Original article

Nature and digitalization challenging the traditional playground

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ABSTRACT

Playing outdoors in nature with peers has been attributed most importance for children's healthy development but is increasingly marginalized because of the attractiveness of screen-based play. Careful merging of digital technology into outdoor play environments rich on nature elements could potentially help bridge digital play with more traditional play activities outdoors. A systematic comparison was made of outdoor play in more or less green settings, with and without digital installations or traditional play equipment. The separate and combined role of digital artefacts, play equipment and natural elements, were investigated, with particular focus on the effects of merging digital materials into nature. A group of children aged 6–8 were involved in a field study in a three-week period playing in a traditional playground, a forest and in a forest with digitally enhanced play artefacts. Children's play behavior was evaluated using a behavioral tracking method, a questionnaire and a contextual interview with the children, and a physical activity measure, in combination with inventories including maps to document the design, and the ecological and physical status of the settings. The study documents differences in children's play behavior across the three settings. It differs most between the digital forest setting and the forest setting regarding the play categories imaginative play, physical play and rule play and the digital forest setting stands out when it comes to expressive play. It is discussed how particular attributes in the physical environment influence the overall play flow and the interactive effects of natural material and digital material. Ecologically, the forest and the forest with digitally enhanced artefacts were more diverse than the traditional playground, but the natural material present was important for play in all settings.

1. Introduction

Children having access to nature in their everyday surroundings is associated with an overall healthy development (Mygind et al., 2021; Roslund et al., 2020; Söderström et al., 2013), and play with peers outdoors the mode of interaction with nature deemed most important for their overall development (Tremblay et al., 2015; Wells and Lekies, 2006). There are also many competencies attributed to children having contacts with nature (Chawla, 2015) and a fear of children developing what is popularly called "nature deficit disorder" (Louv, 2005). However, in the wake of digitalization, with a lot of comfortable indoor life

and digital gadgets permeating life, children spend less time outdoors (Fyhri et al., 2011). Research also shows that traditional play-equipment triggers children to play and to be physically active (Refshauge et al., 2013). However, one can also recognize that some play features tend to engage children more than others, and both natural elements and digital gadgets, games and social media, are features especially captivating to children (Kahn, 1997b). At the same time, we know that designated play spaces make up popular destinations for families, schools and groups of peers, and continue to be important for children thriving in a community (Wales et al., 2022). This study investigates how digital and physical play equipment used together with loose physical materials shape

children's play in more or less nature rich settings. As interactive features are becoming more common in playgrounds (Torres et al., 2021) it is important to understand what effects they might have on play behavior.

The aim with this study is to do a systematic comparison of how play evolves in different types of outdoor environments, in more or less green play settings, with and without digital installations or traditional play equipment. The separate and combined role of digital artefacts, play equipment and natural elements are at the core of the investigation. The result of merging digital material into a natural environment is the dimension least investigated so far. All settings included in this study were more or less embedded in nature, in line with traditional playgrounds in the Scandinavian countries which tend to integrate, or at least border some green environment. Research so far have focused on traditional playgrounds and green play-settings, with digital features studied separately. The aim of this study is to compare new combinations of attributes from these three different types of settings and investigate how particular features interact and together form children's play behavior.

1.1. The open-ended character of play outdoors

The socio-ecological content of the surroundings has documented effects on how children's play evolves outdoors, influencing how play is initiated, negotiated, sustained and its overall character. In the terminology of ecological psychology, the dynamics of children's play in a playground is the result of the social, physical and organizational assets available in a particular "behavior setting" (Barker, 1968) and its "sub-settings" (Ittelson et al., 1970). This perspective can help to describe how the overall milieu with its available affordances form predictable patterns in children's play. There is a history of research in the field of people and environment studies comparing the overall usefulness of different types of playgrounds (Hayward, 1974; Herrington and Lesmeister, 2006; Woolley and Lowe, 2013) but also more recent studies scrutinizing the very interface and behavior patterns evolving between children and particular attributes of the physical environment. Research on restorative environments document children's physiological and cognitive responses to nature and how such benefits are mediated by characteristics typical for play behavior outdoors (Jansson and Mårtensson, 2012; Mårtensson et al., 2009). Such open-ended "play of flux and transformation" (Dyment and Bell, 2008; Mårtensson, 2004) contains high levels of physical activity (Boldemann et al., 2006) and is also acknowledged to house situations which children can adapt very much to their own needs and aspirations (Mårtensson et al., 2009). Further, green settings tend to form common ground for play between girls and boys (Änggård, 2011). Also, in the field of interaction design there is research on how children's interaction with each other and various artefacts evolve (de Valk et al., 2013) indicating that children's play gets more open-ended when the digital artefacts are placed in nature (Back et al., 2018; Sallnäs Pysander et al., 2020; Back et al., 2016).

It is as if the landscape is playing with the children (Mårtensson, 2004) when their activity unfolds in relation to the flowing terrain (Moore, 1986). Attractive surroundings can provide an "outward pull" on children (Chatterjee, 2005), adding a situated character to activity outdoors as they attend to the physical environment while playing. This study has particular focus on such vigorous and versatile open-ended play which tends to evolve outdoors (Moore, 1986) and those "situated play episodes" (Mårtensson, 2004) in which children negotiate the play flow by relying extensively on bodily action and non-verbal cues. It is a type of play maintaining a core of its identity while undergoing continuous change as it evolves, with the children, moving in between different sites, coming and going in a session, and modifying, or even switching narrative as play evolves without any co-current change in the two other dimensions. So far, it is documented that such play, typical for restorative play in green settings (Mårtensson et al., 2009) can appear also in relation to digital gadgets when placed in green settings (Back et al., 2016; Back et al., 2018).

1.2. The elements of playgrounds scrutinized

It is well-documented that play equipment is an important trigger to versatile physical activity (Refshauge et al., 2013), and they also make up the core of most playgrounds today. One finds standardized play equipment programmed for various physical activities as swings for vestibular activity and a frame for climbing and other gross motor activity. The effects of more or less elaborate and colorful installations are moderate, while it is more important that the material is malleable and the place possible to modify (Hayward, 1974). Also, more far-reaching expectations on the potential role of playgrounds in children's lives is lingering in the literature. Playgrounds serve as vital meeting points in children's everyday lives, supporting their formation of local communities in the neighborhood (Wales et al., 2022). Vegetation and other natural elements adjacent to play equipment extend their functions by stimulating children's mobility, imagination and pro-social behavior (Jansson, 2010). Also vital is the size, the presence of greenery and the overall distribution of equipment and other elements across a space (Mårtensson et al., 2014) with the complexity of a biodiverse landscape contributing to the play flow (Fjørtoft and Sageie, 2000). The particular usefulness of "in-between spaces" where patches of land with different character meet, have been especially highlighted (Aminpour et al., 2020). Also, at a more detailed level we need to discriminate one setting from another and improve our understanding of how a more or less biodiverse environment contributes to health promoting play via the encounters children make with various species and ecological processes (Harvey et al., 2020). The documented health implications of introducing forest floor to preschoolers in Finland is a promising example (Roslund et al., 2020).

1.3. Boosting play outdoors with digital elements and nature

Natural elements are inherently fascinating to human beings (Kaplan and Kaplan, 1989). Characteristic for children's health promoting play outdoors are the situated play episodes in which their senses are exposed to ecological assets being the result of various natural processes (biological, geological, seasonal, etc.) (Mårtensson et al., 2009; Mårtensson, 2004). Nature contributes by making space rich in content, diverse, moldable and under constant change (Sebba, 1991). Loose parts is an attribute well acknowledged to nourish play (Nicholson, 1971). The overall structures, features and characteristics of a landscape are also supportive of children's place making by forming niches for certain activities and habitats for certain play narratives (Fjørtoft and Sageie, 2000). As play with natural elements is increasingly marginalized in many children's lives, they might become estranged to traditional outdoor play, but possibly careful merging of digital technology into nature could help to bridge their digital worlds with more traditional play activities outdoors.

There are some reviews of the effects of physical and digital play technology on children's play (Torres et al., 2021) and the effects of augmented play spaces (van Delden et al., 2018). So far, the majority of research on digital play has taken place in delimited playgrounds, such as gyms and labs (Tetteroo et al., 2012; Bekker and Sturm, 2009; Tiemstra et al., 2011; de Valk et al., 2012). These studies are focusing on the individual child and the digital props (Seitinger et al., 2006b; Seitinger, 2006a), with little attention to the physical surroundings. A recurring concept is interactive tiles that give light feedback using built in LEDs (Lund et al., 2005) including GlowSteps (de Valk et al., 2013) and Play-ware (Lund et al., 2005). In a few studies the spatial component of digital play is explicitly considered. For instance, the Water Games (Parés et al., 2005) features interactive water fountains that can be invoked by groups of users holding hands while moving around them. Hitron et al. (2018) conducted play sessions at a lawn-covered area, of approximately 450 square meters, to encourage running, jumping and throwing with man-made sticks that were either digitally or not digitally enhanced. The digitally enhanced sticks significantly decreased

collaborative social interaction and the generation of new rules compared to the non-digital sticks. Furthermore, if the digital feedback was accumulative (collecting points) the competitive social interaction increased significantly. This shows how the digital feedback in itself can affect children's play and the role of programming.

Although informative, none of the mentioned studies explicitly consider how various natural elements nor landscape elements together with digital technology influence children's play outdoors. However, in our previous project, multiple digital, fixed installations were developed with the intent to make sites with natural elements more attractive to play in (Back et al., 2018; Sallnäs Pysander et al., 2020; Back et al., 2016) and the play that evolved in these settings was evaluated. For example, one installation was a tube equipped with three different built-in sensors registering and distinguishing properties like wetness, movement and sound, all installations engaging children in varied and recurring play for sustained portions of time (Back et al., 2016; Back et al., 2018). Two other installations consisted of several posts with LED lights and sound output. In one, a button on any of the posts could be pressed and then the button on another post had to be pushed before the light faded. In the other, children could create a soundscape by selecting between five co-occurring sound options. However, in these studies the play in a digitally enhanced outdoor setting was not systematically compared with play in a traditional playground or forest setting.

