Parent Perspectives on Tangible Digital Toys for Preschool Children's Physically Active Play

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Tangible digital toys can foster physically active play by helping children explore their physical capabilities and expend energy. Although parents are crucial in promoting these toys to support active play, their perspectives remain underexplored. To address this, we interviewed 18 parents of young children. Our analysis revealed three key insights: (1) common design features of the toys and their anticipated roles; (2) parents' preferences for tangible digital toys and how they are used by children; and (3) the play activities and motor skills that parents hope these toys will support. Based on these findings, we discuss implications for research on children's tangible interaction and offer six recommendations for researchers and designers focused on designing interactions and digital toys that promote physically active play.

CCS CONCEPTS • Human-centered computing • Human-computer Interaction (HCI) • Empirical studies in HCI

Additional Keywords and Phrases: Digital Toys, Parents, Physically Active Play, Pre-schoolers, Tangible Interactions

1 INTRODUCTION

Toys play an important role in early childhood by inviting, shaping, and extending children's play experiences [17]. In recent years, designers have increasingly integrated digital features such as interactive screens, auditory features, and light-up components [10]. These elements are essential for delivering prompts, providing feedback, and engaging children's attention and interest [52]. Consequently, a range of digital play products is available for children, including smart toys, tangible digital toys, and robots [10]. Each type offers varying levels of network connectivity and processing capabilities, supporting different aspects of children's development [22].

This paper focuses on tangible digital toys for physically active play, which help children explore their physical abilities and expend energy [45]. Traditionally, such play has been supported by physical toys and equipment like scooters, balls, bikes, monkey bars, slides, and sandpits. Research highlights that digital toys incorporating tangible interaction [28] are particularly effective because they build on children's familiarity with physical objects [16] and involve their bodies in everyday actions [21]. For instance, interactive playmats with music can stimulate and sustain play. Parents are crucial in the adoption of these toys, as they typically make purchasing decisions [37]. Their perceptions of digital technologies – whether seen as opportunities, risks, or a combination of both – affect how these toys are used at home [15]. Additionally, parenting styles and practices influence how parents encourage and support their children's physical activity [32]. While research has shown that parents use digital technologies, such as video games and social media, to inspire physical activity [40], there is a lack of understanding about their perspectives on tangible digital toys specifically designed for physically active play.

Therefore, we conducted semi-structured interviews with 18 parents of young children to explore their perspectives on using tangible digital toys in their children's physically active play. Our goal was to understand their preferred physical and digital features for these toys, how they envision these features functioning during play, and the contexts in which they prefer their

children to use them. We also sought to identify the types of play activities parents hope these toys will support and the motor skills they wish their children to develop. To facilitate the discussion, we used three toys as examples: the Vtech 3 in 1 Sports Centre Playset, the LeapFrog Learn and Groove Musical Mat, and Light-up Rainboots.

This paper outlines the common design features and roles parents envision for digital toys intended for physically active play. It details parents' preferences regarding where, with whom, and under what contexts these toys are used, and the types of active play activities and motor skills that parents expect them to facilitate. The findings contribute to (1) expanding the understanding of parents' perspectives on their children's physical activity with tangible digital toys, and (2) providing design and research recommendations that integrate parents' insights to enhance the effectiveness of these toys in supporting children's physical activity.

2 BACKGROUND

2.1 Physically Active Play and Fundamental Movement Skills (FMS) in Early Childhood

Physically active play is important for young children, as it increases physical activity levels [2], supports imagination, exploration, and learning [44]. While definitions vary - health disciplines emphasise high energy [39, 46] and early childhood education focuses on motor skill development [44] – we define active play as *"a combination of motor skills completed in a fun or motivating way that results in high energy exertion and supports childhood development. Active play can occur in a variety of contexts including structured or unstructured, solitary or social, and indoors or outdoors"* [45]. Active play enhances motor skills proficiency, particularly Fundamental Movement Skills (FMS) [44]: locomotor skills, such as running, hopping and jumping, enable children to move from one place to another [54]; object control skills involve manipulating objects and are crucial for activities like, catching and kicking [54]; and body management skills, such as dancing and twisting, help children to control their own bodies [18]. Despite its benefits, many young children often do not meet the Australian government physical activity guidelines [12], highlighting the need for interventions. Digital devices, particularly those prompting tangible interactions, have demonstrated capability in encouraging full-body movements [4, 29].

