

## Identifying Factors of Young Children's Engagement in Active Play to Inform the Design of TEIs.

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Physically active play is essential in early childhood. Yet, many children aged 3 to 5 do not engage in enough physical activity or active play. Consequently, there is a need to increase young children's engagement in active play and understand the factors that enable them to sustain this play. Tangible, Embedded, and Embodied Interaction (TEI) systems have shown promise to facilitate new opportunities for active play. Few TEIs have been designed to engage children aged 3 to 5 in active play. We ask the question, *how can TEIs be better designed to effectively engage young children in active play?* This paper begins to answer this question through an exploration into how young children currently engage in active play. We conducted semi-structured interviews with fifteen families and five early childhood teachers. These interviews highlighted *activities*, *contexts*, *equipment*, *people*, and *environmental* factors associated with active play engagement. We found that equipment shapes children's activities and provides a context for active play. These findings can inform the design of new and innovative TEIs that facilitate new opportunities to engage young children in active play.

CCS CONCEPTS • Human-centred computing • Human-computer interaction (HCI) • Empirical studies in HCI

**Additional Keywords and Phrases:** Tangible Embedded Embodied Interactions, TEIs, Children, Active Play

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## 1 INTRODUCTION

Active play is essential in early childhood. As adults, we understand the importance of physical activity and exercise to maintain our health and wellbeing. *Active play* is a young child's version of physical activity, as children aged 3 to 5 typically participate in physical activity when they play rather than through structured exercise or sports [7]. Participation in active play can have a positive influence on a child's physical development, health, and wellbeing, as well as their cognitive social, and emotional development [35]. Consequently, it is important that children are provided with numerous opportunities to engage in active play each day.

Tangible, Embedded, and Embodied Interactions (TEIs) can provide new opportunities for active play. Recent studies of TEI systems have demonstrated their potential to engage children in active play activities such as moving randomly and making noises [8], playing hopscotch [9], practicing eye-foot coordination [11], and controlling objects and using them for social play [15]. Despite this, Vickery et al. [39] identified that most of the TEIs designed for children have not been designed specifically for active play, but predominantly for learning and older children aged 5 to 9 [5, 10, 12]. Because of these shortcomings, there is a need to design and develop TEIs that encourage and support engagement in active play for children aged 3 to 5, specifically. Technology is a tool that enables active play, but we need to better understand how active play happens in order to develop better TEIs. Therefore, we ask the question, *how can TEIs be better designed to effectively engage young children in active play?*

In this paper, we take the first step to explore how TEIs could be designed to encourage active play. This study focusses on how children currently engage in active play and identifies the factors associated with active play engagement. To identify these factors, we conducted interviews with fifteen families and five early childhood teachers. The factors we identified from these interviews related to activities, contexts, equipment, people, and environmental influences. These factors informed design insights and considerations to develop TEI systems that are designed to engage young children aged 3 to 5 in active play.

## 2 BACKGROUND

### 2.1 Active Play

Active play has been presented from multiple perspectives, primarily within the fields of education and health sciences. Consequently, there is no widely established definition of active play, which makes it difficult to determine what active play is and how children engage in active play. For this project we identified active play as *a combination of motor skills completed in a fun or motivating way that can result in high energy exertion and supports childhood development*. Active play can be participated in a variety of contexts including structured or unstructured, solitary or social, and indoors or outdoors. This concept of active play was developed from predominantly four definitions [1, 27, 35, 37]. Furthermore, active play has been recognised as an activity that requires children to use various motor skills (gross and fine) and whole-body movements [35, 37]. Although fundamental movement skills (FMS) are often used to represent the basic movement skills required for children aged 3 to 5 [31]. Therefore, this project focuses more on FMS rather than gross and fine motor.

Eddy et al. [16] identified that a child's ability to complete FMS can influence their engagement in active play and physical activity later in life. Similarly, Goodway et al. [17] recognised that a child's perception of their FMS abilities can influence their engagement in physical activities. FMS are separated into three categories: locomotor (i.e., how children transfer their bodies in space), object control (i.e., how children manipulate objects in space) [42] and body management (i.e., how children control their body in opposition to gravity) [17]. Thus, FMS potentially best represents how children

participate in different types of active play activities as they also relate to aspects of gross motor and whole-body movement and are an important aspect of active play.

Furthermore, as active play is a child's version of physical activity, it is often recognised as an activity that involves 'high bursts' of physical exertion, essentially an activity that makes them 'huff and puff' [1]. However, it is important to consider that children have diverse capacities and individual needs, which is also reflected in the definition. It is also important to recognise that active play can be delivered in a variety of contexts, which are often influenced by people and environmental factors. This can include cultural beliefs around physical activity, access to and the availability of equipment and resources, physical space, and time dedicated for active play, play provisions in formal and informal learning environments, as well as a child's cognitive capacity and physical ability. Active play also incorporates aspects of play, it is often recognised as fun [27] or intrinsically motivating [37]. Furthermore, Swift [35] recognised that the combination of play and physical activity enabled by active play can be used to support childhood development in multiple areas – physical, cognitive, social, and emotional. Therefore, enjoyment and developmental benefits are important aspects of engagement in active play.

## **2.2 Concerns for Young Children's Engagement in Active Play**

Current active play guidelines in Australia are provided by the Australian Government Department of Health [4], which recommends that children aged three to five years engage in at least 3 hours of active play throughout each day. Some of the recommended active play activities include running, kicking, throwing, jumping, dancing, and skipping. They state that the more time young children spend engaged in active play, the better. Yet, studies of young children's active play have indicated concerns for their participation in active play [36] and the amount of time children spend sedentary [29]. This is a problem because limited participation in active play can have significant developmental consequences for young children [45].