1.4. Conceptualizing children's outdoor play

In the study of children's play outdoors a number of different measures and typologies have been used to document their playful interaction with the physical environment. The vigorous dimension of children's outdoor play can be documented by step-counting (Raustorp and Fröberg, 2021) as a proxy to health promoting play (Boldemann et al., 2006; Mårtensson et al. 2009). Physical activity is well known to provide multiple health benefits (Poitras et al., 2016). Recommended for the age group 5–17 years is 60 min of daily physical activity on at least moderate intensity level (WHO, 2020) translated into 10000–15000 steps per day in Swedish policy where "more is better than little" (Public Health Authority, 2021). Further, the concept of "affordances" is often used to pinpoint the functional properties of an outdoor play space being runnable, jumpable, swingable, climbable etc. (Gibson, 1979; Heft, 1988; Lerstrup and van den Bosh, 2017). However, capturing children's dynamic and transformative interplay with their surroundings also requires attention to the play flow and children's particular play behaviors. There are some play typologies capturing the role of outdoor play in children's cognitive and socio-emotional development and strategies for the systematic documentation of outdoor play (Moore and Cosco, 2007; Cosco, Moore and Islam, 2010; Cox, Loebach and Little, 2018; Han et al., 2018; Loebach and Cox, 2020). Behavior mapping (Ittelson et al., 1970) can be used to document the distribution and frequency of an activity as play evolves across a setting, at predefined time intervals. The idea is to randomize observations by following a procedure which assigns when and where to direct the attention, creating layers of maps where the positions of children are loaded with specific attributes, such as girl/boy, age and type of play. For playgrounds relying heavily on play equipment and organized activities, such as sports and ball games, it has been reasonable to rely on a typology with distinct behaviors attributed to distinct elements, for example associating locomotor play with climbing frames and socio-dramatic play with play huts (Pellegrini and Smith, 1998). However, this type of mapping is not well-suited to capture the more open-ended play characteristic for more green play settings which is mobile, transformative and tends to evolve across time and space. To evaluate play in school ground greening projects, additions to the typologies has been made in order to capture versatile forms of play characteristics for more unprogrammed space, play behavior in which movement, exploration and creative activity, is at the core (Mårtensson et al., 2014). The Tool for Observing Play Outdoors (TOPOS) is a validated typology for documenting outdoor play in green settings which classifies children's play into nine fundamental types: physical play, exploratory play, imaginative play, play with rules, expressive play, restorative play, bioplay, digital play and non-play (Loebach and Cox, 2020). Further, the elusive character of outdoor play in green settings presents a challenge to traditional mapping of play into discrete variables.

In line with the concept of behavior setting the situated play episodes' denote the identification of lasting patterns of behavior as they take form over time across a space (Ittelson et al., 1970). Ethnomethodology is an approach commonly applied when to describe children's play (Han et al., 2018). Making the situated play episodes into the primary research object is a way to extend the applicability of such descriptive work in the systematic mapping of play behavior. A situated play episode lasts as long as a group of children (or a singular child) interact and/or a particular play narrative prevails, and/or a particular place is used (Mårtensson, 2004). This focus on how the child-place interface evolves over time emanates from the insight of children's play activity being intermittent, changing moment by moment, for example between bursts of intense vigorous activity and moments for restoration or negotiation in the narrative of a pretend play (Mårtensson, 2004; Moore and Cosco, 2007). The tracking of situated play episodes (Mårtensson, 2004; Back et al., 2016; Back et al., 2018) allows the identification and evaluation of play-episodes of longer duration than can be documented by traditional mapping strategies.

2. Method

2.1. Research design

The approach used in this project to study children's outdoor play settings, was the result of common interests in children's play and its physical conditions from the perspective of children's digital worlds and the documented playability of natural surroundings, both domains possibly containing elements supportive for an active lifestyle and healthy development of children and youth. Research in play technology was combined with research in environmental psychology, ecology and sports science. The team was convinced of having to elaborate on the dominating mode of mapping outdoor play environments in terms of its functional properties, so called affordances (Heft, 1988), in order to find common ground for an investigation. It took departure in the observation that outdoors there is often a very dynamic interplay between children and place, with an ongoing and intense exchange between the children and the various materials of a setting. In this study, we focused on the role of digital material, traditional equipment and more or less biodiverse settings.

The study includes different strategies to capture attributes of the physical environment and attributes of children's play behavior during a play session in different types of play settings. It includes data on the type of play, the play narrative, the use of material, the level of physical activity, and the emotional valence during the play. The strategy included in situ behavior tracking and video recording of children's play with measurement of their physical activity, followed up with contextual interviews and a questionnaire with the participating children on how they experienced the play session. An inventory of the physical environment was conducted to obtain maps and descriptions of the design and content of each setting, attributes of the particular day, and the biological profile for each setting. The study plan was vetted by the Swedish Ethical Review Authority, and considered not in need of ethical approval according to Swedish regulations.

2.2. Settings

The design includes a strategic choice of three different play settings, one with play equipment in a traditional playground, one with digital artefacts in a forest, and a third setting in a forest without man-made artefacts (Fig. 1). The settings were located in a Swedish middle-sized

Fig. 1. The map shows the sites for the three settings investigated. The yellow area to the left is the traditional playground, the orange area in the center is the digital forest setting, and the purple area to the right is the forest setting. Above them you see 2–3 story multifamily houses and a parking lot on the left side. Ortofoto © Lantmäteriet, 2022.

city with approximately 126 000 inhabitants, and carried out during three weeks in October 2020. The play settings were all situated in a recreational area containing park and forest and located on the edge of a suburban neighborhood, about five kilometers southeast of the city center (59.234071, 15.244736). The precise extent of each play setting was based on the intention to not cut off attractive space in a way which could disturb the play flow.

The traditional playground setting embedded in a park, includes a climbing frame with a slide, four swings, a sandbox with a small wooden house, a large open grass area, perennial and shrub plantings, seating, various species of trees, and a paved walkway across the area (Fig. 2). The size of the setting was approximately 3700 m^2. The setting is of typical park character with its large moved lawns, planted tree species and exotic perennials (Nielsen et al., 2013). Most play equipment is placed in sand but some of the swings on artificial ground cover. The area contains 15 larger deciduous trees including 4 norway maples (*Acer platanoides*), 1 oak (*Quercus robur*), 4 oaks, unknown species (*Quercus spp*), 3 Swedish whitebeams (*Sorbus intermedi*a), and 3 horse chestnuts (*Aesculus hippocastanum*). There were also 2 plum trees (*Prunus* subg. *Prunus*), 2 cherry trees (*Prunus* subg. *Cerasus*) and 1 apple tree (*Malus domestica*), and additionally 2 native trees, one small birch tree (*Betula pendula*) and one small rowan tree (*Sorbus aucuparia)*. There were also some minor shrubs including bamboo *(Bambuaseae spp*.), lilac (*Syringa vulgaris*) and areas covered with herbaceous plants.

The play in the traditional playground took place during a day with a very light breeze. Rain the day prior had created puddles of water on lawn and asphalt. The sun was warming as it peered through the cloud and the lawn was partially sunlit while the edges with play equipment

was somewhat shaded by tree-crowns. The children were wearing hats and jackets but several of them unbuttoned or took them off during the session. Small birds and magpies chirped and ravens croaked. The deciduous trees had partially shed their leaves creating a blanket of yellow maple leaves covering the ground with chestnuts and acorns by some trees. In perennial beds late-flowering plants bloomed.

The digital forest setting, bordering to the larger park is dominated by conifer with some nature trails of trampled land running across it, and the following play equipment. Two tubes with three different built-in sensors for moisture, sound and movement which respond with colour and sounds depending on what is put into them (stones, pinecones, water e t c (Fig. 3C). A play-hut with a display of three LED bars responding to the above activity. A set of four connected posts in a circle containing multi-colored light source and a speaker. Pressing a button on one post triggers a random post's light and animal sound, followed by a gradual fade, repeated until someone misses the button before the light turns off (Fig. 3B). Five circularly arranged button posts change color and produce sound when pressed, and pressed again alters the sound and color. Each post has a unique playlist, contributing to a harmonious soundscape when pressed simultaneously (Fig. 3A). A ring 200 centimeters in diameter in between four trees perceived to be floating in space (not digitally enhanced) (Fig. 3D). The size of the digital forest setting was approximately 3500 m^2.

This digital forest setting is dominated by 25 larger pine trees (*Pinus sylvestris)* but also a number of larger birch trees and 3 junipers (*Juniperus communis*). The ground is trampled providing bare soil (30% of the area) covered by pine needles, leaves and substantial amounts of blueberry (*Vaccinium myrtillus*), and some lingonberry (*Vaccinium vitis-*

Fig. 2. Overview illustration of the traditional playground with photos illustrating specific sites (A-E) and a panorama capturing a larger part of the setting. Illustration: Anna Litsmark, 2022.

idaea). The bedrock is visible (covering 28% of the area) and in addition many stones are scattered across the space. There were two nest boxes for common starling (*Sturnus vulgaris*) and one for boreal owl (*Aeglius funereaus*). Ferns and small shrubs scattered across the area, but less common towards the park.

The observation-session in the digital forest setting took place on a cloudy and windy day. Most of the birches had lost their leaves and the ground of moss and grass was damp. The sun peeked through the clouds now and then creating strips of light and shadows on the ground. The participating children were wearing jackets, overalls, hats and gloves. A tub of water with four buckets by the digital tubes replaced the water children usually would fetch from a nearby pond when the area was not roped off.

