented spaces, and intelligent playground. Companies developing these systems are limited and hard to find as this is an emerging field. Subsequently, the snowball method was used to ask the interviewees, i.e., the designers working in these companies, to assist in identifying other potential participants. Eventually, seven companies that are actively working on developing interactive play systems for children's outdoor play were found in five different countries, namely the Netherlands, Denmark, England, Canada, and New Zealand. In each company, a designer was approached and asked to participate in the online interview. Participants were placed on the design team that was involved with the design strategy and creating prototypes and products.

Consistent with (van Delden et al., 2018), two main types of interactive play systems were recognized: i) interactive playgrounds, and (ii) geo-location-based games. Table 2 outlines the interviewed companies and their outdoor play system types. Yalp, Playnetic, Playdale, Biba and Kompan are companies that focus on the interactive playground typology (Fig. 3). Yalp developed four interactive playgrounds for children's outdoor play (Sona, Memo, Sutu, and Toro). Playnetic developed a series of interactive playground equipment, such as KineticWheel, KineticSwing, and GameNetic. Playdale developed one digital interactive play system named i.play (intelligent play). In Biba and Kompan, a playground is equipped with a marker or scanner. The virtual

6 https://www.yalp.com/
7 https://playnetic.nl/
8 https://www.playdale.co.uk/
9 https://www.playbiba.com/
10 https://www.kompan.com/smart-playground

Table 1
The study's research questions, methodology, and aims.

Research questions	Methodology	Aim
1) Which underlying factors of children's outdoor play behaviour do the designers of interactive play systems target in their designs? 2) How do designers of interactive play systems target the underlying factors of children's outdoor play?	In-depth, semi-structured interview	To understand the underlying factors of children's outdoor play and design principles used by designers of interactive play systems
3) How can we explain the mechanisms of action of design principles of interactive play systems to stimulate children's outdoor play based on the COM-B model?	Developing a conceptual framework by mapping the design principles onto the COM-B model	To understand the mechanisms of action of design principles to potentially stimulate children's outdoor play

Table 2
The list of companies included in the research.

Company	Country	Type of interactive play system
Yalp	The Netherlands	Interactive playground (Sona, Memo, Sutu, Toro)
Playnetic	The Netherlands	Interactive playground (KineticWheel, AudioSense, GameNetic, etc.)
Playdale	England	Interactive playground (i.Play)
Biba	Canada	Interactive playground (Smart playground)
Kompan	Denmark	Interactive playground (multi-dimensional playground)
Agents of discovery	Canada	Geo location-based games (mobile game platform)
Geo AR games	New Zealand	Geo-location-based games (outdoor mobile gaming)

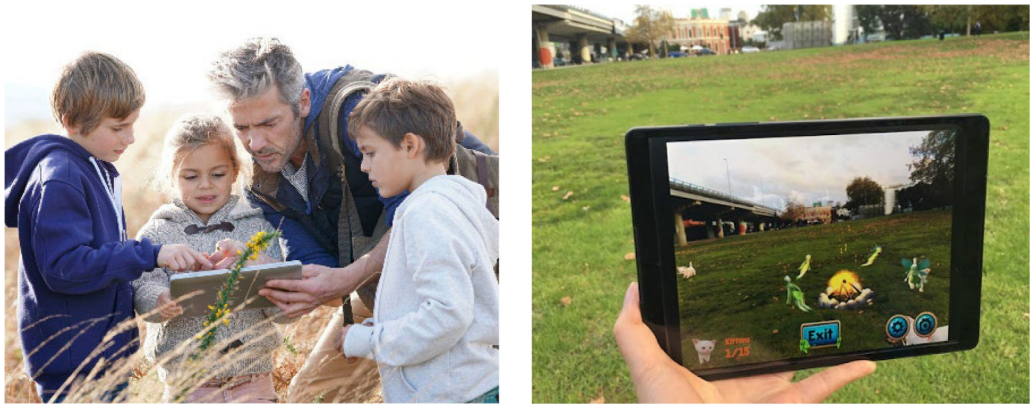

Fig. 4. Geo-location-based games from left to right: Agents of discovery mobile game platform;[11] Bottom right: Geo AR games outdoor mobile gaming.[12]

environment is connected to the playground by scanning this marker.

The products of Agents of Discovery and Geo AR games belong to the second group, i.e., geo-location-based games (Fig. 4). In this type, the virtual environment is connected to the physical environment through geolocation technologies like GPS. Here, the physical environment is a wide, open area like a park. Usually, the games designed for these places are applicable to other open areas if the GPS coordinate system of the app is adjusted to the geographical coordinate of the area. The seven interactive designers of the identified companies were individually interviewed. They were provided with the information and consent form before participating in the interview.