2.2 Designing Tangible Digital Toys for Young Children's Physically Active Play

Digital toys have been explored for their potential to support various aspects of young children's development, including free play [11], music education [29], and physical activity [6]. While they can offer benefits as a natural part of play [9, 37], many digital toys are limited in encouraging physically active play [52] due to their screen-based features, which tends to confine interactions to fine motor skills rather than supporting FMS or whole-body movements [22]. The term "digital toys" covers a broad range of play products with different interaction capabilities [26]. Toys that promote tangible and embodied interactions are referred to as "tangible digital toys" in this paper, which involve material objects that children manipulate [21] and that respond to movements with sensory feedback [29]. These toys offer auditory, visual, and tactile feedback [22] and are particularly suited for developing motor skills in young children [34]. Therefore, we define tangible digital toys as those that: 1) use physical objects to encourage bodily interactions from children; 2) stimulate fun [56]; 3) provide sensory-based digital prompts and feedback in response to children's movements [52].

2.3 Parents' Perspectives of Young Children's Technology Use

Parents' practises and attitudes significantly influence their young children's use of digital technologies [38], which can be vastly different [41]. Some parents restrict digital devices use [38], while others, despite recognising its potential benefits, see it as a double-edge sword [25] – using it for convenience but also believing in the need to regulate its use [25]. Given the benefits of physically active play and the potential of digital toys to support such activities, we explored parents' perspectives for two main reasons. Firstly, despite the acceptance and practise of physically active play with non-digital toys, many children do not engage in sufficient physical activity [12], with concerns that screen time may contribute to this issue [53]. Thus, assessing whether digital toys can offer additional benefits is essential. Second, parents' attitudes shape how digital toys are used by their children [15, 31, 35]. Therefore, incorporating parents' perspectives is crucial to designing digital toys that effectively promote meaningful interactions and support children's development.

3 METHOD

This study explored parents' perspectives on incorporating tangible digital toys into young children's physically active play. To illustrate the concept, we used three example toys for their children to play with. However, when discussing their opinions, parents considered the broader concept of such toys. During each session, children played with the toys freely. After observing their children play, we interviewed parents to gather their insights. The following sections detail the example toy selection, participants, procedure, and data analysis approach.

3.1 Example Toys

We selected three example tangible digital toys for our study: the LeapFrog Learn and Groove Musical Mat, the VTech 3 in 1 Sports Centre Playset, and the Light-up Rain Boots (Figure 1). These toys were chosen to represent different levels of tangibility [50] and the varying degrees of physical interactions required to control digital data [31]. The Boots are the least tangible, offering consistent digital responses regardless of interaction. The VTech is more tangible, providing different digital responses based on specific interactions. The LeapFrog is the most tangible, with each unique physical interaction generating a distinct digital response. Additionally, these toys facilitate a range of active play activities that engage various FMS. The VTech, with its basketball, soccer ball, and mini ball, emphasises object control skills like throwing and kicking. The Boots light up with each step, prompting locomotor activities such as stepping, walking, and running. The LeapFrog includes game, music, and explore modes where children step on various circle patterns with animals, numbers, colours, and musical instruments, focusing on body management skills.

Figure 1 Overview of three toys: (1) LeapFrog Learn and Groove Musical Mat, (2) Vtech 3 in 1 Sports Centre Playset, and (3) Light-up Rain Boots

3.2 Participants and Ethical Conduct

The study involved 18 families, with 15 mothers and 3 both mothers and fathers. Twenty children, aged 3-5 years (10 girls and 10 boys, including siblings from two families), participated in playing with the example toys. All participants were from Brisbane, Australia. This study was ethically approved by the University Human Research Ethics Committee (approval number: 6618).

Parents signed consent forms for interviews and their child's participation. Data is securely stored and accessible only to the research team, with all recordings deleted from recording devices and participants' personal information anonymised.