A factor that is often blamed for their disengagement in active play is young children's use of screen-based devices. Popular media headlines often perpetuate the narrative that young children stay indoors using digital devices such as iPads or watching television rather than playing outside [33]. Warnings and concerns for the negative implications of sedentary screen-time activities are warranted as prolonged engagement in these activities, primarily watching television, has been linked to delays in cognitive and physical development [3], and a rise in childhood obesity [13]. Although these concerns are important to consider, there is now a range of digital technologies, not just TVs and iPads, that can encourage active play such as wearable devices (e.g., Fitbit), active video games (e.g., Just Dance), mobile applications (e.g., Pokémon Go), and digital toys (e.g., VTech 3 In 1 Sports Centre). Therefore, shifting away from sedentary engagement with technology.

Additionally, digital technologies such as television, video game consoles, wearables, and mobile applications have been used by parents to incentivise, facilitate, and encourage young children to engage in active play [30]. Ultimately, how a child uses technology and what the technology enables children to do are the most important things to consider. A child who sits and watches television is not using the television the same way as a child who dances along with characters on the television. Therefore, to mitigate concerns for the use of digital devices and disengagement in active play, there is an opportunity to investigate how new interactive digital technologies could be designed and used to enhance physical development and provide fun active play activities for children.

## **2.3 Tangible, Embedded, and Embodied Interactions (TEIs) Designed for Active Play**

Tangible, Embedded, and Embodied Interactions (TEIs) present new opportunities to engage young children in active play. TEIs combine physical artefacts with interactive digital elements that can be designed to support various physical

interactions rather than limited to a graphical user interface (GUI) such as an iPad screen [20]. As a result, TEIs encompass a range of systems that can be characterised by embodiment, expressiveness, spatiality, and tangibility. Additionally, TEIs offer an alternative to desktop or handheld use as they explore augmented physicality and new interaction methods [19], which can be placed in various locations and allow children to use their whole body to interact with them. Therefore, TEIs can and have been used to facilitate active play.

Tangible interactions enable people to use their bodies to physically interact with the object [20]. The users control and interact with the object as afforded by its physical design and the digital representations such as audio or visual it produces. Additionally, tangible interactions can allow users to understand how their interactions effect the object (e.g., press a button and a light turns on), as the system responds with feedback [41]. The feedback directly represents if the interaction with the object was successful or unsuccessful. An example of a TEI that uses primarily tangible interactions is the *Lantern* [15]. Children could carry around cardboard lanterns with lights inside on the end of long sticks. The children could then make the light inside the lanterns turn on and off by shaking them and change the light colour by banging two lanterns together.

In comparison, embedded interactions allow users to interact with technology through everyday objects, tasks, and environments [22]. Consequently, embedded interactions are those that are seamlessly integrated into technology within a physical context. This interaction type has emerged because computational inputs have evolved beyond interactions with a mouse or keyboard and into physical interactions, gesture-based interfaces, intelligent sensors, Internet of Things (IoT), and RFID tags [38, 32]. *Sounds of Infinity* [8] is an example of a TEI that focuses on embedded interaction. This TEI system is an installation from Vivid 2019 that used multilayer LED lights to encourage the people at the event to make sounds and move within the tunnel to influence the interactive light visuals.

Lastly, embodied interactions refer to the relationship between action and meaning [14]. This means that a user's bodily movements can be leveraged to act within spaces and upon everyday objects to control computation systems [2]. For instance, if a user waves their arms, an avatar on screen will also wave their arms. TEI systems such as *Stomp* [44] employed embodied interactions to enable children to play games such as one where they herd sheep. The children use their physical movement and bodily gestures within the projected floor-based interface to navigate sheep into the correct barn.

In addition, the interactive and digital components of TEIs can appeal to young children's interests in technology. Many young children grow up in a world where they can easily access and interact with devices such as tablets and smartphones and use them as objects and materials for play [26]. However, these devices typically limit children's interaction modality to touch and are often used in a sedentary capacity. To provide opportunities for active play, TEIs can offer new interaction modalities that progress beyond touch-based input. As a result, they could be designed to cater to the physical needs and capabilities of young children, particularly for active play. This can include designing for the inclusion of fundamental movement skills (FMS) and the high energy exertion associated with physical development. TEIs could also provide opportunities to combine whole-body movement with social, learning, or entertainment activities that children need for their development and that they enjoy doing. However, currently few TEIs have been designed to engage children aged 3 to 5 in these rich experiences of active play [39]. Therefore, in this paper we explore how TEIs could be better designed by understanding how children aged 3 to 5 currently engage in active play and identifying design opportunities.

### 3 METHOD

A qualitative research approach was used for this study. The participants involved in this study and the procedure used to conduct this study are outlined in this section.

### 3.1 Participants

Participants in this study were recruited through contacts of the research team via email invitations, flyers, email discussion lists, and social media platforms such as Facebook. Families with children aged 3 to 5 and Early Childhood Teachers (ECTs) who teach children aged 3 to 5 were eligible to participate in the study. In total 15 families and 5 ECTs took part in the study. Participation involved the families and ECTs taking part in an interview conducted by the research team. Ethical approval was provided by the University Human Research Ethics Committee (UHREC). Table 1 provides an overview of the families who participated as it indicates who was interviewed, the age and gender of their child/ren, if their child has siblings, and if their child attends an early childhood education and care (ECEC) centre. Table 2 shows information associated with ECTs who participated such as the ECEC setting they teach in, their current role, and the children they teach.