A consent mechanism was used that was cleared by the author's institution's Ethics Committee and included a commitment to adhere to data protection legislation. The consent form included information about the purpose of the study, the rights of the interviewees, and the usage and storage procedure of the data. The interviews took place from February to May 2021 and were conducted online through Microsoft Teams, each lasting approximately 60 min. Some of the interviewees represent companies that have also developed interactive systems for educational purposes and/or teenagers and adults (e.g., Yalp). Therefore, from the beginning of the interview, the interviewees were asked to focus on the systems that have been explicitly developed for children's outdoor play, with an average age of 4–12 years. Permission was obtained beforehand from the interviewees to record the interview.

3.2. Interview protocol

An in-depth interview method was used to collect data. An in-depth interview is a conversation between an interviewer and interviewee to gain insight into certain issues using a semi-structured interview guide (Hennink, Hutter, & Bailey, 2011). The interview guide was organized based on the first and second research questions. The first interview topic originated deductively from the COM-B components (capability, opportunity, and motivation) and included a series of topical probes. Probes are used to remind the interviewer to ask about specific topics to ensure that detailed information on the topic is collected. Here, the probes were based on the underlying factors of children's outdoor play, as identified by Khalilollahi et al. (2022). As soon as the designers determined an underlying factor of children's

11 https://agentsofdiscovery.com/
12 https://www.geoargames.com/

Table 3
Interview questions.

Interview topic	Main interview questions	Probes
Underlying factors of children's outdoor play behaviour	Capability: Have you addressed the individual physical and psychological capacity of children in your project?	- Independent ability – The ability to understand the environment – Social capital and feeling connected to the environment – Socio-cultural norms and values
	Opportunity: Did the project intend to take the social/physical context into account?	- Parents' socioeconomic status – Walkability of the area – The greenery of the area – The presence of other play spaces
	Motivation: Have you considered children's intrinsic and extrinsic motivations for outdoor play?	- Quality, size and layout, and maintenance of play areas – Parental perception and practices of the family – Creative and explorative experience – External encouragement
Design principles	How did you expect your system to help achieve your intentions?	–

outdoor play, they were asked "how" they did so. We aimed to gain an inductive insight into the design principles used by designers without being prompted by any topical probes. Table 3 shows the main interview questions and topical probes. The interview questions were approved by the Ethical Review Board of the Eindhoven University of Technology. Before conducting the interview, pilot testing with some researchers took place to ensure that the questions were easy to understand and their order was logical.

3.3. Data analysis

A qualitative data analysis method was used to gain an evidence-based understanding of the given responses in the interviews. This method includes a circular process of textual data analysis to develop an empirical theory based on qualitative data (Hennink et al., 2011). The process includes three steps: verbatim transcribing, developing codes, and modifying and developing theory. These steps are conducted in a circular manner, which means they are repeated during the data analysis and are also conducted simultaneously at different points in the analysis. Verbatim transcribing of the recorded interviews enables researchers to understand the viewpoints of the interviewees in their own words. Moreover, it helps reach conclusions that are well-rooted in the data. The transcription started as soon as the first interview was completed to identify new issues that may further be explored in subsequent interviews.

Code development involved deductive and inductive strategies. Codes are topics discussed by participants and are identified through reading transcriptions. Deductive codes relate to topics that have been prompted by the interviewer and are derived from the theory in the research literature. These codes were developed based on the interview questions and topical probes and included information on the underlying factors of children's outdoor play behaviour in terms of the COM-B model components. Deductive codes and their definitions were used to understand which underlying factors of children's outdoor play are addressed by the designers.

Inductive codes are topics raised by the interviewees and reflect the issues of importance to the participants. Developing inductive codes involved reading and rereading data to identify explicit and more subtle underlying codes. To identify the inductive codes, the data were scanned to highlight issues indicating a design idea. The interviewees usually mentioned a design idea like "designing a safe playground" when explaining how they address different underlying factors of children's outdoor play behaviour. This step involves identifying words and phrases with similar attributes and grouping them into broad categories indicating inductive codes.

These inductive codes indicate general design ideas (meta-principles). Furthermore, the relevant pragmatic (key phrases describing a practical solution) and specific design principles (examples of how a design solution has been manifested) were searched across different interviews. Fig. 5 shows an example of identifying a meta-principle and subsequently its relevant pragmatic and specific design principles. The code development stopped at the point where no more issues were left unidentified in the data. The meta-principles and their corresponding pragmatic and specific design principles are explained in the findings section.