3.3 Protocol

The interviews were conducted in 2022, ranging from 10 to 25 minutes. All interviews were conducted in person with two researchers present. To accommodate participants' preferences, interviews were either conducted in their homes or on the campuses of Queensland University of Technology. However, due to COVID restrictions, we were unable to conduct this study in consistent locations. During each session, one researcher supervised the child while the other interviewed the parent. The interviews were audio-recorded using the researchers' mobile phones. When discussing digital toys, the questions covered a broader range of tangible digital toys beyond the example toys presented to the parents. Each session began with a play period, where the child interacted with the example toys freely. Following the play session, the parent(s) were interviewed. The questions were:

1. What do you think about the digital toys your child used today?
2. Do you think that digital toys would change how your child actively plays? How?
3. How do you see your child using a digital toy for active play?
4. Where would your child most likely use a digital toy (e.g., at home, day care, outdoors) for active play?
5. Do you think your child would use digital toys regularly for active play? Why/How?
6. What types of active play would you like to see digital toys facilitate? What would you like your child to experience from using digital toys?
7. Do you have any concerns around children's engagement with digital toys or how they might use them?

3.4 Data Analysis

For data analysis, we employed a Thematic Analysis [7] approach. We transcribed the audio recordings using Otter.ai software and had each transcript reviewed for accuracy by two researchers. Coding was performed using ATLAS.ti [3]. Each transcript was coded twice by one researcher, with a one-month interval between coding sessions.

Our approach combined both deductive and inductive coding methods. We began with deductive coding, using the Elements, Behaviours, and Experiences (EBE) framework [14] to establish theme groups based on our research questions. The EBE framework guided our scheme: Elements refer to toy features, Behaviours include the active play and FMS, and Experiences encompass contexts supporting physically active play. Table 1 provides an overview of these theme groups and their encompassed themes. Codes for FMS within the Behaviours theme group were adapted from [44], while codes for other themes were developed inductively. We then applied inductive coding to analyse the transcripts, categorising data into relevant themes to refine our understanding of how elements influence play behaviours and experiences.

Table 1 Overview of Key Theme Groups

Theme Group	Theme	Description
Elements: Design Feature	Physical Feature	Physical features of toys (physical components and material properties)
	Digital Feature	Digital features of toys (auditory, tactile, visual features)
Behaviours: Active Play	Activity Type	Types of play activities such as role play or ball sports
	FMS [47]	Locomotor
		Body Management
		Object Control
Experiences: Context	Environment	Environment of children's active play (indoors or outdoors)
	People	The people involved in play (e.g., friends, family members)

4 RESULTS

This section presents the findings from the semi-structured interviews. Results are shown as both code frequency (CF) and participant total (PT). CF presents the number of times a concept was coded, while PT indicates the number of participants who made comments in each category. Table 2, 3, and 4 detail the codes under each theme group listed in Table 1, along with their CF and PT as identified from the interviews.

Table 2 Design Feature Identified from the Interviews

Theme	Code	Description	CF	PT
Physical Feature	Button	Buttons on the digital toys associated with digital or mechanical responses.	9	5
	Screen	Integrated screens or interfaces of digital toys; or screens of mobile devices/tablets.	6	5
	Size	The physical size of digital toys.	5	5
	Layout /Pattern	The graphical patterns of digital toys that affect children's interactions.	5	5
	Colour	The different colours as part of digital toy design that parents believed could affect children's interactions; or form a part of play activities.	2	2
Digital Feature	***Roles***			
	Feedback	When digital toys provide feedback to children's interactions in digital form	16	8
	Goal	When the digital features motivate children to play with the toy or perform certain movements by setting goals	8	5
	Prompt	When the digital features prompt children to play with the toy and take part in the facilitated activities	3	3
	Modality			
	Sounds	Noises, talking voices, and sounds relating to pretend play and role play	23	13
	Music/Song	Music or songs	19	10
	Lights	Toy features that can light up	11	8

Table 3 Context Identified from the Interviews

Theme	Code	Description	CF	PT
People	Social Play	Children playing with digital toys with friends	24	15
	Solitary Play	Children playing with digital toys alone	5	5
	Family Play	Family members forming a part of their children's play	5	5
Environment	Weather	How different weather conditions affect children's interaction	9	4
	Indoor Play	Children playing with digital toys at home	17	13
	Space	How different spaces affect children's interaction	4	4