Table 1: Family Participants

Family	Interviewee/s	Child	Age	Gender	Siblings	ECEC
F1	Mother and Father together	C1	3	F	Yes	Day-care
		C2	5	F	Yes	Prep
F2	Mother	C3	5	F	Yes	Day-care
F3	Mother	C4	4	M	Yes	Day-care
F4	Mother	C5	4	M	Yes	Day-care
F5	Mother and Father together	C6	5	M	No	Kindergarten
F6	Mother	C7	4	F	Yes	Prep
F7	Mother	C8	5	M	Yes	Prep
		C9	4	M	Yes	Unspecified
F8	Father	C10	3	F	Yes	Kindergarten
F9	Mother	C11	3	F	Yes	Unspecified
F10	Mother	C12	4	F	Yes	Kindergarten
		C13	5	M	Yes	Prep
F11	Grandmother	C14	3	F	Yes	Unspecified
		C15	5	M	Yes	Prep
F12	Mother	C16	5	F	Yes	Prep
F13	Mother	C17	5	M	Yes	Kindergarten
F14	Mother	C18	5	F	No	Prep
F15	Mother	C19	5	M	Yes	Prep

Table 2: Early Childhood Teacher (ECT) Participants

ECT	ECEC	Current Role	Children
E1	Kindergarten	Kindergarten Teacher	Aged 3 to 4
E2	Primary School	Prep and Grade One Teacher	Aged 4 to 5
E3	Primary School	Inclusive Program Liasson and Relief Teacher for the whole school	Aged 4 to 5 and with additional needs
E4	Primary School	Organises and Operates Intervention Programs	Aged 4 to 5 and with a first language other than English
E5	Primary School	Grade One Teacher	Aged 5 to 6

### 3.2 Procedure

Semi-structured interviews were conducted to investigate the perspectives of families (parents and caregivers) and ECTs in relation to the active play of children aged 3 to 5. Most of the semi-structured interviews took approximately 15-20 minutes to complete, however some interviews exceeded 30 minutes. We conducted interviews in person at participant's homes, in parks, and online via zoom. The interview consisted of two types of questions – questions that related to demographics of the children and questions that related to active play, toys, and equipment. There were also two separate sets of interview questions, one for families and another for ECTs. Although the questions we asked both participant groups were similar. We also asked interviewees follow-up questions to explore their responses in more depth. Examples of the questions asked include:

*How do you encourage active play or physical activity at home? (Families)*

*Does your child have a favourite toy or play equipment they use? Can you please show/ tell us about it? (Families)*

*Does the childcare/school have activities that encourage children to be active? (ECTs)*

*Are there particular times of the day that the children are more active (or inactive)? Why do you think that is? (ECTs)*

*Do you have any technology-based toys that you use for active play? Can you please show/tell us about it? (Both)*

The interviews were conducted by the research team and were recorded digitally using audio recording software, to be transcribed, coded, and analysed.

### 3.3 Data Analysis

The interview transcripts were imported into ATLAS.ti software and a thematic analysis was conducted. A detailed coding scheme was developed by the team to analyse the interview transcripts. We used the Observational System for Recording Physical Activity in Children for home contexts (OSRAC-H) [24] as a resource to develop our coding scheme. The OSRAC-H is an appropriate resource, as it was developed to document children's physical activity in addition to the associated social and environmental contexts. As such, it provided us with a foundational coding scheme, which we adapted to suit this study. The coding scheme we developed for this study was separated into six themes: Types of Active Play Activities (Table 3); Contexts of Active Play (Table 4); Types of Physical/Traditional Toys and Equipment (Table 5); Types of TEIs, Digital Toys, and Screen-based Technology (Table 6); The Role of Other People for Active Play (Table 7); Environmental Influences on Active Play (Table 8). We also looked at co-occurrences between the codes in these six themes.

The coding scheme used to identify types of active play activities is outlined in Table 3. These codes were adapted from the 'Activity Type Codes' presented in the OSRAC-H [24]. However, we separated the different activities into fundamental movement skill (FMS) categories – locomotor (e.g., running, jumping), body management (e.g., dancing, swimming), and object control (e.g., throwing, pushing) [16]. We separated the activities into FMS categories because this terminology refers to different types of motor behaviours and activities children do [16], rather than using terms such as gross and fine motor as these terms refer to large and small muscle groups [40].

Table 3: Types of Active Play Activities

Code	Example
Locomotor	Climbing, Hanging “They’ve got a swing set and climbing sets, so they are <b>climbing</b> ” – F11
	Crawling, Rolling, Rocking, Sliding “They’ll go down <b>slides</b> , you know, outdoor equipment at day-care...” – F4
	Cycling, Skateboarding, Roller-skating, Scootering “So, all three of us, we’ll go, we’ll <b>ride our bikes</b> from here (there house) to the bike path and just go for bike rides” – F2
	Jumping, Skipping, Hopping, Galloping “ <b>Jumping</b> on the bed and on the couch” – F5
	Running Walking, Marching “My daughter (C11) is very fast at running” – F9
	Dancing, Expressive “C7 will do <b>ballet</b> . She does ballet. So, she does that on a Wednesday. She’ll do 45 minutes... she loves that, she loves to <b>dance</b> ” – F6
Body Management	Movement “When C8 and C9 know they’re supposed to be winding down, that’s when the <b>wrestle</b> mania begins” – F7
	Rough and Tumble Play. Wrestling, Tumbling “... we do <b>swim</b> a lot, and she did classes for a while, but she hated that... we do do that probably twice a month, go for a swim” – F14
	Swimming or playing in a pool “... we do <b>swim</b> a lot, and she did classes for a while, but she hated that... we do do that probably twice a month, go for a swim” – F14
Object Control	Pulling or pushing an object or child “When C1 started to learn to walk, she just loved it (referring to a push along toy). She’d <b>push</b> it and hold on and just walk up and down” – F1
	Swinging on a swing “And we also have a trapeze <b>swing</b> because the kids are into gymnastics. It hangs on our pergola, and they swing out on that” – F12
	Throwing, Kicking, Catching “We bought them those cheap foam planes; they love those things. They will stand out there and <b>throw</b> them backwards and forwards, for you know, an hour” – F10

Table 4 shows the coding scheme used to identify the different active play contexts. This coding scheme was developed from the interview responses and the ‘Indoor Activity Contexts’ and ‘Outdoor Activity Contexts’ codes from the OSRAC-H [24].