Eventually, the mechanisms of action of design principles to potentially stimulate children's outdoor play was identified based on the COM-B model. This enabled mapping of the design principles of interactive play systems onto the COM-B model and clarifying the mechanisms of action of interactive play systems to potentially stimulate children's outdoor play behaviour. As Michie et al. (2011) explain, the mechanisms of the action of intervention are elaborated through the links between intervention actions and the components of the COM-B model. Subsequently, the linkage between the identified design principles and the components of the COM-B model is distinguished as follows:

(1) If a design principle addresses the psychological and physical underlying factors, it is linked to the capability component. (2) If a design principle addresses the socio-cultural underlying factors and the opportunities afforded by the physical environment, it is linked to the opportunity component. (3) If a design principle addresses the underlying factors that energize and direct a child's outdoor play behaviour, it is linked to motivation. It should be noted that the term "design principle" here refers to all the corresponding meta/pragmatic/specific principles.

4. Findings

4.1. The underlying factors of children's outdoor play targeted by designers

This section uses the lens of the COM-B model to discuss the underlying factors of children's outdoor play behaviour that designers of interactive play systems target in their designs. Table 4 shows the underlying factors of children's outdoor play based on the deductive codes, examples of interviewees' responses indicating these codes, and the share of interviewers that pointed them out. In terms of capability, "children's independent ability" and their "ability to understand the environment" are the underlying factors addressed by some designers.

In terms of opportunity, "opportunities for social interaction" and "safe outdoor play areas" have been considered by designers. However, the designers did not take into account the children's

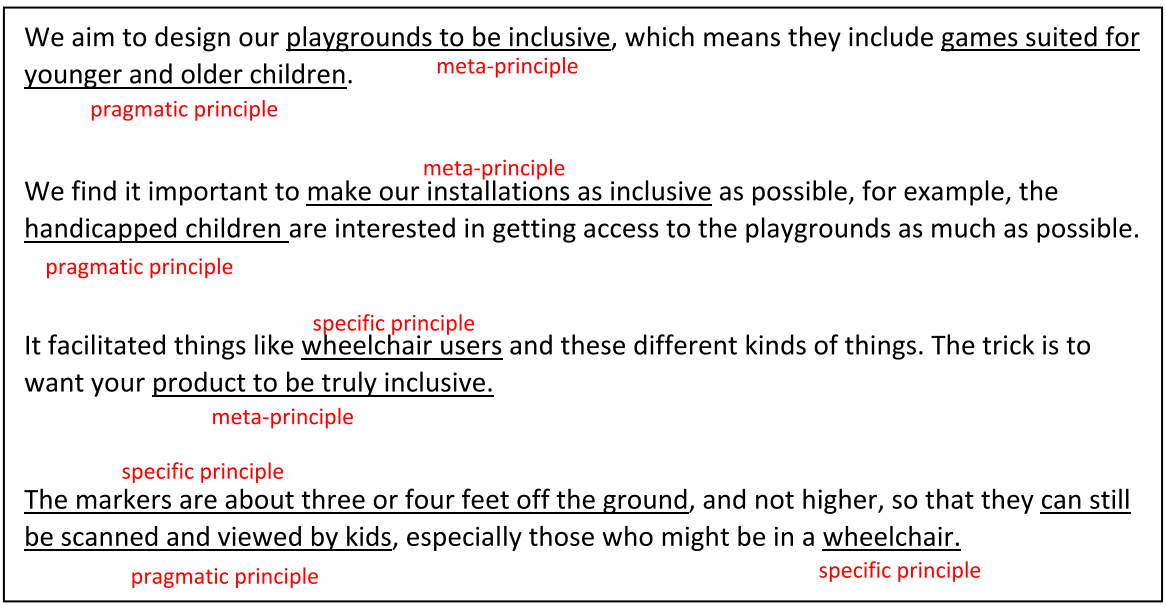

Fig. 5. Example of developing meta, pragmatic, and specific design principles.

Table 4
Underlying factors of children's outdoor play of interactive play systems.

Deductive code		Underlying factors of children's outdoor play		Example from interview data	Share of interviewees that mentioned this code
The COM-B model components	Capability	Physical	Children's independent ability	"We tend to design the playground in a way that is accessible and suitable for all children with different abilities to play on their own. For example, children with a wheelchair can play without any [extra] physical effort."	4/7
		Psychological	Children's understanding of the environment	"Our playground has a simple form that can be perceived easily by children."	5/7
	Opportunity	Social environment	Opportunities for social interaction	"Parents and adults can also join children to engage in games and play activities."	5/7
		Physical environment	Safe outdoor play areas	"We tend to suggest flat sports fields and big open parks for children's play areas so that they can run around free from cars and obstacles."	7/7
	Motivation	Automatic	Creative and explorative experience	"We wanted to create different games to raise children's sense of curiosity and exploration in the playground."	4/7
		Reflective	External encouragement	"While children are playing, the playground generates energy, and the energy is used to produce music and light shows."	7/7

cultural backgrounds. Their rationale was that play is universal, and playing activities should be designed in a way that allows everyone to engage regardless of their cultural background. The economic status of families was also not considered by designers as the usage of these systems, and related applications are mostly free of charge. So, children with potentially different economic statuses can potentially play with them.