Table 4 Active Play Identified from the Interviews

Theme	Code	Description	CF	PT
Activity Type	Pretend Play	Parents mentioned their children like to engage in pretend play; or digital toys that could facilitate pretend play	11	10
	Ball Sports	Ball activities in play	10	8
	Made-up Games	When children re-appropriate play objects to form their own games	4	3
	Unstructured Free Play	When children engage in unstructured activities and free play	3	3
Movement Type	Locomotor (LC)	Discussion of jumping, walking, running, stomping, swinging/spinning	23	18
	Body Management (BM)	Discussion of dancing, swimming, hanging, gymnastics	13	11
	Object Control (OC)	Discussion of throwing/catching, pushing/pulling, digging, kicking	11	11
	Combination of LC, BM, OC	Discussion of riding/cycling/scootering, climbing	11	11

4.1 Features of Toys

4.1.1Incorporating Familiar Physical Features

Our findings reveal that certain physical features are commonly associated with digital toys, with buttons and screens being the most frequently mentioned. Parents noted that familiar features like buttons can alleviate uncertainties about new toys. Buttons were the most frequently mentioned feature (CF = 9; PT = 5), and they were associated with increased functionality. For example, P4 highlighted the appeal of multiple buttons on the Vtech, noting it seemed to offer many options.

Screens were also frequently noted (CF = 6; PT= 5). Some parents considered screens crucial for providing information and feedback, like P3, who said, *"If the toys do not have some kind of sounds or, what do you call that, visual… the little screen here, it might be the parent's job to chat with her".* Conversely, other parents associated screens with passivity and repetition, as P18 commented, *"Especially games or things that involve screens usually means that the kids are, even if they are thinking a lot and problem solving, they are still quite sort of passive and they are repetitive".*

4.1.2 Utilising Digital Features to Communicate with Children

Auditory and visual features were often coded. Parents (CF=6; PT=6) preferred these features to be responsive rather than repetitive. While children enjoyed toys with sound, excessive and repetitive noise was a concern, as P17 noted "*I certainly would not rule out having them at home. The noise aspect does bother me."* Similarly, visual features like the Boots initially attracted attention, but the interest diminished quickly due to repetitive patterns and colours.

Parents expect digital features to fulfill various roles, such as setting goals, providing prompts, and providing feedback. Clear goals (CF=8; PT=5) were seen beneficial for engagement. P1 noted that *"positive reinforcement when they (their children) got a goal or whatever, it kept them going"*. Levels and rewards were also appreciated, as P1 mentioned, *"when the child gets to a certain level and they get a number of points, which means that they can then play a game at the end of it."*

Digital prompts (CF=3; PT=3) are also valued for encouraging interaction and cognitive development. Parents noted that waiting for prompts encourages interaction, interpreting them fosters thinking, and acting on them promotes physical activity. For example, P9 preferred the LeapFrog because it required active listening and engagement. Feedback (CF=16; PT=8) was valued for being age-appropriate, meaningful, and responsive. P1 described a *"talking bird"* that provided feedback and prompts, while P17 appreciated the simplicity and responsive feedback from the Boots, noting, *"… just the simplicity and the joy she seemed to get about just stomping around in these lights that seemed to flash when she stomped on them"*.

4.2 Interaction Contexts

Parents largely envisioned digital toys as suitable for indoor physical activity when outdoor play is not possible due to weather, lack of ideas, or busy schedules (CF=17; PT=3). For example, P7 noted, *"The only time that they play with digital toys is when they isolate at home and have no one else to play with."* Some digital toys, like the Boots, are considered appropriate for specific outdoor contexts, as P17 remarked, *"Boots are normally for rainy times, not a dry place"*. Generally, parents prefer outdoor play to involve playgrounds and social interactions, as P4 noted, *"We usually take her to the park where there are different activities to engage her"*.

Space is also a consideration; some parents are concerned about whether they have enough room for certain digital toys (CF=4; PT=4). For example, P20 said about the VTech, *"It is quite space demanding."* In contrast, toys like the LeapFrog requires less space.