Table 4: Contexts of Active Play

Code	Example
Construction Activities	“They love <b>digging in the mud</b> out the back and <b>building the little race pits</b> and whatever else they do...” – F10
Educational Activities	“We used to go to the library a lot. We used to go to a library, like parents’ sessions, and <b>read books together</b> ” – F8
Music	“They love the music, so we’ve popped the <b>music</b> on quite a bit” – F12
Organised Activities	“C4 does <b>soccer</b> on a Saturday morning” – F3
Sociodramatic	“...they <b>pretend</b> to be a bunny, they pretend to be a kangaroo or frog or anything and mimic the movements...” – F1
Board games	“We’ve got a lot of <b>board games</b> as well... So, we’ve got like a dinosaur, and it has eggs in its nest. And so, it’s got like a 30 second timer or something, so you’ve got to try, and you’ve got these tweezers, and you’ve got to try and get the eggs before the dinosaur finds you and goes ‘waa’...” – F6
Digital Games	“He’s been into you know, <b>screen games</b> quite a bit. Like the iPad and other games, you know on screen or XBOX type of games” – F15
Made-up games with rules, Sports Games	“I think the main game that they play at the moment is <b>tag</b> . And it could be any version of tag. And they will do it anywhere, all over the playground” – E4

The coding scheme used to analyse the different types of physical toys and equipment is shown in Table 5. This coding scheme was developed from the interview responses.

Table 5: Types of Physical Toys and Equipment

Code	Example
Balls	“ <b>Basketballs</b> , they have a hoop out the front” – F11
Bikes/Scooters	“It would probably be their <b>bikes</b> I would say, especially the younger two. They love bike riding” – F7
Costumes	“I’ll do lots of <b>dress ups</b> and be you know, Rapunzel and all that sort of jazz. I’ll be princesses for the day and yeah, so lots of dress ups.” – F6
Furniture	“So, they will build <b>two couches</b> in the living room, they like to squish them together and they put a <b>chair</b> on one side, they jump over the back of one. They like rolling and then they’re jumping back over the end of the other one, sort of like an obstacle course.” – F13
Licensed Toys/Media	“His favourite toy and the one that’s probably lasted the longest is probably <b>Lego</b> .” – F5
Nature	“... and also, some <b>trees</b> with wide branches that C1 and C2 can climb” – F1
Playground Equipment	“C4 loves to <b>swing</b> , but also likes the <b>tower</b> , things he could climb on. He likes to run through the little sort of tower” – F3
Push-along Toys	“They both loved their <b>walker</b> . Like, they’d scoot around here and there.” – F10
Small toys/Props	“C3 got a <b>marble run</b> for her birthday, so the room is a total disaster. Um, a lot of <b>stuffed toys</b> , and she’ll interact with the toys and do a lot of imaginative stuff, but it’s sitting on the floor playing” – F3
Sports Equipment	“We also have the <b>soccer nets</b> , so we have the big soccer nets for the big students and then we have the little token nets that are a little bit smaller.” – E2
Trampoline/Bouncer	“We had a <b>trampoline</b> outside that got used multiple times a day” – F4

To identify the types of TEIs, digital toys, and screen-based devices children use, the coding scheme in Table 6 was used. These codes were developed from the interviews in combination with previous explorations of TEIs for children conducted by Vickery et al. [39].

Table 6: Types of TEIs, Digital Toys, and Screen-based Technology

Code	Example								
Digital Toys	“We often have <b>Bee-bots</b> that we will use. We do have them and Pro-bots which are like cars” – E2								
Screen-based Devices	“We have you know, traditional things like an <b>iPad</b> ” – F3								
TEIs	<table> <tr> <td>Augmented Sports</td><td>“...another technology-based toy is a <b>football rack</b> or something, it’s like the gate of a football, and you just kick the ball in, and it will say ‘<b>hooray for you</b>’ and will count how many goals you have, and they similar also have a basketball hoop and it will also count” – F9</td></tr> <tr> <td>Educational</td><td>“The one we’ve got you <b>feed it</b>, like a certain colour to the <b>dinosaur</b> that you feed, or a strawberry... lots of those sorts of toys” – F3</td></tr> <tr> <td>Pretend Play</td><td>“They have like a <b>grocery</b>. It’s like a Shopkins thing you can tap it, and then it makes a <b>beep noise</b>, and you put the money in the cash registers, and it makes a noise. So, it’s probably technology teaching them, you know, about shopping and how they buy things. So, we do use that a bit” – F4</td></tr> <tr> <td>Wearable</td><td>“They’re <b>gumboots</b>, the fact that they have those <b>electronics</b> in the heel and light up” – F1</td></tr> </table>	Augmented Sports	“...another technology-based toy is a <b>football rack</b> or something, it’s like the gate of a football, and you just kick the ball in, and it will say ‘ <b>hooray for you</b> ’ and will count how many goals you have, and they similar also have a basketball hoop and it will also count” – F9	Educational	“The one we’ve got you <b>feed it</b> , like a certain colour to the <b>dinosaur</b> that you feed, or a strawberry... lots of those sorts of toys” – F3	Pretend Play	“They have like a <b>grocery</b> . It’s like a Shopkins thing you can tap it, and then it makes a <b>beep noise</b> , and you put the money in the cash registers, and it makes a noise. So, it’s probably technology teaching them, you know, about shopping and how they buy things. So, we do use that a bit” – F4	Wearable	“They’re <b>gumboots</b> , the fact that they have those <b>electronics</b> in the heel and light up” – F1
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Wearable	“They’re <b>gumboots</b> , the fact that they have those <b>electronics</b> in the heel and light up” – F1								



Code	Example
Installations	“... the <b>screen and the projector</b> casting onto the floor, so sometimes he will play you know, like jumping onto fish, or like kicking that ball, or playing the racing car” – F15

The coding scheme in Table 7 was used to identify children’s relationships with other people during active play. These codes were established from the interviews responses.