The forest setting was a bit denser than the digital forest having 46 larger pines, 45 pine trees, 2 spruces 1 aspen (*Populus tremula*) and 5 birches. The forest setting includes some small groves with a small ravine, some slopes, one particularly big pine tree (197 cm in circumference), some wood and some trampled nature trails running across it (Fig. 4). The setting lies hidden from houses and larger paths. There is one higher cliff of bedrock overlooking the area and one lower height covered by vegetation, and in between an undulated area of moss, some dead wood and an undergrowth of blueberry and lingonberry. Yellow birch leaves and leaves from rowans (*Sorbus aucuparia*) lied scattered. The size of the setting was approximately 3500 m^2.

The observation-session in the forest took place on a cloudy, windless day with fresh misty air. One could hint the sun behind the grey clouds, but it was shady below, and the moss was damp except at the highest

cliff. The children were wearing rainwear, hats and gloves.

2.3. Participants

The participants were children 6–8 years old recruited from an after-school club at a school nearby the neighborhood of the three play settings. Written informed consent to participate was acquired from parents and oral informed consent from children at each occasion. The school regularly visited the recreational area of the three play settings, one afternoon per week, and the children were thus accustomed with the area, however the digital functions and the particular forest site were new to them. Table 1 shows how many of the children were present in each of the play sessions. The same group of children were invited in all three sessions but not all children were present and could participate in all three sessions.

2.4. Procedure

The study took place October 7th (traditional), 14th (digital forest) and 21st (forest) in 2020 with preparations and environmental mapping taking place in the morning, play-observations taking place during 45 min in the afternoon, and a first compilation of data taking place late afternoon. The length and time of the day for the session was adapted to how the school usually spends time outdoors and was conducted at the same time of the day on each occasion. Nine video cameras were set up and the play area roped off to avoid capturing people not participating in the study. Inventories for ecologic content and status of the physical

Fig. 3. Overview illustration of the digital forest setting with photos illustrating specific sites (A-E) and a panorama capturing a larger part of the setting. Illustration: Anna Litsmark, 2022.

environment were filled out. When the group of children arrived with their teachers at 1:40 pm they were again informed about the study and the signed consent forms were gathered. Three teachers were present during the whole session taking responsibility for the children as in their ordinary outdoor activities. Each child was equipped with a numbered vest (for identification on video) and a pedometer (Fig. 5). The play activity was initiated at 2:00 pm and stopped after 45 min by a teacher blowing in a whistle. The children were informed that they could play whatever they wanted within the roped-off area. The pedometers were collected and interviews were carried out in groups with up to four children, based on having belonged to the same situated play episode. The teachers delivered snacks. Finally, each child filled out a written questionnaire with the support of a researcher or teacher when needed.

2.5. Play tracking

The documentation of children's play behavior was carried out as play tracking of situated play episodes (Cox, Loebach and Little, 2018), as described in the introduction. The TOPOS typology (Loebach and Cox, 2020), was applied with some minor modifications in the final selection of categories and in wording (Table 2). Instead of including a particular category for digital play, other more general categories applied also to this kind of play. Further, a non-play category was excluded and language and conversation as sub-categories in the expressive play category, were merged into one, and finally for nature play also harming nature was included while no division between attention to wildlife and plants was made.

Each play setting was divided into three zones (1, 2 and 3) with one observer in each and the observers moving clockwise across the zones during the session. The task was to document all situated play episodes within the zone for 15 min and then circulate clockwise to the next zone (3 ×15 min). Each observer got to assess all zones. The observer scanned the zone to identify the different ongoing situated play episodes and then watched each situation for about 15 s, before categorizing it according to the protocol. Each situated play episode was categorized with the two play types best capturing the spirit of the play. The observations started with the situated play episode in the far-left corner of a zone and then moved across the zone to the right to find new situated play episodes. After this, a new round across the zone was carried out, and if any new play episode had appeared, a new sheet for this particular play episode was filled out. Each situated play episode was also assessed in terms of children's expressions of mood while playing. The scale for mood contained descriptions of core affect in terms of positions at an unpleasantness-pleasantness-scale (Derbaix and Pecheux, 1999). Each situated play session was evaluated from minus minus to plus plus with plus, minus and neutral in between (- -, -, 0, +, ++). Plus plus was defined as a very positive vibe with intense expressions of positive emotion such as laughter, squeals of joy, and very playful movements, and minus minus was defined as negative vibe with signs of negative emotions such as sadness, disagreements and brawl. Neutral was defined as a neutral emotional state, often associated with the children being involved in practical matters of transport or being negotiating with the pedagogues. For each situated play episode, the physical and digital materials children attended to or used during play, were documented in

Fig. 4. Overview illustration of the forest setting with photos illustrating specific sites (A-E) and a panorama capturing a larger part of the setting. Illustration: Anna Litsmark, 2022.

Table 1
The number of boys and girls that participated in the play sessions in the traditional playground, digital forest setting and forest settings.

Play settings	Participants boys			Participants girls			
	age 6	age 7	age 8	age 6	age 7	age 8	Total (*n*)
Traditional	1	3	3	3	1	4	15
Digital forest	0	3	7	0	2	2	14
Forest	1	2	5	1	3	2	14

a separate matrix in the protocol using predefined items that correspond to the materials reported in Table 7. The items in the matrix were determined based on an ocular inventory of the play settings before the study. If the observer saw that children used other materials than the ones in the matrix, those were also noted down in the protocol.

For the analysis, the protocols from the play tracking were combined to create a rough timeline for the situated play episodes. Due to the way observers moved around the settings in three time slots, different observers had noted different phases of the same situated play episodes. In this process we also found some short-lived episodes that only had been observed by a single observer. Next, observer notes were matched

Fig. 5. Pictures from the field study sessions showing children in action at the site in the traditional (A), digital forest (B) and forest setting (C).

Table 2

The selection of main categories and subcategories used in the study, based on the TOPOS typology.

Main categories	Sub categories
Physical play	Gross motor, fine motor, vestibular, rough and tumble
Exploratory play	Sensory, active, construction
Imaginative play	Symbolic, socio-dramatic, fantasy
Play with rules	Organic, conventional
Expressive play	Performance, artistic, verbal
Nature play	Attention to nature, care of nature, harm nature
Restoration	Resting, retreat

against the video recordings to validate the duration, the constellation of participants, how play evolved, and the use of material in each situated play episode. No new situated play episodes were discovered in the recordings, but a few episodes were partly taking place outside the recorded area. Each situated play episode was labelled in a way that should capture the place as well as character of this activity. The notations by all observers in all observation rounds were summarized for each respective play setting and used to validate each other. The observation protocols were analyzed to extract the relative frequencies of the different play types for further analysis.

2.6. Questionnaire on play experience

A questionnaire collected information on children's own experiences of their play and the setting (Appendix 1). The questionnaire consisted of two background questions, about gender and age. Two questions evaluated the mood on two dimensions called activation and valence from the framework of the Children on foot project (Derbaix & Pecheux, 1999; Westman et al., 2013), using an emoji scale with five levels. One yes or no question, asking if the child had been to the setting before or not. Five questions evaluating the experience of the play session, using questions with a four-point scale with labelled choices. Furthermore, eleven four-point scale questions asking about what the child did during the play session, using questions with labelled answering choices. Finally, three open-ended questions that the child answered with their own words asking about their experience of the play. The items in the questionnaire were determined based on experience from earlier evaluations of play and was validated between the researchers. An ordinal logistic regression model was used to analyze the questionnaire data.

2.7. Measure of steps

Steps were measured with the criterion pedometer YamaxTM (SW-200 Tokyo, Japan) (Tudor-Locke et al., 2006). The pedometers were attached to the waistband and placed in line with the midpoint of the child's right knee. The pedometer is a handy objective measure of physical activity in a way that is regarded as unobtrusive to the participants which can be used to estimate to what extent a particular physical environment triggers children's play (Boldemann et al., 2006, Mårtensson et al., 2014).

2.8. Inventory of physical environment

The status of the physical environment for the particular day and season was documented by taking notes about the weather, mapping objects lying around as leaves, puddles, toys, nuts, animals and litter, documenting the children's clothing, and other attributes particular for the day and place as noise and social activity. This part was carried out by researchers in environmental psychology. The ecological content and variety of the place were assessed in the following dimensions, content of sub-area settings of each play setting, field layer cover in percentage of the whole setting (e.g. lawn, herbs, blueberry, soil, sand etc.), large trees (species and circumferences <47 cm Breast Height (BH, 1,5 m), small trees, 13–45 circumferences BH, shrubs, higher than 50 cm and

> 13 cm circumferences, crown cover of trees in percentages of the whole area, average density of trees (measured as a mean distance between three average trees, laying and standing dead wood, larger branches on the ground >5 cm, bird nests, sight (how far you can see at the area) > 10 m, 10–20, 20–30, 30 + , rock > 50 cm circumferences. The settings were mapped based on the NILS methodology (National Inventory of Landscapes in Sweden (Ståhl et al., 2011). The different field layers on the traditional playground setting were estimated using Google earth pro polygon tool. All other measurements were conducted in the field using measuring tape for circumferences of large trees, small trees, lying and standing dead wood and mean distance between trees. Crown cover of trees was subjectively estimated in the field and complemented using Google earth pro polygon function. This part was carried out by an ecologist.