Parents also see digital toys for social play with friends (CF = 24; PT = 15) and family (CF = 5; PT = 5), as they can foster skills like sharing and turn-taking. P8 observed that the VTech allows for turn-taking. They have noted that children often reinvent play with digital toys when friends visit, leading to new interactions compared to solo play. They also appreciate that digital toys offer solo play options. For example, P8 highlighted, *"On a Saturday morning when I am trying to sleep in, that is when they (digital toys) come in handy"*.

4.3 Active Play Activities and Fundamental Movement Skills

4.3.1 Aspects of Pretense, Imagination, and Exploration

Pretend play was frequently discussed by parents (CF=11; PT=10) as a central aspect of their children's daily routines. This form of play, where children act out scenarios and roles through imaginative and creative activities [5], is seen crucial for developing creativity. Parents observed their children using toys in novel ways, such as P3's child imitating adult behaviour with a toy phone and P5's child creating stories with Legos. This ability to invent and adapt play scenarios is valued by parents. Conversely, parents expressed frustration with digital toys that limit creativity, as noted by P7: *"Those kinds of interactive games and they do not allow space for creativity."* They also emphasised that unstructured play fosters more active thinking than play confined to specific instructions. For example, P17 said, *"If you give him a toy, it does not mean that he will play with the toy exactly like that you know. He is going to use his imagination and bring in other toys as well, make some new game"*.

4.3.2 Involving Multiple and Unfamiliar FMS in Play

Parents expect digital toys to support a range of FMS and enhance coordination through activities such as climbing, riding, cycling, and scootering. For example, P15 appreciated the coordination benefits of the sports centre playset, while P9 hoped digital toys would improve hand-eye coordination and target hitting. They also seek digital toys that promote less commonly developed motor skills, such as throwing, catching, and dancing. While running is often part of play, parents particularly valued toys like the VTech and the LeapFrog for their targeted practise opportunities. P1 noted, *"We see our children engaged a lot more with the ball and actively playing with that a bit more would be something we could imagine them using",* reflecting a desire for digital toys to provide focused practise in ball sports and other underrepresented motor skills.

5 DISCUSSION

5.1 Parents' Perspectives of Tangible Digital Toys

Our findings highlight parents' perspectives for integrating tangible digital toys into their children's daily active play. They expect these toys to support the development of comprehensive motor skills, preparing children for more complex activities later on. This aligns with previous research indicating that parents view motor skills development as crucial during their children's sensory-motor stages [19, 23]. However, while earlier studies focused mainly on fine motor skills, our research provides new evidence that parents value the development of all aspects of Fundamental Movement Skills.

Our findings also highlight the value parents place on imagination and creativity in digital toys. They hope these toys will support not only physical activity but also imaginative play. In the literature, terms like symbolic, imaginative, and pretend play

are often used interchangeably; here, we use "imaginative play". This type of play is frequently linked to physical activity. For instance, previous studies have shown that incorporating imaginary elements into play can encourage physical activity [48], and children often connect imaginative scenarios with physical play [21], such as pretending to crawl like a dinosaur. While existing research (e.g., [5, 13, 55]) has explored how various technologies can support imaginative play, it has typically focused on imaginative play in isolation rather than its integration with physical activity. Our findings suggest that parents see significant value in blending imaginative play with physical activity. This indicated a promising avenue for future research to explore how imaginative elements can enhance physical play experiences.

However, many parents have expressed their disappointment with existing digital toys, feeling they fall short of their expectations. A prior study [52] found that many toys designed for children aged 3 to 5 were not age-appropriate, lacking clear prompts and not aligning with young children's physical capabilities. Our findings further emphasise the need for perceivable prompts and feedback in digital toys in order to foster meaningful interactions with children. Parents also worry that excessive technology use might limit their children's face-to-face interactions. While technology has potential to enhance in-person connections – such as strengthening family bonds [8, 42] – there is increasing interest in how technology can support rather than obstruct social interactions [1, 27, 26]. Our study reveals that parents desire digital toys that facilitate group play, allowing family members and friends to engage together. Unlike screen-based technologies, our findings suggest that parents see tangible digital toys as more effective in promoting social interaction.