Table 7: The Role of Other People for Active Play

Code	Example
ECTs	“I (ECT) also have a gross motor afternoon where we really work on skill-based activities” – E2
Parents/caregivers	“I think they like piggy in the middle the most... their <b>mum or dad</b> is in the middle, and I think that is probably why they like it the most. When they’re in the middle, it’s just meltdowns... they do get their turns in the middle, but I think the enjoyment for them is trying to beat mum or dad” – F4
Peers/Friends	“When the <b>neighbours</b> come over, which is frequently, they will do some sort of tag game” – F11
Siblings	“Yeah, they have role play at home. Yeah, so one pretends to be the policeman and the other sometimes the, always it’s the little one asked to the <b>big sister</b> to be a criminal or something like that” – F9

Table 8 presents the coding scheme used to identify the different environments associated with active play. These codes were created from the interview responses.

Table 8: Environmental Influences on Active Play

Code	Example
Indoors at Home	“Riding a scooter down the <b>hallway</b> (in their house). Things like that.” - F13
Outdoors at Home	“Yes, playing <b>outside</b> ... we have a little jungle gym play equipment outside. We have a trampoline we like to jump on” - F8
Indoors at School	“Even active play <b>inside the classroom</b> and move all of the furniture back.” - E2
Outdoors at School	“We’ve also got <b>ovals</b> and <b>basketball courts</b> .” - E2
Indoor Public Space	“The other place I go to is like that <b>indoor playground</b> .” – F7
Outdoor Public Space	“There’s a <b>park</b> near us that has these massive, I call them hamster wheels, I don’t know what they’re called, where the kids can get in them and run around.” – F13

## 4 RESULTS

This section presents the findings from the semi-structured interviews conducted with the 15 families and 5 ECTs in this study. The results from this study have been presented as both code frequency and participant total. Code frequency refers to the number of times a code was mentioned in the interviews. Participant total refers to the number of participants who discussed the code. We used a combination of code frequency and total participant responses to identify clearly the dominant factors associated with active play. These descriptive statistics are presented to provide a higher-level overview of the key themes and present the data in a transparent way. We have used key quotes from the interviews to further illustrate the importance of the factors we identified.

#### 4.1 Types of Active Play Activities

A total of 32 active play activities were identified using the coding scheme presented in Table 3. The results are shown in Table 9. Although the coding frequency may indicate that running was the most common activity, the same number of participants indicated children participate in jumping activities. As the code frequency may be misrepresentative, we focussed on the number of participant responses to determine the active play activities that are the most participated in by children. As a result, we found that the most common active play activities are running, jumping, cycling, climbing, and swimming. For example, F4 discussed how their child uses their own initiative to go outside and run around in the morning. F15 revealed that their child “*jumps onto the fish*” projected on the floor at a local library. Similarly, F8 mentioned that they take their child to a bike park as they are learning how to ride a bike.

Interestingly, we identified that the most common activities involve locomotor FMS. Fewer participants mentioned body management and object control activities. The most common body management activity was swimming. F12 stated that their child “*loves to swim*” and “*swims all the time*”. Additionally, the most common object control activity was swinging on a swing. E1 discussed how the children at their kindergarten spend a large amount of time outside using the swings. Overall, our results for this category indicate that body management and object control activities were mentioned significantly less than locomotor activities.

Table 9: Active Play Activities Identified from the Interviews

<b>FMS Category</b>	<b>Code</b>	<b>Code Freq.</b>	<b>ECTs</b>	<b>Families</b>	<b>Participant Total</b>
<i>Locomotor</i>	Climbing	16	4	8	12
	Hanging		0	0	0
	Crawling	11	1	2	3
	Rolling		1	4	5
	Rocking		0	0	0
	Sliding		0	4	4
	Cycling	38	0	12	12
	Skateboarding		0	0	0
	Roller-skating		0	2	2
	Scootering		0	10	10
	Jumping	31	4	12	16
	Skipping		1	0	1
	Hopping		0	0	0
	Gallop		0	0	0
	Running	59	3	13	16
	Walking		0	7	7
	Marching		0	0	0
<i>Body Management</i>	Dancing	20	2	6	8
	Expressive Movement		2	2	4
	Yoga		1	2	3
	Gymnastics		1	2	3
	Rough & Tumble Play	13	0	2	2
	Wrestling		0	5	5
	Tumbling		0	1	1
	Swimming/Playing in a pool	21	0	12	12
	Balancing	2	2	0	2
<i>Object Control</i>	Pulling/Pushing an object or child	5	0	2	2

FMS Category	Code	Code Freq.	ECTs	Families	Participant Total
	Swinging on a Swing	12	2	8	10
	Throwing	20	2	3	5
	Catching		2	1	3
	Kicking		2	6	8
	Bouncing		1	0	1

## 4.2 Contexts of Active Play

There were 7 contexts of active play identified in the interviews. The coding scheme in Table 4 was used to identify the most common contexts for active play. The results are shown in Table 10. In comparison to the active play activities identified in section 4.1, there was a more direct relationship between the code frequency and the number of participants who discussed the context. As a result, it was easier to say confidently that active play that incorporates aspects of sociodramatic play were the most common contexts. ‘Sociodramatic’ contexts included imaginative play and role play. For instance, F1 mentioned how their children play *“chicken school”* and pretend to be animals and teachers. F14 discussed how her child often plays *“mummies and daddies”* and *“puts her dolly in the (toy) car and takes her shopping”*. ‘Made-up Games with rules, Sports Games’ were also mentioned, as children play games such as tag or chasey, hide and seek, and soccer. E2 discussed how younger children have their own small games of soccer or their own game of handball at their school. ‘Organised activities’ were also commonly discussed as active play contexts and included scheduled activities organised by families such as swimming, gymnastics, soccer, dancing, and classroom-based activities, as well as planned by ECTs such as brain breaks, gross motor or movement activities. For example, F2 stated that their child does *“gymnastics on a Friday morning”* and E4 mentioned that children in their school *“do PE lessons once a week with the PE teacher”*. ‘Digital Games’ were also common contexts and include Minecraft, Simply Piano, Wii Sport, and GoNoodle. Although few digital games were used for active play.