2.9. Video-recordings of interviews and play behavior

Nine GoPro cameras were used to document the play sessions and the contextual post-test interviews. The cameras were placed in strategic locations to either provide close-up captures of activity by specific landscape features or play equipment, or provide an overview of a larger area. The location and angle of video capture was documented for each camera. The contextual interviews were done in a walk-and-talk manner, with the children showing where and how they had been playing. The cameras were dismantled and used to document the interviews. The raw video was edited to have a joint start time so that observations could be synchronized. Using Geographic Information System tool QGIS, the position of each child was plotted on a detailed map for each setting on a minute-by-minute basis. The QGIS data is used to illustrate where the children gathered in each setting, sorted by gender, and mapped against the rough locations of the situated play episodes.

3. Results

3.1. The play flow of each setting

In the *traditional playground* eight situated play episodes were observed (T1-T8 in Fig. 6). One lasting play activity was the socio-dramatic play Chestnut Shop-Museum episode (T2) initiated by three girls and that gradually over time attracted more and more of the children. The Chestnut-Tree Play (T8) was in part related to T2 with children bringing nuts from trees to the seating area with its tables, benches and planting beds as shelves for the display of nuts. Other lasting play episodes were the Shoveling Water Game (T1) dominated by explorative play and the Ball-Dart Game combining rule play with locomotor play (T3), both initiated by groups of boys. The situated play episodes T5 and T6 by the climbing equipment were of shorter duration, and T7 refers to a solo-play of a boy walking around collecting things which caught his interest.

In the *digital forest setting* seven situated play episodes were observed (T1-T7 in Fig. 7). One lasting play episode was the Zombie Duo (T6), in which two girls moved around large parts of the area trying to climb on bedrock and avoiding the forest floor. The three digital installations inspired several play episodes (T1, T2 and T5). The Post-Pile Light Game episode (T1) in which a group of children chased the light before it faded, but where they also invented new rule games like guarding one's own post. The Post-Pile-Music Game episode (T2) where a group of children explored the lights and the different sound options on each of the five posts (T2). The Charge-Tube game episode (T5) was intense and attracted a large group of children moving back and forth filling the interactive tubes with material such as water and stones. Two sessions centered on installations that were not interactive, stepping up and about a wooden hand sculpture (T7) and playing underneath a ring elevated in the tree canopy (T3).

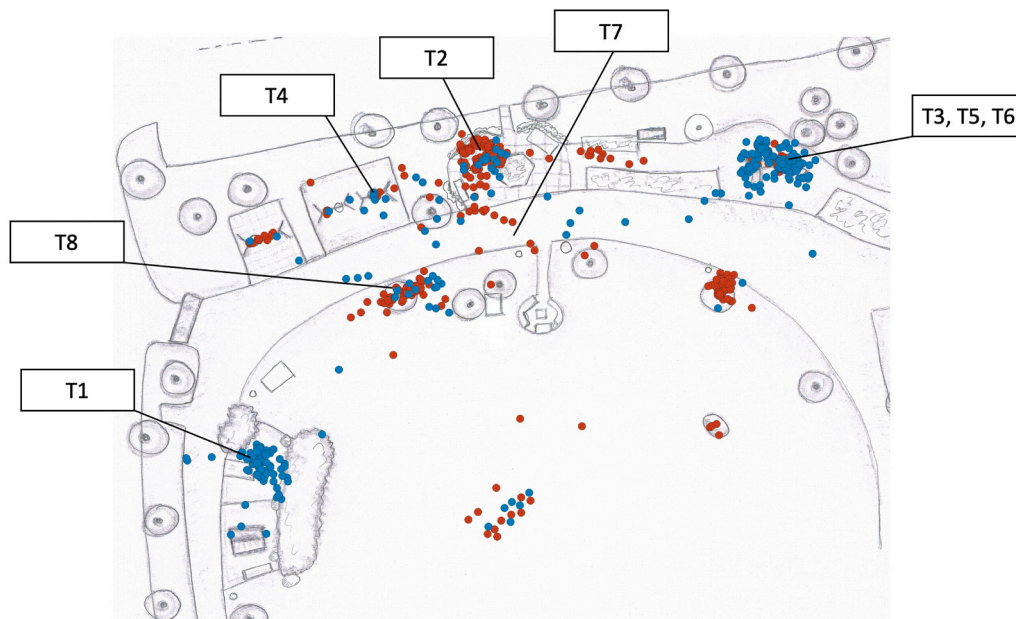In the *forest setting* seven play episodes were observed (T1-T7 in

Fig. 6. QGIS plot of children's (girls coded red and boys blue) locations in the traditional playground as well as the location of the situated play episodes: T1) The Shoveling Water Game: Mixing water and sand into a bucket with a "snake" in the shrubbery, T2) The Chestnut Shop-Museum: Collecting and sorting chestnuts for display, T3) The Ball-Dart Game: Climbing the play structure to hit a spot on the ground with a ball, T4) The Duo-Swinging: Swinging in the swings together, T5) The Jogger Play: Making rounds around the play structure, T6) The Climb and Slide: Making rounds clinging to the structure and sliding down, T7) The Solo Collecting: Wandering around collecting leaves and chestnuts, T8) The Chestnut-Tree play: Climbing and collecting nuts.
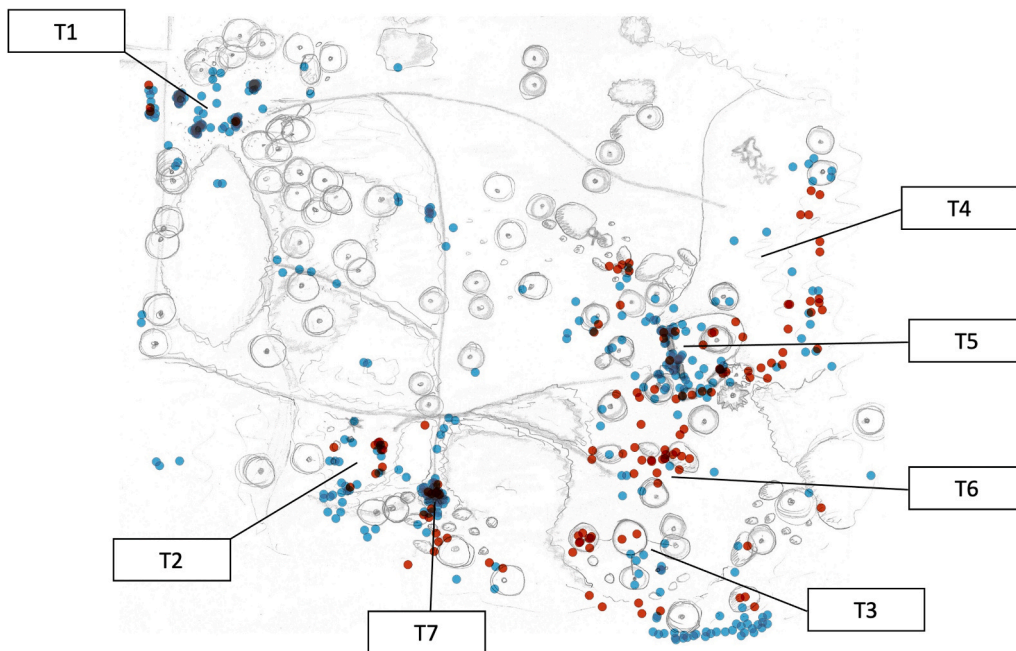

Fig. 7. QGIS plot of children's (girls coded red and boys blue) locations in the digital forest setting as well as the location of the situated play sessions. Seven sustained play activities were observed: T1) The Post-Pile Light Game: chasing a light before it fades, T2) The Post-Pile-Music Game: Exploring the functions of light and five co-occurring sound options, T3) The Magic Ring Play: Under the ring making various movements, T4) The Branch Duo: Moving around while holding on to branches, T5) The Charge-Tube game: Moving back and forth filling the interactive tubes with material such as water and stones, T6) The Zombie-Duo: Pretend play by the ravine, T7) The Climbing- Hand- play: Stepping up and about a wooden hand sculpture.