Most of the neighbourhood-scale underlying factors, such as the walkability of the neighbourhood, the availability/amount of greenery, and the presence of other play areas, have not been considered by designers. Designers explained that this is due to the fact that the locations of these systems are most often determined by the customers, such as municipal authorities, school boards, and park officials. Therefore, the designers mostly consider the physical characteristics of the systems at the scale of the playground rather than the neighbourhood in their designs. In terms of motivation, children's intrinsic inspiration for engaging in creative and explorative experiences and extrinsic desires for external encouragement have been addressed by the designers.

4.2. The design principles and their mechanisms of action

This section discusses the design principles and their mechanisms of action to potentially stimulate children's outdoor play. Overall, six meta-principles, including their relevant pragmatic and specific design principles, were identified from the transcriptions. Table 5 shows the meta principles derived from the

Table 5
Identified Meta-Principles derived from the inductively coded interviews.

Meta-Principle (inductive code)	Corresponding words and phrases to define inductive codes	Share of interviewers that pointed out this code
Make the systems inclusive for all children	"suitable for everyone"; "includes disabled children"; "includes a variety of activities"	**7/7**
Enable children to understand the systems easily	"understood without explanation"; "without instructions"	**4/7**
Provide opportunities for children to socialize with other children and people	"Includes group activities"; "involves parents and caretakers"	**6/7**
Make the systems safe for children's playing	"without causing risk and danger";	**7/7**
Provide children with opportunities to be involved in challenging activities	"offers competition"; "promotes skills"	**5/7**
Give external encouragement to children	"gives score"; "feedback"; "reward"	**7/7**

inductive codes, their corresponding words and phrases, and the share of interviewers who pointed out the code. "Make the systems inclusive for all children", "make the systems safe for children's playing" and "give external encouragement to children" are design principles that are considered by all designers. "Enable children to understand the systems easily" is less used by designers.

Table 6 presents the identified meta-principles and their corresponding pragmatic and specific design principles. The mechanisms of action of design principles to stimulate children's outdoor play are also clarified in this figure. These mechanisms of action are elaborated in the linkage between the design principles with the COM-B model components through the underlying factors of children's outdoor play. As an example, in terms of capability, two meta-principles have been identified to target children's capability of outdoor play: "Make the systems inclusive for all children" and "Enable children to understand the systems easily". These meta-principles are supported by practical design solutions in terms of a pragmatic-principle, such as "Provide a system where children with different abilities can play with low physical effort" and "Design a system suitable for audibly and visually impaired children".

These pragmatic principles have been manifested through some examples of design ideas in terms of specific principles like: "Make the playing areas accessible and suitable for children with a wheelchair" and "Install the markers on an accessible height for all abled and disabled children, like children in a wheelchair". Other pragmatic principles describing a practical solution to support the above meta-principles are: "Design the playground in a simple form that can be perceived easily by the children" and "Design the games with a level of difficulty that fits all children". "Take into account children with hearing problems by considering the whole audio range", or "Use sounds for the visually impaired children and lights flashing for audibly impaired children" are other specific principles used by designers. These meta-principles and their corresponding pragmatic and specific design principles have been claimed by designers to address children's independent ability and ability to understand the environment and subsequently the capability component of the COM-B model. This process of influencing children's capability with design principles can potentially result in stimulating children's outdoor play. Other meta design principles and their corresponding pragmatic and specific design principles and their links to the underlying factors of children's outdoor play and the components of the COM-B model are elaborated in Table 6.

5. Discussion

This paper investigates the design principles used by designers and the mechanisms of action of these design principles to stimulate children's outdoor play behaviour. These design principles are identified through in-depth interviews with the designers of seven companies that develop interactive playgrounds and geo-location-based games. The design principles were investigated through the lens of the COM-B model of behaviour change. This model posits that, to stimulate children's outdoor play, healthy behaviour change mechanisms of action are required that enhance children's capability and motivation, as well as opportunities provided by their physical and social environments.

The COM-B model was chosen to identify the design principles as this model explains the underlying factors of behaviour and the mechanisms through which an intervention action can support a healthy behaviour change. Thus, investigating the design principles used by designers through the lens of the COM-B model can help clarify which underlying factors of children's outdoor play behaviours are intended to be addressed by the designers of interactive play systems and which mechanisms they intend to trigger. Overall, the interview results indicate that designers of interactive play systems intend to address some underlying factors of children's outdoor play through six meta and their corresponding pragmatic and specific design principles. These design principles are discussed and outlined by the COM-B model categories of capability, opportunity, and motivation.