Table 10: Active Play Contexts Identified from the Interviews

Code	Code Freq.	ECTs	Families	Participant Total
Construction Activities	14	2	4	6
Educational Activities	12	1	6	7
Music	18	0	6	6
Organised Activities	44	4	11	15
Sociodramatic	55	5	13	18
Board games	5	0	4	4
Digital Games	38	2	8	10
Made-up games with rules, Sports Games	51	4	11	15
Creative Activities	2	1	1	2

## 4.3 Physical Toys and Equipment used for Active Play

A total of 13 types of toys and equipment were identified from the interviews using the coding scheme in Table 5. The results are shown in Table 11. The most common type of equipment mentioned for active play was ‘Playground Equipment’. Playground equipment included things such as slides, swings, forts, and climbing structures. F10 stated that her daughters *“big thing at the moment is just playing on their fort”* and F1 mentioned that they take their children to the several different playgrounds in their local area as they have different equipment for them to play on. ‘Small toys/Props’ were also common. Some of these toys included figurines, Lego, vehicles, dolls, and soft toys. However, this type of toy

was often not used for physically active play. Although, F5 stated that if their child “*built a Lego ship, he would run with it*”.

Table 11: Equipment and Toys used for Active Play Identified from the Interviews

Code	Code Freq.	ECT	Families	Participant Total
Balls	30	3	11	14
Bikes/Scooters	45	0	11	11
Costumes	2	0	2	2
Furniture	7	1	3	4
Licensed Toys/Media	26	2	7	9
Nature	5	1	4	5
Playground Equipment	54	5	14	19
Push-along Toys	5	0	2	2
Small toys/Props	46	2	13	15
Sports Equipment	14	3	3	6
Trampoline/Bouncer	31	2	10	12
Roller-skates	2	0	2	2

#### 4.4 Digital Equipment used by Children

There were 3 distinct types of digital technologies identified using the codes identified in Table 6. The results are presented in Table 12. ‘Screen-based technology’ was the most common digital equipment children use. Of these devices, the most common were iPads. For example, F3 stated that they have “*traditional things like an iPad*”. Projector Screens and televisions were also discussed, as well as gaming consoles, mobile phones, and computers. Of these screen-based devices, only seven participants indicated that they use them to encourage active play. For example, E5 discussed how they use screen-based technologies, mostly projectors and screens for movement breaks or to play movement games. Similarly, F10 and F13 mentioned that they use the Nintendo Wii to play games such as tennis and bowling to encourage their children to be physically active indoors. Children also use digital toys, which included vehicles with digital features, interactive books, interactive Pets, programmable Robots, and remote-control cars. Although these types of digital toys were often not used for active play. Lastly, we found that some parents did own TEIs, although many didn’t know that they could be categorised as such. Some of these TEIs, such as the ‘Augmented Sports’ mentioned by F9 and F10 were used for active play, as their children could throw or kick balls into a goal or hoop.

Table 12: Digital Toys Equipment Children Use Identified from the Interviews

Code	Code Freq.	ECTs	Families	Participant Total
Digital Toys	28	3	8	11
Screen-based Devices	77	5	15	20
TEIs Augmented Sports	3	0	2	2
Educational	2	0	2	2
Pretend Play	5	0	2	2
Wearable	2	0	2	2
Installations	1	0	1	1

#### 4.5 People Who Influence Active Play

From the coding scheme presented in Table 7 we found that 5 different groups of people influence active play. The results are shown in Table 13. Most commonly, ‘Friends and Peers’ were identified to influence active play. For example, F6,

F11, and F12 all mentioned that their children are friends with neighbouring children and play with them often. E2, E3, and E5 also discussed that children play games with friends and peers at school. ‘Parents and Caregivers’ was the next common, as families spoke about how they participate with, model, and encourage active play. F13 said that “we’re (the whole family) outside, and it’s chasing each other or kicking the ball, or game, they just love to play chasey”. In comparison, E2 mentioned that they noticed a decline in active play activities since they started teaching and speculate it “*may be a time thing with parents, or maybe not willing to supervise them outside, or maybe they are just being a bit more protective*”. Thus, parents may also unintentionally be a barrier to participation in active play. Additionally, siblings can also influence active play. 13 of the 15 families in this study had multiple children, meaning many children had siblings. Siblings often played together. Families and ECTs also indicated that older siblings and students modelled active play for younger children. For example, F6 discussed how their oldest child often chooses to do an activity such as soccer or cricket and their younger siblings join in with their activity.

Table 13: The People Who Influence Active Play Identified from the Interviews

Code	Code Frequ.	ECTs	Families	Participant Total
Friends/Peers	43	4	12	16
Siblings	26	0	9	9
Parents/Caregivers	30	1	12	15
ECTs	15	5	0	5
Individual	8	2	5	7

#### 4.6 Environmental Influences on Active Play

We identified 6 different active play environments from the codes presented in Table 8. The results are shown in Table 14. ‘Outdoor Public Spaces’ were the most commonly discussed in the interviews as they were coded 25 times and mentioned by 12 families (no ECTs). Parks were the most common outdoor spaces discussed by families. For example, F4 stated that “*in the mornings, as soon as they’re up and they’ve had brekky they want to get out of the house, so my husband took them to (a local) park*”. ‘Outdoors at Home’ was also mentioned often as it was coded 16 times and mentioned by 10 families (no ECTs). Families such as F3 who have homes with backyards mentioned that their children often play there. Similarly, ‘Outdoors at School’ was expressed by the ECTs who work in primary schools as the place where children most typically participate in active play. These spaces included sports courts, and ovals. In comparison, E1 who works at a kindergarten described that the children often participate in active play both indoors and outdoors as they are always moving and doing things within the two environments. There were some interesting mentions of indoor spaces both at home and accessible to the public. For example, F7 mentioned that they often go to indoor playgrounds and F13 discussed indoor trampoline centres. Additionally, families such as F10 revealed that their children participate in active play inside their home.