Fig. 8). The Minecraft Play (T4), The Ravine Den Play (T3) and the Spruce Den Play (T2) were the three most long-lasting play episodes. The Minecraft Play episode taking place on a plateau with undulated terrain of moss and tree stumps got more and more intertwined with the particularities of the site as the narrative developed. In this play, the children enacted the computer game Minecraft. Other episodes were shorter, dominated by explorative interaction with the physical environment and its affordances, such as the Picking Berry Duo (T7), The Not Touch the Ground Play Duo (T6) and the Romping by a Slope Play (T5), all episodes taking place in the vast areas of uneven ground dominated by moss. The Solo Collecting (T1) refers to one boy walking around collecting things which caught his interest and putting them on display.
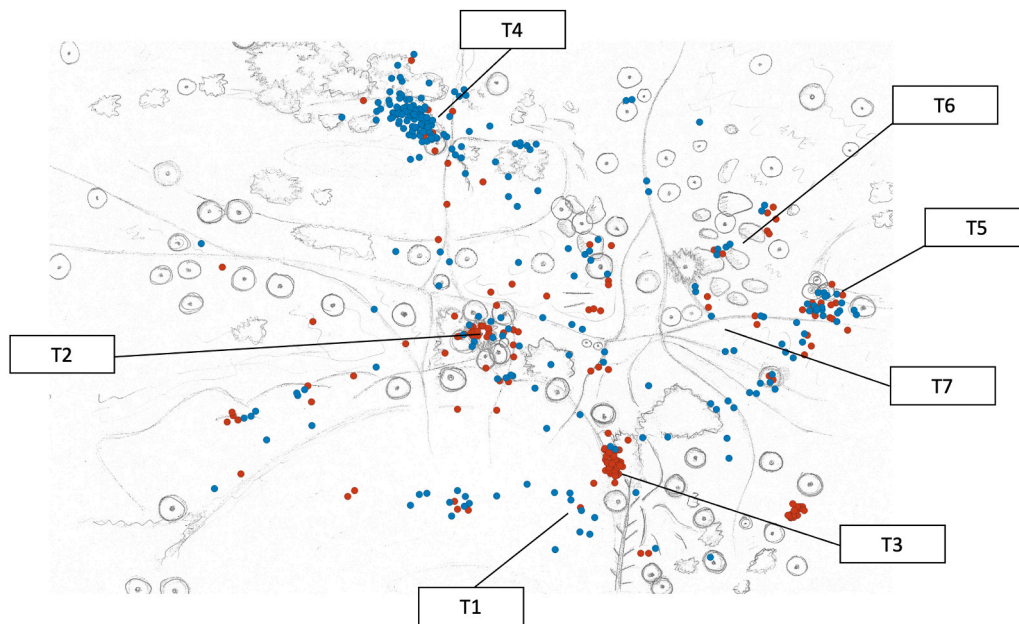
Fig. 8. QGIS plot of children's (girls coded red and boys blue) locations in the forest setting as well as the location of the situated play episodes. Seven sustained play episodes were observed: T1) The Solo-Collecting Expedition: Wandering around picking up leaves, stones, seeds to a collection, T2), The Spruce-Den Play: Venturing into and under a spruce tree, T3) The Ravine-Den Play: Playing den in a narrow ravine with slug, T4) The Minecraft Play: Pretend play on a height. T5) The Romping by a Slope Play: Rolling down the slope and getting exhilarated. T6) The Not touch the ground Play Duo: Climbing around in the rugged terrain. T7) The Picking Berry Duo: Walking around picking berries.
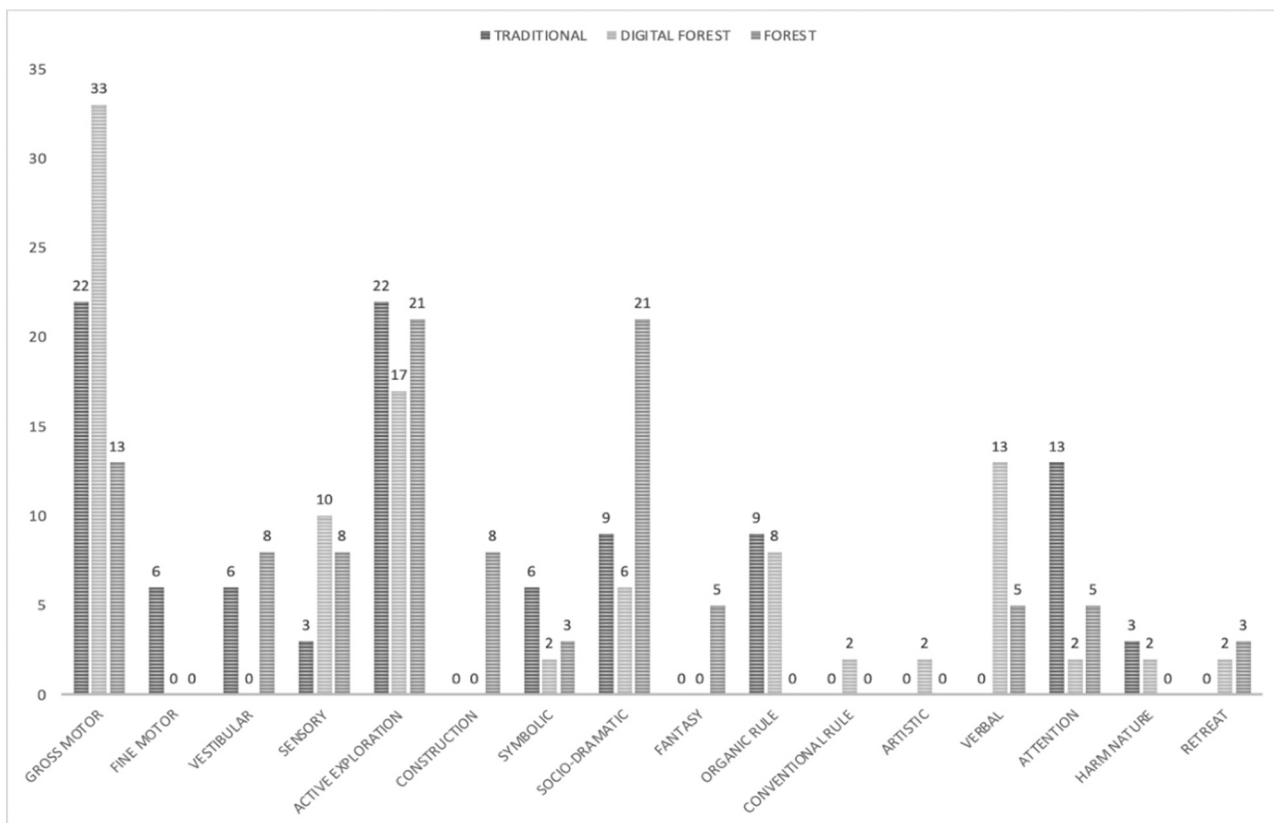

Fig. 9. Proportions (%) of observed play types in all situated play episodes in the traditional, digital forest and forest settings at sub category level. The play types with zero observations in all play settings have been excluded, those were Rough and tumble, Performance, Care for nature and Resting.

3.2. The play behavior of situated play episodes across settings

The observed play tracking data was compared using descriptive statistics and proportions. In accordance with the TOPOS typology, the analysis was conducted on a micro (sub category level) and a macro level (main category level).

At the sub category level, the results show that gross motor play accounted for the major part of the situated play episodes in the digital (33%) and in the traditional play setting (22%), but not as much in the forest (13%) (Fig. 9). Active explorative play was common in all three settings; traditional (22%), forest (21%), digital forest (17%). A rather large part of the play in the digital forest setting was categorized as the more passive type of explorative play called sensory play (10%) as children responded to the digital feedback, compared to the forest (8%) and traditional play setting (3%) where many situated play episodes involved more intentional manipulation of objects. In the forest, the more elaborate type of imaginative play called sociodramatic play accounted for a large part of the play (21%) whereas it was not as common in the traditional (9%) and the digital forest setting (6%). However, in the traditional playground, 6% of the play was categorized as symbolic play compared to the forest (3%) and digital forest setting (2%). Children attending to nature was more common in the traditional playground (13%) than in both the forest (5%) and the digital forest setting (2%) while children expressing care or harm towards nature were absent from the forest setting. Organic rule play in which rules are negotiated as play evolves, was found in the traditional (9%) and the digital forest setting (8%) while more conventional rule play only was found in the digital forest setting (2%). In the digital forest setting, a considerable amount of the expressive play was categorized as verbal (13%) including sequences in which children joke while interacting by the digital installations, compared to the forest (5%) and the traditional (0%).

The play types were aggregated into six *main category level* play types (Fig. 10). The category restoration was excluded due too small frequencies. Results showed that for both the traditional playground setting and digital forest setting the major proportion of play was categorized as physical play (34%) and in second place exploratory play (digital 28% and traditional 25%). In contrast, the largest proportion of play in the forest play setting was categorized as exploratory play (38%) and secondly imaginative play (30%). Rule play was observed in the digital forest (11%) and traditional playground setting (9%), but not in the forest. In the digital forest setting 15% of the play was categorized as expressive play whereas this play type was less common in the other two play settings. Nature play was frequent in the traditional play setting (16%) due to the abundance of recently fallen chestnuts staying in the focus for much of the activity. Also, in the forest and digital forest settings the natural materials were integrated or used a lot in many situated

play episodes, but were less in focus.

3.3. Emotional state

The observers´ evaluations of mood state in the different situated play episodes showed that the mood of the children was rather similar in the three settings, with few deviations. In most of the situated play episodes, the children´s mood was categorized as positive (+) in terms of having a positive vibe with engagement in the play and occasional smiles indicating them also feeling content (Table 3). No events were categorized as minus minus (–) which was defined as very negative vibes with intense expressions of sadness, distress, brawl and disagreement.

3.4. Questionnaire data

Mean values of responses to the questionnaire across the three settings are shown in the left panel of Table 4. These means cannot be compared using traditional T-test or ANOVA because the response variable is neither in the continuous scale nor normally distributed. Instead, an ordinal logistic regression model was used, a procedure that takes due account of the ordinal nature of the response variable, and captures any differences between the play settings more accurately (McCullagh, 1980; Agresti, 2010; Liddell and Kruschke, 2018).

The dependent variable in the ordinal logistic regression model is the logarithm of the cumulative odds of answering j to a questionnaire item (where j varies between the lowest 1 to the highest 4 in most of the items). Results from such a procedure are shown in the right panel of Table 4 in the form of odds ratios and their corresponding 95% confidence intervals. There were $18 \times 3 = 54$ pairs to compare but in 4 of them the corresponding frequencies were not compatible with the requirements for ordinal logistic regression model. Among the remaining 50 pairs, we found significant differences between play settings among 7 pairs where the 95% confidence interval does not include 1. These are indicated in bold font in Table 4.

There were significant differences between the traditional playground and digital forest setting for the items *happy* and *energetic* with

Table 3
Number of observed emotional states in the situated play episodes observed in the respective play settings, traditional, digital forest and forest.