Additionally, parents have expressed concerns about the noise associated with digital toys. One major issue is the potential for excessive noise to negatively impact hearing health, a risk highlighted by prior research [33]. The presence of constant or repetitive noise from digital toys can disrupt the home environment, affecting not only the child's concentration and learning but also the overall family dynamic [51]. These concerns highlight the need for digital toys designed with adjustable sound levels and features that minimise noise pollution.

Finally, parents also worry about how digital toys fit into their living spaces. Many worry that digital toys, especially larger or more complex ones may require significant room, potentially cluttering living areas and reducing space available for other activities [43]. Parents are also concerned about whether there is sufficient space for their children to safely and comfortably engage with these toys without obstructing movement or play areas. These considerations highlight the need for digital toys that are compact, easily storable, and adaptable to various living arrangements, ensuring that they enhance rather than complicate the use of home space.

5.2 Recommendations for Design

This section outlines recommendations for toy and interaction designers to better align with parents' preferences when designing tangible digital toys that promote physical activity for young children.

Findings from Section 4.1.1 suggest incorporating familiar features for both parents and children to alleviate uncertainties about new digital toys. This approach reduces the learning curves and enhances usability [24], benefiting both child engagement and parental confidence. Therefore, the first recommendation is to design digital toys with common objects or experiences familiar to children and parents.

Section 4.1.2 emphasises the use of digital features to set goals, provide prompts, and deliver feedback. Findings suggest avoiding repetitive and constant auditory features; instead, ensuring that the auditory elements are meaningful and responsive to different types of interactions from children. Meaningful feedback can enhance learning and engagement, while varied auditory features prevent sensory overload and maintain interest [34]. Therefore, the second recommendation is to develop digital features that offer diverse and contextually relevant audio cues and integrating feedback mechanisms responsive to children's actions.

Section 4.2 highlights the importance of considering the space limitations of home environments to design toys children can safely access and interact with. Designing with spatial constraints in mind ensures that toys are usable within typical home settings and avoids safety issues related to limited play space [36]. The third recommendation is to create compact, modular, or easily storable toys that are safe and suitable for various home environments.

Section 4.2 also points to the benefits of designing for both social and solitary play. This approach supports diverse play experiences and caters to different social dynamics and preferences [30]. Therefore, the fourth recommendation is to incorporate

features that facilitate group activities and family involvement, such as cooperative games, while also providing engaging solitary play options.

Section 4.3.1 suggests incorporating aspects of pretence, imagination, and exploration in activities. Such elements contribute to cognitive and emotional development, making play more engaging and meaningful [47]. The fifth recommendation is to design activities that promote creative co-playing, scenario-building, and open-ended exploration, using themes and scenarios that encourage children to use their imagination.

Section 4.3.2 suggests designing activities that encompass a range of FMS, including those less frequently practiced, such as body management skills like balancing and dancing. This approach ensures a more comprehensive development of physical abilities [44]. The sixth recommendation is to create activities that target a broad range of movement skills, and to incorporate feedback mechanisms that support and guide skill development.

5.3 Limitations & Future Work

This study has three main limitations. First, the participant demographic was limited, with a majority of parents being mothers, and the interviews were conducted exclusively in Brisbane, Australia, which restricted the diversity of the sample. Second, due to COVID-19 restrictions, we could not maintain a consistent study location, which may have influenced the results. Variations in play environments might lead to differences in how children interact with digital toys, potentially affecting parents' opinions based on their observations. Third, presenting example toys to parents might have influenced their opinions and the subsequent discussion.

Future research should aim to recruit participants from more diverse backgrounds to validate our findings and explore how different environments – such as the presence of other people, location, and context – impact children's interactions with digital toys. Additionally, investigating how specific toys might influence parental opinions would be valuable.

6 CONCLUSION

In this paper we presented findings from interviews with eighteen families, aiming to gather parents' perspectives on toy design and their children's physical interactions with these toys. Our findings indicate that parents seek digital toys that foster imagination, socialisation, and the development of FMS. However, they expressed concerns that many current toys fail to provide meaningful interactions due to inadequate feedback and prompts. Additionally, parents worry about toys that demand significant space or produce excessive noise. This work lays a foundation for understanding parents' views on tangible digital toys designed for physically active play and provides recommendations addressing familiarity, digital interaction, spatial constraints, social dynamics, and FMS.

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