5.1. Capability

In terms of capability, designers of interactive play systems aim to provide a system where children can play with low physical effort and easily perceive the systems and games. In this regard, the designers consider children with different abilities, including children with movement, visual and hearing problems. For instance, in terms of movement, they make the playing areas accessible and suitable for children in a wheelchair, and in terms of hearing, they consider the whole audio range in their systems. However, few designers develop truly inclusive interactive play systems, yet it is a prerequisite for children with different abilities. Moreover, children's ability to understand the system easily was less mentioned by designers as a design principle. However, it is a necessity for children to play freely and without controlling adults (Moran, Plaut, & Merom, 2017).

5.2. Opportunity

In terms of social opportunity, designers aim to create game and play activities for a group of children and have parents involved in playing activities with their children. For example, the system gives the role of leader in the game to the parents. Designers do not consider the sociocultural differences of children; however, sociocultural norms and family values are important underlying factors of children's outdoor play (Khalilollahi et al., 2022). In terms of physical opportunity, all designers intend to make the systems and surrounding environment safe for children's play. This finding shows that designers are aware of the importance of providing a safe play environment as a prerequisite

Table 6
The mechanisms of action of design principles of interactive play systems to stimulate children's outdoor play.

Design principles		The underlying factors of children's outdoor play in terms of the COM-B model components			Behaviour change
Meta	Make the systems inclusive for all children	Children's independent ability Children's understanding the environment		Capability	Stimulating children's outdoor play
	Enable children to understand the systems easily				
Pragmatic	Provide a system where children with different abilities can play with low physical effort				
	Design a system suitable for audibly and visually impaired children				
	Design the playground in a simple form that can be perceived easily by the children				
Specific	Make the playing areas accessible and suitable for children with wheelchair				
	Install the markers on an accessible height for all abled and disabled children like children in a wheelchair				
	Take into account children with hearing problems by considering the whole audio range				
	Use sounds for the visually impaired children and lights flashing for audibly impaired children				
Meta	Provide opportunities for children to socialize with other children and people	Opportunities for social interaction Safe outdoor play areas		Opportunity	Stimulating children's outdoor play
	Make the systems and surrounding environment safe for children's playing				
Pragmatic	Include game and play activities that can be played by a group of children				
	Involve parents in playing activities alongside children				
	Make both installations and the surrounding environment safe				
Specific	Involve parents by giving the role of leader in game				
	Do not use sharp edges or any dangerous elements which can hurt children				
	Stand standard measures for using electronic equipment to avoid causing any dangerous electronic situations				
	Make playgrounds resistant to water, and other external factors				
	Assign wide lands without natural or artificial obstacles (waterways or roads for example) like national parks and big open parks be used as a field of play				
	Assign restricted and earmarked for children's playing free from dangers and makes it possible for parents' supervision				
Meta	Provide children with opportunities to be involved in challenging activities	Creative/ explorative experience External encouragement		Motivation	Stimulating children's outdoor play
	Give external encouragement to children				
Pragmatic	Involve children in physical and cognitive challenges				
	Engage children in imaginary challenges				
	Provide feedback to children as extrinsic encouragements				
Specific	Apply sports elements to challenge children's gross motor skills				
	Design a game to engage children's memory and movement				
	Encourage children to engage in pretend play and perform an activity according to imaginary characters				
	Apply score systems to assess children's level of activity				
	Feedback children's accomplishment of activity by giving lights and sound				

for children with different abilities (Giraldi et al., 2017). For example, there are no sharp edges or any dangerous elements in the designs that can hurt children. In the design of a geo-location-based game, wide lands with no natural or artificial obstacles such as national parks and big open parks have been assigned to be used as a safe area of play.

5.3. Motivation

In terms of motivation, designers of interactive play systems aim to engage children in physical, cognitive, and imaginary challenges. For example, children are involved in sports and pretend play activities. Designers also provide children with extrinsic encouragement. All designers took into account children's desire for external encouragement. This finding can be explained by the fact that designers are aware of the role of external encouragement as the main driver of reflective or extrinsic motivation for children's playing. For example, children receive external feedback through a system that uses scores, lights, and sounds. Designers should give greater attention to fulfilling children's automatic motivation as children's intrinsic motivation (including their preferences for exploring, creativity, imaginary role-play, learning, problem-solving, rule-based and skill-based team games) is the main driver of children's outdoor play (Cumbo et al., 2014).

6. Conclusion

This study provides a theoretical underpinning for the design principles of interactive play systems. The findings of this research contribute to the theory of behaviour change and are beneficial for practitioners, and in particular, interactive designers who develop systems that promote children's outdoor play. Furthermore, mapping the identified design principles of interactive play systems onto the COM-B model provides designers with a guide to designing effective interactive play systems to stimulate children's outdoor play behaviour. We should note that this study takes a first step toward providing a theoretical underpinning of the design principles and their mechanisms of action based on the COM-B model. Whether following the identified design principles actually lead to behaviour change in practice requires further empirical investigation.