Table 14: Environments Associated with Active Play as Identified in the Interviews

Code	Code Freq.	ECTs	Families	Participant Total
Indoors at Home	4	0	4	4
Outdoors at Home	16	0	10	10
Indoor Public Spaces	5	0	4	4
Outdoor Public Spaces	25	0	12	12
Indoors at School	2	2	0	2
Outdoors at School	7	4	0	4

#### 4.7 The Relationships Between Activity, Context, and Equipment

We identified relationships between the activities, contexts, and equipment associated with active play. These were operationalised as co-occurrences, which arise when two codes overlap within sections of the interview transcripts. The co-occurrences are presented in Table 15. The most common co-occurrence between activities and equipment was between ‘Bikes/Scooters’ and ‘Cycling, Skating, Roller-skating, Scootering’. For example, F4 mentioned that their children use their bikes and scooters and *“cut laps around their house”*. There was also a strong relationship between ‘Playgrounds’ and ‘Climbing, Hanging’ as well as Swinging on a Swing. For instance, F11 stated that *“they’ve got a swing, and climbing sets, so they are climbing on that”*. We also identified that activities have relationships with contexts. The most common was between ‘Running, Walking, Marching’ and ‘Made-up Games with Rules/ Sports Games’. E4 mentioned the children will play Minecraft inspired tag games *“that will involve a lot of running and a lot of chasing”*. There was also a connection between context and equipment. For example, ‘balls’ were often associated with ‘Made-up Games with Rules/ Sports Games’ such as soccer. Similarly, sociodramatic play was often related to ‘Small toys/Props’. For example, F6 stated that her child would *“just pick up a baby (doll) and she’ll walk it and feed it”*.

Table 15: Co-occurrences between Active Play Activities, Contexts, and Equipment

Activity	Context	Equipment	Co-occurrence Freq.
Climbing, Hanging		Playgrounds	12
Swinging on a Swing		Playgrounds	10
Cycling, Skating, Roller-skating, Scootering		Bike/Scooters	35
Jumping, Skipping, Hopping, Galloping		Trampoline/Bouncer	11
Throwing, Kicking, Catching		Furniture	6
		Balls	26
Running, Walking, Marching	Made-up Games with Rules/ Sports Games		18
Swimming	Organised Activity		9
Dancing	Organised Activity		4
	Music		6
	Made-up Games with Rules/ Sports Games	Balls	12
	Sociodramatic	Small Toys/Props	12

## 5 DISCUSSION

In this study we aimed to uncover the current factors associated with young children’s engagement in active play. We interviewed families and ECTs as they can provide insights into how children aged 3 to 5 typically engage in active play at home and in educational environments. From the interviews, we identified factors that relate to activities, contexts, equipment, people, and environments associated with active play. Unlike previous studies of young children’s active play that focussed on one participant group within a specific environment and studied children outside the age of 3 to 5 [e.g., 6, 23, 34], we interviewed two different participant groups – families and ECTs with children aged 3 to 5, which provided a broader range of factors associated with engagement in active play. Our findings are used to propose design considerations for TEIs that could engage young children in active play. Currently, explorations into TEIs for active play typically focus on prototype development and user testing [e.g., 9, 15], rather than an exploration into what factors can facilitate rich active play experiences. Furthermore, Cibrian et al. [11] recommended more studies explore how TEIs could sustain engagement

over longer time periods. Therefore, this study aims to uncover important considerations for TEIs designed engage young children in active play based on the current associated factors.

Our results suggest that the activities, contexts, people, equipment, and environments associated with active play are not isolated. There are often relationships between these factors that can influence how young children engage in active play. These relationships are important to consider as they can also influence and inform how TEIs should be designed to facilitate active play. The most significant relationships we identified in this study that can be used to inform TEI design are between activity and equipment, activity and context, and context and equipment as presented in Table 15. As TEIs can be viewed as ‘equipment’ to encourage active play, these relationships help to identify key design considerations for TEIs. Factors related to people and environment are also important to consider as they play a part in these relationships. Therefore, the interrelationships between the five factors highlight opportunities for how TEIs could be designed to facilitate active play.

### **5.1 Equipment can Influence Activities and Contexts**

We identified in section 4.7 there is a significant relationship between the active play activities children participate in and the equipment they use. Many of these relationships may be quite obvious. For example, bikes and cycling, trampolines and jumping, throwing and balls. However, these relationships provide keep insights that can be used to inform how TEIs might be designed to engage young children in different active play activities. For instance, if we wanted children to jump, trampolines could be used as a part of a TEI system to enhance that activity. These relationships also highlight the popularity of equipment and activities, which could be leveraged in TEI systems. Additionally, these findings could help identify new opportunities to engage children in underrepresented active play activities.

Our results highlight that the equipment children have access to enables the different active play activities children engage in. This was reflected in both the traditional and digital equipment children use, as those who had access to different types of equipment typically participated in more varied active play activities. Moss et al. [25] also found that the type of equipment that children have access to, whether that be fixed, portable, or electronic, can influence physical activity. Furthermore, Gunter et al. [18] indicate that children’s access to fixed and portable play equipment may be instrumental to maintain children’s engagement in physical activity. Consequently, it is important to consider how accessible the TEI is to young children.

Furthermore, the connection between activities and equipment highlights an opportunity to develop TEIs that can facilitate different types of FMS – locomotor, object control, and body management. This study highlights the prevalence of locomotor FMS activities. The relationship between equipment and activity may be a reason why locomotor activities are highly represented in this study. As it is important that children develop FMS across the three categories for physical and mental health [16], cognitive, perceptual, and social skills [42], and school readiness [35], there is an opportunity to explore how TEIs may facilitate active play activities that incorporate more body management and object control FMS.