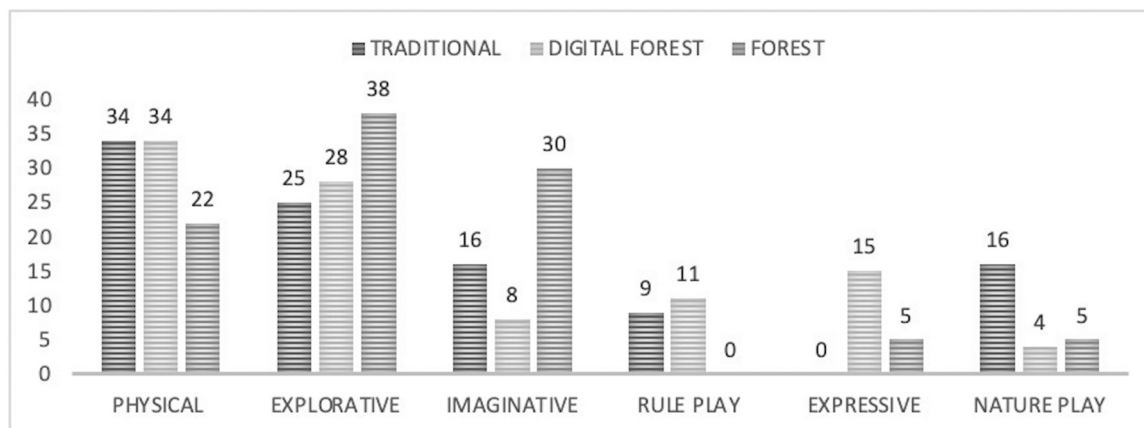| Emotion categories	Traditional	Digital forest	Forest
Very positive vibe	0	2	3
Positive vibe	13	10	10
Neutral	2	3	2
Negative vibe	1	2	0
Very negative vibe	0	0	0

Fig. 10. Proportions (%) of observed play types in situated play episodes in traditional, digital forest and forest setting at main category level.

Table 4

Mean values and results from Ordinal Logistic Regression Models (Proportional Odds Models) on the questionnaire items regarding children's reported emotional state and their reports on what they were doing while playing in the different settings.

Questionnaire item	Mean values			Odds Ratios (and 95% confidence intervals)		
	Traditional	Digital forest	Forest	Digital forest vs Traditional	Forest vs Traditional	Forest vs Digital forest
Happy (1–5)	4.87	4.14	4.77	**12.01 (1.21, 119.01)**	3.50 (0.32, 38.14)	0.29 (0.06, 1.51)
Energetic (1–5)	4.87	4.15	4.30	**7.08 (1.16, 43.04)**	4.52 (0.65, 31.39)	0.64 (0.13, 3.14)
Fun (1–4)	3.87	3.36	3.77	0.210 (0.03, 1.34)	0.59 (0.08, 4.11)	2.80 (0.52, 15)
Cosy (1–4)	2.87	2.85	3.08	1.04 (0.27, 4.01)	1.82 (0.48, 6.88)	1.74 (0.42, 7.30)
Brawl (1–4) reversed	1.29	1.29	1.23	1.57 (0.22, 11.18)	1.45 (0.20, 10.29)	0.93 (0.15, 5.55)
Things to do (1–4)	4.00	3.00	3.69	**-**	**-**	**5.14 (1.09, 24.34)**
Exciting (1–4)	2.93	2.57	3.23	0.58 (0.15, 2.23)	1.93 (0.51, 7.39)	3.33 (0.79, 14.01)
Run (1–4)	2.87	3.14	3.15	1.67 (0.44, 6.38)	1.74 (0.44, 6.86)	1.04 (0.27, 3.99)
Climb (1–4)	2.07	1.93	1.92	0.71 (0.19, 2.65)	0.54 (0.14, 2.10)	0.76 (0.19, 3.13)
Plants (1–4)	3.07	2.31	3.08	0.26 (0.06, 1.09)	0.73 (0.18, 2.96)	2.85 (0.74, 10.92)
Insects (1–4)	1.40	1.57	2.77	1.88 (0.41, 8.62)	**12.92 (2.57, 65.10)**	**6.87 (1.53, 30.89)**
Animal (1–4)	1.36	1.14	1.08	0.5 (0.17, 1.46)	0.33 (0.05, 2.10)	3.00 (0.48, 18.93)
Friend (1–4)	3.67	3.69	3.77	0.64 (0.12, 3.54)	3.12 (0.28, 34.33)	4.86 (0.47, 50.46)
Pretend (1–4)	2.13	2.07	2.61	0.89 (0.23, 3.45)	2.26 (0.58, 8.75)	2.54 (0.64, 10.08)
Create (1–4)	2.07	1.43	2.15	0.21 (0.04, 1.01)	1.14 (0.31, 4.21)	**5.51 (1.11, 27.31)**
Build (1–4)	1.47	1.29	2.00	0.33 (0.05, 1.96)	2.35 (0.56, 9.80)	**7.16 (1.14, 44.95)**
Hut (1–4)	1.00	1.43	2.08	**-**	**-**	3.21 (0.69, 14.93)
Collect (1–4)	3.07	2.00	2.38	0.220 (0.05, 0.86)	0.340 (0.08, 1.41)	1.56 (0.39, 6.31)

Table 5

Results from pairwise Chi-squared analyses of the contingency-tables of the corresponding frequencies for the questionnaire items Things to do and Hut.

Item	Pair (Contrast)	Chi-squared	d.f.	P-value
Things to do	Traditional vs Digital forest	11.837	2	0.003
	Traditional vs Forest	4.971	1	0.026
Hut	Traditional vs Digital forest	4.667	2	0.097
	Traditional vs Forest	10.177	3	0.017

odds ratios 12.01 and 7.08, respectively and corresponding 95% confidence intervals (1.21, 119.01) and (1.16, 43.04) (Table 4). That the odds ratios are greater than 1 indicate that children playing in the traditional playground were happier and more energetic than their counterparts in the digital forest setting. There was a significant difference between the digital forest and the forest settings for questionnaire item *things to do*, odds ratio 5.14 with 95% confidence interval (1.09, 24.34). When the children were playing in the forest setting, they were more likely to find things to do than when playing in the digital forest setting.

Furthermore, children playing in the forest setting have higher odds of *finding insects* than children in the traditional playground or the digital forest setting. The odds ratio relative to the traditional playground is 12.92 with 95% confidence interval (2.57, 65.10) while that relative to the digital forest setting is 6.87 with 95% confidence interval (1.53, 30.89). Lastly, there are significant differences between the digital and forest settings for the items *create* and *build* with odds ratios 5.51 and 7.16, respectively and corresponding 95% confidence intervals (1.11, 27.31) and (1.14, 44.95). Children playing in the forest setting had higher odds of creating and building things while playing, than when playing in the digital forest setting.

For the entries marked with a bold hyphen (-) (Table 4), it was not possible to fit the ordinal logistic regression (or even the binary logistic regression) because all answers in the traditional setting fell into a single

value. In *things to do* there were 15 responses and all belonged to the highest choice v*ery much*. In *hut*, on the other hand, there were 14 responses and all belonged to the lowest choice *not at all*. In such situations, the other choices get zero frequencies and any pair involving the traditional setting will lead to odds ratios that are either zero or infinity depending on whether the setting is used as numerator or denominator in the odds. For this reason, comparison of these four pairs was done using Chi-squared analysis of the frequencies.

In the 4 pairs for which fitting ordinal logistic regression was impossible pairwise Chi-squared analyses of the contingency-tables of the corresponding frequencies was used. Results show that, there are significant differences (at 5% significance level) between the traditional playground and digital forest setting as well as between the traditional playground and forest setting in questionnaire item *things to do* (Table 5). This shows that children reported that there were more things to do in the traditional compared to both the digital forest and the forest setting. In questionnaire item *playing hut*, on the other hand, there is significant difference only between the traditional and forest settings while the difference between the traditional playground and digital forest setting is not significant.

3.5. Physical activity

The play in the three settings contributed to different extent to children's physical activity in terms of total number of steps, steps per minute and the relative contribution to recommended levels of physical activity for the age-group (Table 6).

The forest setting triggered most physical activity with an average of 2321 steps accumulated during the play session and adding up to 51.5 steps per minute. In the traditional playground they accumulated 1867 steps on average (41.4 steps per minute) and in the digital forest setting 1744 steps (38.7 steps per minute). In relation to the step recommendations per day children got 23.2% of this amount in the forest setting

Table 6

Description of play settings contribution to children's physical activity as pedometer determined mean of total steps and steps per minute for all children, boys and girls. In addition, adopted percent of recommended daily steps (lower endpoint i.e 10000 steps per day) for all children are displayed. In the digital forest and forest setting some step counters were lost, explaining the lower numbers (n).

All				Boys		Girls	
Play setting	Tot steps	Steps/min	% of rec	Tot steps	Steps/min	Tot steps	Steps/min
Traditional ($n = 15$)	1867	41.4	18.6	2607	57.9	1487	33.0
Digital forest ($n = 9$)	1744	38.7	17.4	1754	38.9	1640	36.4
Forest ($n = 11$)	2321	51.5	23.2	2628	58.4	2248	49.9

Table 7
Play materials used by the children in the traditional, digital forest and forest play setting based on observations during tracking.

Play material frequencies	Traditional	Digital forest	Forest
Digital sound	0	8	0
LED light	0	7	0
Tube	0	2	0
Posts	0	8	0
Sculpture	0	6	0
Hut	0	3	6
Rock	0	4	6
Stone	0	2	1
Log	0	2	1
Stick	0	13	9
Forest litter (pine needle, moss)	0	1	9
Herbaceous plant	0	1	1
Mushroom	0	1	1
Tree	2	0	2
Seed (chestnut, pine cone)	9	0	7
Water	3	1	0
Animal	1	1	0
Bucket	3	1	0
Climbing frame	4	0	0
Swing	2	0	0
Ball	3	0	0
Table	1	0	0
Sand	3	0	0
Mud	2	0	0
Leave	4	0	0
Bush	0	0	0

compared to 18.6% and 17.4% in the traditional playground and the digital forest setting respectively.