Consequently, there is a need for more evidence-based research to evaluate the effectiveness of interactive play systems in stimulating children's outdoor play. Here, the children's perspectives and behaviours while playing with these systems need to be further investigated. Only then can we conclude whether the designers' purposes have been realized or not. In addition, investigating children's in situ behaviour and attitudes would also help identify more design principles based on children's needs and their outdoor play behaviour. Moreover, assessing the effectiveness of interactive play systems with other non-technical approaches such as environmental education (EE) programs and nonformal environmental education (NFEE) is needed to evaluate the efficiency of these systems compared to other approaches.

Based on our findings, a number of recommendations can be made for designers of interactive play systems to improve their systems to fulfil children's needs for outdoor play. First of all, designers should consider all identified underlying factors of children's outdoor play in their designs. For example, a critical missing underlying factor is parental perception, which is about the attitudes of parents toward interactive outdoor play and their safety concerns. This underlying factor is significantly associated with children's perception of playing outside and the motivation to do so (Khalilollahi et al., 2022) and needs to be considered by designers. Moreover, designers should consider the neighbourhood-scale underlying factors, such as the availability/amount of greenery, and the presence of other play areas while designing and developing interactive play systems as successful play spaces are carefully located, and considering the attributes of their surrounding environment (Giraldi et al., 2017).

In addition, designers could further incorporate upcoming technological developments to create more effective interactive play systems. For example, one interviewee pointed out that they intend to create "open-ended systems". This feature means that there are no fixed or rigorous rules for playing, and children can invent their own games. This design idea is important to motivate children to create and control the environment according to their needs (Dylan et al., 2020). Another interviewee explained that the reason that this design idea is less used by designers is that "open-ended" play systems are usually sophisticated ones. The interviewee elaborated that the existing interactive play systems are the first generation of such systems that apply rather simple techniques and design ideas. As technology advances, there is a need for designers to further explore and use more innovative design solutions to address children's outdoor play through interactive play systems.

Selection and participation

First, to find interview participants, an internet search for companies that design and develop interactive play systems was conducted. This consisted of performing a search for the following keywords and their variations in Google: children's interactive play, co-located augmented spaces, and intelligent playground. Companies developing these systems are limited and hard to find as this is an emerging field. Subsequently, the snowball method was used to ask the interviewees, i.e., the designers working in these companies, to assist in identifying other potential participants. Eventually, seven companies that are actively working on developing interactive play systems for children's outdoor play were found in five different countries, namely the Netherlands, Denmark, England, Canada, and New Zealand. In each company, a designer was approached and asked to participate in the online interview. Participants were placed on the design team that was involved with the design strategy and creating prototypes and products.

Consistent with (van Delden et al., 2018), two main types of interactive play systems were recognized: i) interactive playgrounds, and (ii) geo-location-based games. Table 2 outlines the interviewed companies and their outdoor play system types. Yalp, Playnetic, Playdale, Biba and Kompan are companies that focus on the interactive playground typology (Fig. 3). Yalp developed four interactive playgrounds for children's outdoor play (Sona, Memo, Sutu, and Toro). Playnetic developed a series of interactive playground equipment, such as KineticWheel, KineticSwing, and GameNetic. Playdale developed one digital interactive play system named i.play (intelligent play). In Biba and Kompan, a playground is equipped with a marker or scanner. The virtual environment is connected to the playground by scanning this marker.

The products of Agents of Discovery and Geo AR games belong to the second group, i.e., geo-location-based games (Fig. 4). In this type, the virtual environment is connected to the physical environment through geolocation technologies like GPS. Here, the physical environment is a wide, open area like a park. Usually, the games designed for these places are applicable to other open areas if the GPS coordinate system of the app is adjusted to the geographical coordinate of the area. The seven interactive designers of the identified companies were individually interviewed. They were provided with the information and consent form before participating in the interview.

A consent mechanism was used that was cleared by the author's institution's Ethics Committee and included a commitment to adhere to data protection legislation. The consent form included information about the purpose of the study, the rights of the interviewees, and the usage and storage procedure of the data. The interviews took place from February to May 2021 and were conducted online through Microsoft Teams, each lasting approximately 60 min. Some of the interviewees represent companies that have also developed interactive systems for educational purposes and/or teenagers and adults (e.g., Yalp). Therefore, from the beginning of the interview, the interviewees were asked to focus on the systems that have been explicitly developed for children's outdoor play, with an average age of 4–12 years. Permission was obtained beforehand from the interviewees to record the interview.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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References

Anon (2017). *Cities Alive: Designing for urban childhoods*. London: Arup's Foresight, https://www.arup.com/perspectives/publications/research/section/cities-alive-designing-for-urban-childhoods.