Similar to activity, the equipment children have access to can enable children to engage in active play in different contexts. How a child uses equipment can influence the context in which they engage in active play. How the equipment itself is designed can also facilitate different contexts of active play. Thus, the equipment children use can both infer and be specific to contexts of active play. Therefore, it is important to consider how TEIs could be designed and used by children to enable their engagement in different contexts of active play.

## **5.2 Activities can be Context Dependent**

We also found that there is a relationship between active play activities and contexts. Similar to equipment, context can influence the activities children participate in. Some of the contexts were unstructured or daily activities, whereas others were structured or organised by parents and ECTs. As such, how often the context appeared in the lives of children influence their engagement in active play. For example, the activities that were more unstructured typically related to activities that children participated in more often. These activities often also involved locomotor FMS. In comparison, structured active play contexts such as swimming and dancing were less frequent, which meant that children did these activities less often (e.g., a weekly lesson). Most of these contexts provided children with opportunities to participate in body management and object control activities. Consequently, children may participate in these activities less often, which also may explain why body management activities were less common than locomotor. Therefore, context can enable children to engage in different active play activities.

## **5.3 Other People can Influence Activities, Contexts, and Equipment**

Our study also identified that the social relationships children have with other people can influence the activities, contexts, and equipment associated with active play. Our results indicate that active play is often a social activity enabled by their relationships with friends, peers, parents, caregivers, and ECTs. Most typically, we found that children engage in active play with other children, often similar in age. This often enable children to engage in more unstructured and imaginative types of active play, where their play is centred around different activities, contexts, and equipment relationships. In comparison, older children model active play, where younger children mimic them. This is typical behaviour in collaborative play, as children take on a hierarchical structure when they play together [28]. There, it is important to consider how TEIs could be designed to support the different social relationships children have with other people and how this influences their engagement in active play.

## **5.4 Environment can Determine the Activities, Contexts, Equipment, and People**

Our findings also indicate that the environment influences how children engage in active play. A child's environment effects factors that relate to activities, contexts, equipment, and people. Similar to Johnstone et al. [21], we found that children often participate in active play outdoors as children generally have more space to engage in more high energy active play especially and to use portable equipment such as bike and balls. Outdoor environments such as backyards at homes, school yards in ECEC centres, and public parks often have fixed equipment such as playgrounds to engage children in active play. A child's access to these environments often depends on the setting they are in. For instance, when children are at home and under their parent's supervision, they have access to different environments for active play compared to at an ECEC centre or primary school. Such environments also allow for children and other people to participate in active play together and can influence who they might play with. Consequently, TEIs should be designed with an environment in mind such as homes, ECEC centres, and public spaces and how these spaces can influence how children engage in active play. These findings also highlight an opportunity for TEIs to engage children in active play indoors, which could be beneficial in situations where outdoor active play is impacted by extreme weather for example.



## 5.5 Design Considerations for New TEIs

From our findings we propose design considerations for future TEIs. We suggest that TEIs designed to engage children in active play should:

**Facilitate less common active play activities.** TEIs could be designed to develop FMS skills and facilitate active play activities that are not as common – body management and object control. We make this suggestion because there is a broad range of equipment that enables children to engage in active play activities that incorporate locomotor FMS. Thus, TEIs could provide additional opportunities to engage young children in wide-ranging active play activities. Particularly, when tangible, embedded, and embodied interactions are combined to allow for more diverse movements and actions.

**Incorporate contexts that children enjoy.** TEI design should consider how they may facilitate different active play contexts. As children often incorporate sociodramatic play types and made-up games into their active play, TEIs could incorporate such contexts to encourage engagement. Incorporating these contexts may also enhance opportunities for rich active play experiences that not only enables physical development, but occasions for cognitive and social development also.

**Allow for individual and social play.** Active play is often a social activity, thus TEIs should be designed to allow children to use them individually and with other people. As such, TEIs could be designed to support different social relationships and play between a child and other children, their parents, and ECTs.

**Consider the environment they are being designed to be used in.** A child's environment has overarching implications on how they engage in active play and should be designed to suit the environments children play in. Consequently, designers should consider if the TEI is to be used at home, educational, or public spaces, and if children will use the TEIs indoors or outdoors in these spaces. As children typically play outdoors, there is an opportunity to develop TEIs that could be used indoors to offer further instances for active play.

## 5.6 Limitations

A limitation of this study is that the results are based on the perspectives of adults – parents, caregivers, and ECTs – not from the perspectives of children aged 3 to 5. It also should be considered that our results are based on the perceptions and experiences of parents and ECTs, rather than direct observations of children made by the research team, early childhood teachers, or TEI experts. Consequently, the participants in this study may have more diverse ideas of what active play is and use their personal experiences to inform their responses. However, the participants we interviewed spend a large amount of time with children aged 3 to 5 and could provide insight into the factors associated with their engagement in active play. A previous study conducted by Wiseman et al. [43] used a draw and tell method to allow children to talk about their preferences for active play. Our study uncovered similar findings, as parents and ECTs expressed children's preferences for outdoor, unstructured, and social play activities.

## 6 CONCLUSION

The aim of this study was to uncover the factors associated with young children's current engagement in active play to inform the design of new TEIs. We identified activities, contexts, equipment, people, and environments often associated with active play. The results of this study reveal that equipment shapes how children engage in active play as it encourages different activities and provide a context. This finding highlights that TEIs could impact how children participate in active play through the activities and context types that TEI can facilitate. Furthermore, this study identified that people and environmental factors can determine how children engage in active play and are also important considerations for TEI design. We have used these findings to present design considerations for TEIs that may provide new opportunities to

engage young children in active play. Our future work will use these design considerations to inform the design and development of TEIs to encourage children aged 3 to 5 in active play.

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