3.6. Play materials

The majority of the materials used by children according to the tracking data (Table 7) consisted in the traditional playground of loose play material found on the ground such as chestnuts, leaves, sand, water and mud together with a few small buckets. The fixed man-made artefacts used consisted of a climbing frame, a table and swings which were involved in particular situated play episodes. Children climbed in one tree and they collected nuts under some others. They also brought nuts to a table with some benches and a low-bricked wall by some planting beds, a central node for imaginative play in which they were putting nuts on display on tables and walls. In the digital forest setting, the material used the most was sticks. Sticks were used to feed into the tubes to excite the sensors generating sound and light feedback but sticks were also used to push the buttons on the posts. Furthermore, sticks were used in situated play episodes in the digital forest setting not involving digital artefacts. Stones, and water were used to feed the tubes. The digital material (sound and LED light) was used for exploratory play. The man-made artefacts were used extensively, both the digitally enhanced physical artefacts such as the sets of posts, the tubes, and a wooden hut. A wooden sculpture in the shape of a human hand was used to climb up and sit on. Rocks and logs were used to hop around on (don't touch the ground). A few children collected mushrooms and plants and one group of children were playing by an anthill. In the forest setting, the materials used the most in the situated play episodes were loose materials found on the ground such as sticks, forest litter, moss, pinecones and stones. Also berries, a mushroom and half-detached lumps of wood were involved in play. The hut category denotes a large solitaire spruce, a large rock surface in the fringe of the area covered with forest litter, and a centrally placed ravine with some spruce beside.

4. Discussion

4.1. Nature and play equipment do trigger physical activity

Outdoor play is vital for children reaching the recommended levels of daily physical activity, and in this study the children adopted around a fourth to a fifth of what they need while playing during 45 min in the different play settings. In comparison, a study in Sweden showed how recess during the school-day provided children with 30–40% of the recommended level when having access to a spacious school ground (Mårtensson et al., 2014). On average the children got more physical activity in the forest setting than in the traditional playground setting where play equipment was at the core of the design or in the forest setting augmented with digital installations. According to an earlier study the presence of forest in a playground can be associated with higher levels of physical activity (Pagels et al., 2014). Possibly, it was the presence of attractive fixed installations where the children tended to stay put that contributed to the children moving about comparatively less in the two latter settings. In addition, the lower ecological diversity of the digital forest setting than the other forest setting, might have made it less likely that the children would seek out and find other parts of this environment attractive. In the forest setting much of the activity was the result of the children moving about while walking and climbing around in the undulated terrain of moss, stones and stocks while seeking out various landscape features, like the plateaus, the ravine, the slope and the spruce, that all turned into sites of particular play episodes. The play in the forest evolved in relation to natural features becoming the object of exploration and physical activity, activity that now and then evolved into more elaborate imaginative play. That physical play turned out to be more common in the traditional playground and the digital forest setting, could be explained by the typology for play behavior applied in which physical activity often got embedded in the episodes denoted as pretend play and explorative play (Loebach and Cox, 2020). In spite of it being quite demanding to move across the undulated terrain of the forest environment it is not likely that this type of activity is classified as gross motor play. At the day of the study in the traditional playground setting, the rich access to chestnuts and leaves inspired foraging behaviors associated with physical activity also in the traditional playground, as the children were moving back and forth across the setting to collect the natural material. On the other hand, the climbing frame programmed for the gross motor activity was primarily appropriated for two games, as a feature to run around and as a height from which to hit balls. The results are in line with earlier research showing how exploration is at the core in play settings dominated by nature and how such play tend to encompass pretend play as well as physical activity (Mårtensson et al., 2014; Dyment, Bell and Lucas, 2009). In this study an approach to document the play flow in terms of situated play episodes (Mårtensson, 2004) were elaborated in order to pin-point, name and further understand how play evolved in interaction between children and place. Pretend play is sometimes described as an inward-looking activity shielding the children off from their surroundings. However outdoors, children tend to stay connected to the place and its particular attributes, and especially so in green play settings. Important to recognize is that this kind of open-ended play in which children continuously adapt their behavior to the circumstances and have the opportunity to modify their surroundings, has been attributed having positive effects on children's health and wellbeing in several studies (Boldemann et al., 2006; Mårtensson et al., 2009; Söderström et al., 2013).

4.2. Nature trigger fantasy while artefacts raise the social temperature

The study contributes to our understanding of how children's play varies with type of play setting, its overall features, type of physical attributes and the overall availability of loose materials. Some of the documented differences in play-behavior between the three settings are

in line with previous studies (Boldemann et al., 2006; Herrington and Lesmeister, 2006; Lerstrup and van den Bosh, 2017) but the higher resolution of documentation on biological content and man-made artefacts highlight how additional factors at the site influence the play flow. The profile of play types for the digital forest setting stands out compared to the other two play settings. Rule play was more common in the digital forest than in the forest setting while imaginative play was more common in the forest setting. On the other hand, expressive play was more prevalent in the digital forest setting compared to both the traditional and the forest settings. Exploratory play was, besides physical play, the most common play behavior in both the traditional and the digital forest setting. However, in the forest, exploratory play was the most common play type and the imaginary play is the second most common play type. Nature play, representing a keen attention to natural features, was most common in the traditional playground setting, in this case related to the abundance of chestnuts. In summary, a very large part of children's play outdoors is vigorous and explorative to its character with biodiversity (here exemplified by forest and chestnuts) promoting imaginary play. It also shows how settings augmented with man-made artefacts can trigger rule play and expressive play, play types which to a large extent rely on language in their performance and negotiations.

In all settings, most children reported having a friend to play with in the questionnaire. The mood of the children was generally positive in all the three play settings according to our observations. The questionnaire confirmed this but also indicated that they felt most happy and energetic when playing in the traditional playground, slightly less in the forest setting and the least in the digital forest setting. Possibly, adding to the social temperature in the traditional playground setting was the abundance of natural elements (chestnuts) creating a clear goal for the children to work for, a common theme in human interaction with wildlife and gardens. The children reported that the traditional playground was the setting offering most things to do, followed by the forest play setting and the digital forest play setting. Collecting things, running around, finding plants and pretend play, were the most commonly reported activities with no significant differences between settings. This is also apparent in the materials they used according to our observations with extensive references to sticks, moss, chestnuts and pinecones. They primarily linked the forest play session with discovering insects, crafting, and building. This connection was evident in their situated play episodes, which often featured forest-inspired structures, while the traditional playground was considered less conducive to hut play.

4.3. Adding nature to our crude knowledge on how material is used in children's play

The material provided in the respective play settings was indeed the materials used by the children. Well-used artefacts in the traditional playground setting were the climbing frame and tables, and in the digital forest the sculpture, digital posts and tubes. Surprisingly, the swings in the traditional playground setting were only used very little, in spite of it including the so-called buddy swings. The use of natural material like sticks, chestnuts, pinecones, moss, sand, mud, water and leaves dominated very much both in the traditional playground setting and in the forest setting. The importance of natural materials is in accordance with previous research (Chawla, 2015; Fjørtoft and Sageie, 2000; Moore, 1989). In the digital forest setting, their use was more evenly distributed across man-made artefacts, natural material and digital material (LED light and sound), but often the man-made installations were used together with natural elements as sticks, water, stones and forest litter. In the forest play setting, a large rock covered by moss and stumps of trees, a large spruce and a ravine with some deciduous plants and a soft slope, were important features for play. The inventory of the physical environment shows that grass dominated as ground material in the traditional playground while blueberry and lingonberry rice dominated in the forest. In the digital forest setting, the ground material consisted of equal parts bare rock and forest litter with pine needles, but also

included ferns, blueberry and lingonberry rice. The traditional playground setting was the only one containing some artificial ground. As a whole, the digital forest and the forest setting were the two more diverse settings, but an abundance of chestnuts made nature present also in the traditional playground setting this early autumn day.

This study tries to start filling what appears to be a knowledge gap in the systematic evaluation of how children use various materials in different types of play settings, and how this contributes to play behavior and the overall play flow. For example, we noticed that children used slightly more sticks in the digital forest setting than in the forest setting, and none in the traditional playground. The ecological sampling did not support us in understanding how much sticks were available and if this affected how play evolved. For future studies, we suggest doing a more careful inventory of loose materials, for example recording the number of sticks per/m2 and the number of rocks within an area to make an estimate of connectivity to say if children can jump between them. Here we used a simplified version of an ecological sampling strategy used in monitoring programs, which could be further developed for the assessment of play settings.

4.4. How functions override the potentially restorative play flow

Overall, the play flow in each of the three settings was distributed into seven to eight distinct situated play episodes, episodes which were sustained by a particular narrative, a particular place, or a particular social set up of one or more children. Two such episodes were the Minecraft play episode in the forest, and the Chestnut shop/museum episode in the traditional playground. Other episodes are less coherent from a narrative perspective, but are the result of children´s playful mobility evolving in relation to particular structures in the landscape. This includes the Romping by the slope episode in the forest and the Jogger episode in which they were dedicated to run around and around the climbing gear in the traditional playground. Other situated play episodes are more strictly place-dependent as the Duo Swinging in the traditional playground and the Magic ring episode in the digital setting.

The forest ground stands out in its high level of imaginary play, significantly higher than in the digital play setting also placed in a forested area. It included all sorts of imaginative play, from the more modest pretense acts part of symbolic play to the more elaborate fantasy play and enduring socio-dramatic sequences, such as The Minecraft episode and The ravine den episode. Furthermore, all three sub-categories of explorative play are represented in the forest setting in its investigative as well as its sensuous forms, and it was also the site where children most actively shaped place while playing. The wide variety of play types in the forest setting indicates how integral exploration is to the other types of play common outdoors, physical activity play, as well as imaginative play, and how these types of play feed into each other. This is in line with earlier research documenting how green surroundings tend to promote vigorous and versatile play evolving in relation to the physical attributes of a natural environment (Dyment, Bell and Lucas, 2009; Mårtensson et al., 2009).