Ansari, A., Pettit, K., & Gershoff, E. (2015). Combating obesity in head start: Outdoor play and change in children's body mass index. *Journal of Developmental & Behavioral Pediatrics*, *36*, 605–612. http://dx.doi.org/10.1097/DBP.0000000000000215.

Arzate Cruz, C., & Igarashi, T. (2020). A survey on interactive reinforcement learning: Design principles and open challenges. In *Proceedings of the 2020 ACM designing interactive systems conference, ACM, Eindhoven Netherlands* (pp. 1195–1209). http://dx.doi.org/10.1145/3357236.3395525.

Back, J., Heeffer, C., Paget, S., Rau, A., Sallnäs Pysander, E.-L., & Waern, A. (2016). Designing children's digital-physical play in natural outdoors settings. In *Proceedings of the 2016 CHI conference extended abstracts on human factors in computing systems, ACM, San Jose California USA* (pp. 1359–1366). http://dx.doi.org/10.1145/2851581.2892416.

Back, J., Turmo Vidal, L., Waern, A., Paget, S., & Sallnäs Pysander, E.-L. (2018). Playing close to home: Interaction and emerging play in outdoor play installations. In *Proceedings of the 2018 CHI conference on human factors in computing systems, ACM, Montreal QC Canada* (pp. 1–11). http://dx.doi.org/10.1145/3173574.3173730.

Bekker, T., Sturm, J., & Eggen, B. (2010). *vol. 14, Designing playful interactions for social interaction and physical play* (pp. 385–396). Pers Ubiquit Comput, http://dx.doi.org/10.1007/s00779-009-0264-1.

Bell, P., Hoadley, C., & Linn, M. (2004). Design-based research as educational inquiry. In *Internet environemnts for science education*. New Jersey: Lawrenee Elbaum Associates, Inc, Publishers.

Chiasson, S., & Gutwin, C. (2005). *Design principles for children's technology* (p. 9).

Clements, R. (2004). An investigation of the status of outdoor play. *vol. 5*, In *Contemporary issues in early childhood* (pp. 68–80). http://dx.doi.org/10.2304/ciec.2004.5.1.10.

Cooper Marcus, C., & Sarkissian, W. (1986). *Housing as if people mattered: Site design guidelines for medium-density family housing*. Berkeley: University of California Press.

Crawford, M. R., Holder, M. D., & O'Connor, B. P. (2017). Using mobile technology to engage children with nature. *Environment and Behavior*, *49*, 959–984. http://dx.doi.org/10.1177/0013916516673870.

Cumbo, B. J., Jacobs, B. C., Leong, T. W., & Kanstrup, A. M. (2014). What motivates children to play outdoors?: potential applications for interactive digital tools. In *Proceedings of the 26th Australian computer-human interaction conference on designing futures: The future of design, ACM, Sydney New South Wales Australia* (pp. 168–171). http://dx.doi.org/10.1145/2686612.2686637.

Darnton, A. (2008). *Reference report: An overview of behaviour change models and their uses* (p. 83).

Davis, R., Campbell, R., Hildon, Z., Hobbs, L., & Michie, S. (2015). Theories of behaviour and behaviour change across the social and behavioural sciences: a scoping review. *Health Psychology Review*, *9*, 323–344. http://dx.doi.org/10.1080/17437199.2014.941722.

van Delden, R., Gerritsen, S., Heylen, D., & Reidsma, D. (2018). Co-located augmented play-spaces: past, present, and perspectives. *Journal of Multimodal User Interfaces*, *12*, 225–255. http://dx.doi.org/10.1007/s12193-018-0269-z.

Dylan, T., Wood, G., Durrant, A. C., Vines, J., Torres, P. E., Ulrich, P. I. N., et al. (2020). *Designing IoT resources to support outdoor play for children*.

Felix, E., Silva, V., Caetano, M., Ribeiro, M. V. V., Fidalgo, T. M., Rosa Neto, F., et al. (2020). Excessive screen media use in preschoolers is associated with poor motor skills. *Cyberpsychology, Behavior, and Social Networking*, *23*, 418–425. http://dx.doi.org/10.1089/cyber.2019.0238.

Fogg, B. (2009). A behavior model for persuasive design. In *Proceedings of the 4th international conference on persuasive technology - Persuasive '09* (p. 1). Claremont: ACM Press, http://dx.doi.org/10.1145/1541948.1541999.

García-Hermoso, A., Hormazábal-Aguayo, I., Fernández-Vergara, O., Olivares, P. R., & Oriol-Granado, X. (2020). Physical activity, screen time and subjective well-being among children. *International Journal of Clinical and Health Psychology*, *20*, 126–134. http://dx.doi.org/10.1016/j.ijchp.2020.03.001.

Giraldi, L., Benelli, E., Vita, R., Patti, I., Filieri, J., & Filippi, F. (2017). Designing for the next generation, children urban design as a strategic method to improve the future in the cities. *The Design Journal*, *20*, S3068–S3078. http://dx.doi.org/10.1080/14606925.2017.1352814.

Hennink, A., Hutter, Monique, & Bailey, Inge (2011). *Qualitative research methods*. London: Sage.

Hikihara, Y., Watanabe, M., Kawakatsu, S., & Ishii, K. (2018). Benefits of organized sports participation and voluntary outdoor play in children and adolescents based on evidence-related health outcomes. *Japanese Journal of Physical Fitness and Sports Medicine*, *67*, 83–98. http://dx.doi.org/10.7600/jspfsm.67.83.

Hinkley, T., Brown, H., Carson, V., & Teychenne, M. (2018). Cross sectional associations of screen time and outdoor play with social skills in preschool children. *PLoS ONE*, *13*, Article e0193700. http://dx.doi.org/10.1371/journal.pone.0193700.

Hulshof, A., Pemberton, L., & Griffiths, R. (2013). Design principles for preschool children's interactive TV. *Universal Access in the Information Society*, *12*, 21–35. http://dx.doi.org/10.1007/s10209-011-0263-7.

Khalilollahi, A., Kasraian, D., Kemperman, A. D. A. M., & van Wesemael, P. (2022). Application of the COM-b model to the correlates of children's outdoor playing and the potential role of digital interventions: a systematic literature review. *Children's Geographies*, 1–17. http://dx.doi.org/10.1080/14733285.2022.2075692.

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, *6*, 42. http://dx.doi.org/10.1186/1748-5908-6-42.

Moran, M. R., Plaut, P., & Merom, D. (2017). Is the grass always greener in suburban neighborhoods? Outdoors play in suburban and inner-city neighborhoods. *IJERPH*, *14*, 759. http://dx.doi.org/10.3390/ijerph14070759.

Moriya, K., Iio, T., Shingai, Y., Morita, T., Kusunoki, F., Inagaki, S., et al. (2022). Playing with invisible animals: An interactive system of floor-projected footprints to encourage children's imagination. *International Journal of Child-Computer Interaction*, *32*, Article 100407. http://dx.doi.org/10.1016/j.ijcci.2021.100407.

Moyse, K. (2019). Children's and parents' views about using mobile phones to support outdoor play. In *Nursing children and young people*. http://dx.doi.org/10.7748/ncyp.2019.e1026.

Poppe, R., van Delden, R., Moreno, A., & Reidsma, D. (2014). Interactive playgrounds for children. In A. Nijholt (Ed.), *Playful user interfaces* (pp. 99–118). Singapore: Springer Singapore, http://dx.doi.org/10.1007/978-981-4560-96-2_5.

Prestwich, A., Sniehotta, F. F., Whittington, C., Dombrowski, S. U., Rogers, L., & Michie, S. (2014). Does theory influence the effectiveness of health behavior interventions? *Meta-Analysis Health Psychology*, *33*, 465–474. http://dx.doi.org/10.1037/a0032853.

Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. *The American Journal of Health Promotion*, *12*, 38–48. http://dx.doi.org/10.4278/0890-1171-12.1.38.

Razak, L. A., Yoong, S. L., Wiggers, J., Morgan, P. J., Jones, J., Finch, M., et al. (2018). Impact of scheduling multiple outdoor free-play periods in childcare on child moderate-to-vigorous physical activity: a cluster randomised trial. *International Journal of Behavioral Nutrition and Physical Activity*, *15*, http://dx.doi.org/10.1186/s12966-018-0665-5.

Soute, I., Markopoulos, P., & Magielse, R. (2010). *vol. 14*, *Head Up Games: combining the best of both worlds by merging traditional and digital play* (pp. 435–444). Pers Ubiquit Comput, http://dx.doi.org/10.1007/s00779-009-0265-0.

Sturm, J., Bekker, T., Groenendaal, B., Wesselink, R., & Eggen, B. (2008). Key issues for the successful design of an intelligent, interactive playground. In *Proceedings of the 7th international conference on interaction design and children - IDC '08* (p. 258). Chicago, Illinois: ACM Press, http://dx.doi.org/10.1145/1463689.1463764.

Tetteroo, D., Reidsma, D., van Dijk, B., & Nijholt, A. (2014). Yellow is mine!: Designing interactive playgrounds based on traditional childrens play. In T. Romão A.D. Cheok (Ed.), *Entertaining the whole world* (pp. 63–84). London: Springer London, http://dx.doi.org/10.1007/978-1-4471-6446-3_5.

Turkle, S. (2011). *Alone together: Why we expect more from technology and less from each other*. New York: Basic Books.