The traditional playground containing play-equipment integrated in a green park was documented high on gross motor activity, but exploratory and imaginative play were also prevalent. We found some enduring episodes with substantial amounts of vigorous activity in this setting. In the Chestnut-shop-episode, children were moving back and forth to collect the nuts and leaves scattered around some trees and had a shop/museum where they refined the material and put it on display on the brick wall by some flowerbeds. It confirms the importance of placing playgrounds and play equipment adjacent to greenery (Jansson, 2010) and points out how seasonal variation contributes with novelty. At the day of the study, the leaves had just turned into colors and the nuts were in the stage of falling down, still fresh and exciting, but how would play evolve after some weeks when the material was trampled, or dispersed and gone? We are inclined to think that the elaborate pretend play taking place on this day had its high-peak during this early autumn

period. We know that play equipment of different sorts can trigger physical activity (Refshauge et al., 2013) and in the traditional playground setting this activity evolved into more rule-oriented games. The ball-dart game was an organically evolving game in which children threw a ball from the climbing structure to hit a particular spot in the sand below. Also, balls are documented as powerful triggers to physical activity (Verstraete et al., 2006), but in this case a mistake, not catching our eyes when preparing the area. The Jogger play was another rule-based game also evolving by the climbing equipment. Further, the swings should explain the incidence of vestibular activity in the setting, one of few sensations commonly associated with play at playgrounds which can be hard for children to attain beyond the equipment of playgrounds.

The play in the digital forest setting was dominated by gross motor play and active explorative play with sensory play, related to light and sound, being key to many of the episodes. Sometimes the play was very task oriented, for example when feeding natural material into the tubes and accumulating points on the LED displays. The children soon understood the game logic and collaborated and coordinated in joint efforts to feed the tubes before the lights would fade. In the Post pile light game, the children reinvented new rules during the whole session, for example recruiting sticks to push the buttons instead of using their hands. The programmed functions seemed to take precedence over the more open-ended qualities that a forest environment can have under other conditions. Children's interaction with nature in the forest setting was much more considerate to its unique properties while they seemed to focus on the utility of natural elements to reach a particular goal in the digital forest setting. One example is how they took anything they found on the ground to create noise in the Charge-tube game. Overall, the digital feedback seemed to be in focus for the children in this setting, promoting game and competition, rather than any other play type. To further illustrate how the digital forest setting appears to have hampered the development of more imaginative play and hindered more open-ended play episodes, usually associated with green play settings, we give an example. There were places in the digital forest with similar biological content as in the forest setting, such as a ravine, a small grove, mushrooms and the many large stones, but few of these elements captured the children's attention, and even less so became sites for more elaborate play. An exception was the imaginary play in the Zombie-duo episode where two girls were walking around in the fringe of the digital forest setting and fantasizing about zombies, without getting much involved with the other children nor the artefacts of the place. The "soft fascination" associated with our perception of the natural experience (Kaplan and Kaplan, 2002) seems to be easily overridden by man-made artefacts, and even more so of digital than traditional play equipment. The rich supply of chestnuts in the traditional playground setting were at the core of play behavior this particular day, and not the play equipment. It is an important lesson that nature easily is drowned in the input from man-made artefacts, and how particularly digital attributes can thwart the type of open-ended play otherwise associated with children's play in green play settings.

4.5. Biodiversity and children's play

So far, we have highlighted play patterns related to the overall character of a site and its implications for children's access to digital artefacts, play equipment and a natural environment. Yet, there are differences in the relative influence of nature in the different settings linked to species composition. Lawn, a highly managed habitat, is species poor (Hedblom et al., 2017; Ignatieva and Hedblom, 2018), covered 75% of the traditional playground, making this setting less biodiverse than the two more forested areas. We took the cover percentages and number of species as indicators for biodiversity similar to Gunnarsson et al. (2017) documenting how urban forests had higher biodiversity than parks, allotments and yards. Thus, we assume that the traditional playground had lower biodiversity and fewer indigenous species than

the forest. As an example, the traditional playground was more open containing less trees and shrubs than the forest (3–4 m between trees in the forest and 12 m in the traditional playground). The forest floor had higher cover of mosses, herbaceous plants, ferns and edible dwarf shrubs such as blueberry (*Shpangnum sp.*), and wooden plant parts, such as Scotch pine (*Pinus sylvestris*) and also cones and sticks.

Earlier studies point out the importance of experiencing nature during childhood for understanding and engagement in nature conservation as adults (Beery and Jørgensen, 2018; Soga and Gaston, 2016; Verstraete et al., 2006). However, surprisingly few studies highlight the role of more or less biodiversity in a particular setting and its potential effects on children's play, play behavior having a mediating role on such trajectories across the life-course (Wells and Lekies, 2006). A recent study in Finland revealed that removing lawn on a kindergarten and adding a forest floor (similar to a forest floor in Sweden), diversified children's physical activity, adding rolling, creeping, crawling, doing somersaults and cartwheels (Puhakka et al., 2019). In this study there were differences in the wear and tear of the ground cover between the digital forest setting (30% bare soil) and the forest (80% mosses). Still the digital forest setting contained a large variation with its mix of bare rocks, areas with pine needles, ferns and herbaceous plants. Variation is indeed one of the most commonly mentioned attributes of a child-friendly environment (Jansson et al., 2022) but also more tangible factors of the forest can be decisive. The play value of moss with its sensuous character and content of flora, mushrooms and insects, should not be underestimated. The forest is also forming an overall landscape configuration inviting children to run in between different features having one den under a spruce, one at a height of undulated terrain and one in a ravine with tiny trees to swing in, each making up a complex play space for pretend play.

The study of how biodiversity and children's play interlace is in its cradle, but there are practices in planning, design and management getting established which are worth mentioning. Allowing trees in different succession of their life-cycle is acknowledged in many Swedish municipalities, of benefit both to wildlife and children (e.g. lying sticks for building huts or logs to climb). Moving lawns could be done differently by allowing parts of lawns be left as meadows for biodiversity (Ignatieva and Hedblom, 2018) and paths in-between as mazes for children to run.

The vitalizing effects of biodiversity to children's play acknowledged in this paper needs to be scrutinized in relation to how children approach the surroundings with their senses, not only using nature elements as affordances for physical activity but also tuning into its details. Further, could this apply to digital effects too? We have in this paper acknowledged how chestnuts stimulate to play in the quite plain setting of a traditional playground, but what was the role of the colorful flowerbeds adjacent to the benches where they played chestnut-shop museum, or the mushrooms and many insects observed in the moss floor of the forest? When evaluating play spaces our perspective, tools, concepts and inventories need to reflect the complexity of nature itself when relevant for children's play.

4.6. Limitations

Limitations in this study could be that the sample of participating children was rather small and the gender balance differed across the play sessions, which could have accounted for some of the observed differences between settings. The play sessions were set to 45 min, in line with ordinary time schedule for the after-school club, so it is an example of how playgrounds can be used in children's everyday life. The play settings were also in the area where the after-school club went every week, thus familiar to the children. However, one limitation could be that the digital equipment had not been on before the study, so the children encountered the digital functions for the first time when participating in the study. This could have increased the number of observations of explorative play in this setting due to the children

spending time figuring out how the equipment worked. Also, more visits to the three settings by this or another group of children would have added strength to the results. The weather differed slightly between test sessions with somewhat more harsh conditions during the session in the digital forest, which possibly influenced mood and activity. Finally, the analysis of step counting data was challenged by the fact that some children dropped the step counter which makes the sample smaller for this analysis.

5. Conclusions

This comparison of a traditional playground containing natural elements and forest with and without digital installations, was a way to challenge the dichotomy between nature-based outdoor play, and children's attraction to man-made artefacts and digital devices. However, the digital installations seem to have hampered the development of varied and versatile play episodes. Settings augmented with man-made artefacts trigger rule play with some competition at the expense of a more open-ended play flow which is more inclusive to various types of play and beneficial to children's overall health and socio-emotional development. This study also confirms previous research telling us that children´s access to the natural environment, exemplified by the presence of forest and trees with an abundance of chestnuts, is supportive of their exploration and imagination, and contributes to them getting their daily dose of health promoting physical activity. However, this study also illustrates the power of man-made artefacts in how they can intensify the social exchange and the playfulness of the children by triggering them to express themselves through words and bodily movement. In summary, the study points out the importance of making biodiverse land accessible to children of benefit to their play and overall development while highlighting some of the difficulties in making play equipment and digital artefacts contribute to such play flow without taking over.

CRediT authorship contribution statement

Eva-Lotta Sallnäs Pysander: Conceptualization, Methodology, Funding acquisition, Project administration, Supervision, Writing – original draft, Writing – review & editing, Data curation, Visualization, Investigation, Formal analysis, Software. **Fredrika Mårtensson**: Conceptualization, Methodology, Funding acquisition, Writing – original draft, Writing – review & editing, Data curation, Investigation, Formal analysis. **Annika Waern**: Conceptualization, Methodology, Funding acquisition, Writing - original draft, Writing – review & editing, Data curation, Visualization, Investigation, Formal analysis, Software. **Anna Litsmark**: Methodology, Writing – original draft, Writing – review & editing, Data curation, Visualization, Investigation, Formal analysis. **Marcus Hedblom**: Writing – original draft, Writing – review & editing, Data curation, Investigation, Formal analysis. **Anders Raustorp**: Writing – original draft, Writing – review & editing, Formal analysis. **Gebrenegus Ghilagaber**: Writing – review & editing, Methodology, Formal analysis. **Hui Zhu**: Writing – review & editing, Data curation, Visualization, Investigation.

Declaration of Competing Interest

None.

Acknowledgements

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2023.128148.

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