Considering Parents in Coding Kit Design: Understanding Parents' Perspectives and Roles

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ABSTRACT
As education researchers, policymakers, and industry leaders recognize the importance of computing, many coding kits (toys and apps) have emerged to help young children learn to code at home. However, how parents perceive and support their children's use of the kits at home are less understood. In this study, we performed semi-structured interviews with eighteen parents who obtained coding kits for their young children for home use. The results show parents expected their kids to have fun and meaningful interactions with the kits. In supporting the play, parents took on various roles, mostly acting as spectator, scaffolder, and teacher. While parents perceived benefits of coding kits like a changed perspective on coding, they also reported concerns, such as their limited programming knowledge to provide help. Finally, we reflect on design and research implications to develop coding kits that consider parents' perspectives and important roles in supporting young children's exploration with computational thinking.

Author Keywords
Coding toys and kits; educational technology; informal learning; young children; parents' perspectives; parent roles

CCS Concepts
•**Human-centered computing** → **Empirical studies in collaborative and social computing;** *Empirical studies in HCI;*

INTRODUCTION
As our daily lives become more and more digitally mediated, computational thinking has become a valuable literacy like reading, writing, and arithmetic [20, 54, 69]. Computational thinking is about problem formulating and solving that borrow concepts and approaches from computer science, such as breaking down complex ideas into smaller parts and uncovering issues in instructions [8, 49]. Research has shown that learning opportunities in early childhood are promising to cultivate children's interests in computing, lower barriers for participation in computing, and support their social, emotional, and cognitive development [4, 13, 45]. Therefore, many coding toys and kits have been developed to help cultivate computational thinking in young children [72], including physical kits (e.g. Bee-Bot [6] and Cubetto [19]), virtual kits (e.g. ScratchJr [26] and LightBot [43]), and hybrid kits (e.g. Coding Awbie [15] and Roberto [35]). At these early ages, parents[1] are usually the decision-makers of whether or not to get a coding kit (i.e. coding toy/app) for their children.

Parents play important roles in early-childhood learning, play, and uses of technology, such as being collaborators and teachers [2, 56]. Parent-child interactions also significantly influence the quality of children's experiences at home, even with more individual activities like playing with mobile apps [29]. Although there has been a significant body of literature studying parent-child interactions in children's technology uses (e.g., [2, 5, 38, 46, 61]), less research has focused on how parents perceive and support their children's play with learning technologies at home, especially coding kits that are specifically designed to help kids learn STEM knowledge and skills. Overlooking the perspectives and roles of parents can lead to missed design opportunities that foster more meaningful learning experiences for children and empower parents to better support their children's play with coding kits.

In this work, we examine parents' perspectives and roles regarding their young children's informal learning with coding kits at home. We performed semi-structured interviews with eighteen parents who obtained coding kits for their young children between 3-9 years old. Interviewing these experienced parents provides insights into how parents support their children's interaction with coding kits and how they view these kits after their kids have played with the kits. We focus on the following research questions: (1) What are parents expecting from their children's use of coding kits? (2) What roles do parents play during their children's interaction with coding kits? (3) What benefits do parents perceive from their children's play with coding kits? And (4) what are parents concerned about their children's use of coding kits?

The results show that parents hoped that (1) playing with coding kits could help their kids learn coding skills and get more prepared for the future; (2) the kids could have fun and meaningful interactions with coding kits; and (3) a coding kit should be attractive and include features to scaffold their children's learning experience. In supporting children's interaction with the kits, parents took on various roles, mostly

[1] In this paper, we loosely define parents as different-form caretakers, such as a biological parent, stepparent, legal guardian, etc.

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acting as spectators, scaffolders, and teachers. Some other roles were identified, such as being an enforcer and executor. Parents also reported a number of benefits of coding kits like changing their perceptions about coding and enhancing family bonds. Finally, parents reported some concerns, such as the noises generated by some kits and not being personally helpful enough to support their kids. Based on the findings, we call for attention to parents in design practices and reflect on design implications for coding kits to consider parents' perspectives and the important roles that they can play.

This work makes the following contributions: (1) expanding the understanding of parent roles in children's informal learning with educational technologies at home and why they take up those roles; (2) parents' perspectives on their children's learning with coding kits; and (3) design and research implications for coding kits and other learning technologies to consider the roles and perspectives of parents in supporting children's informal learning with technologies.

RELATED WORK

As many coding kits have become available for home use, this study aims to understand parents' perspectives and roles in this educational context of computational thinking. This study also builds on previous work within HCI about parent-child interaction with technologies. Therefore, we primarily focus on literature about parents' roles and perspectives on children's use of playful and/or learning technology, as well as coding kits for young children.

Parent Roles in Children's Technology Use

Parents play different roles in children's learning and use of technologies. Barron et al. [2] interviewed eight parents whose middle-school-age children had technology fluency, such as programming and web design. They identified seven important parent roles in children's development of technology fluency, including: teacher, in which parents teach children how to do something; collaborator, in which parents collaborate with children on a project; learning broker, in which parents seek learning opportunities for children; resource provider, in which parents provide resources to support children's technology learning; nontechnical consultant, in which parents provide information on non-technical issues; employer, in which parents employ children for technical services; and learner, in which parents learn technical skills/contents from children. Hiniker et al. [32] identified four parent roles in parent-child interactions during the play with digital apps and analog toys in a lab study, including bystanders (maintaining physical presence), spectators (actively watching children's play), coaches (guiding children and providing support), and teammates (engaging in the play as a participant). Sadka and Zuckerman [58] observed parent-child interactions in joint making activities with eight families using craft-making kits and summarized two parent roles, including: peer-parent whose goal is to successfully complete an activity regardless of who takes the lead; and mentor-parent who is more focused on children's learning process and leading position.

There has not been a consensus on the terms and definitions of different parent roles in children's use of technologies. Different literature defines their own role terms, and those roles may overlap or cover each other. For example, the mentor-parent role in [58] overlaps with the coach in [32] and teacher in [2]. In this study about children's informal learning with coding kits, we continue to explore the kinds of roles parents can play and validate these roles identified in the aforementioned literature. We focus on the following questions: Are parents playing the same roles identified in children's other technology uses? Do parents play new roles that are missed in the literature? And how do parents take up these roles?

Parents' Perspectives and Mediation

In this section, we focus on parents' perspectives on their children's use of playful/learning technologies and parental mediation patterns. With early-childhood educational apps, parents expect that play can help their children build academic competence, such as literacy, numeracy, and social skills, so that the children can become more prepared for school education [16, 17]. At the same time, parents express the desire for their children to become independent learners and players because they need to attend to other demands like meal preparation [16, 60]. For children's more general technology uses, a significant body of literature reports that parents are concerned about children's online and screen time [5, 38, 46, 61]. Another common concern is safety issues around children's media use. With online media and video games, parents worry about their kids' cyber safety, such as contacting unknown people [46], exposing children to inappropriate contents like violence [31, 38]. Some literature also reports parents' anxieties about children's addiction to certain media and time away from school work or physical activity [41, 24, 60].

To address the concerns and anxieties around children's media use, parents would mediate in three ways under the framework of joint media engagement [65], including restrictive mediation, active mediation, and co-viewing/using [12]. Restrictive mediation refers to the strategies parents take to regulate or restrict their children's media use, such as setting rules and placing limits. For example, to address their screen concerns, parents would set time limits, require children to finish school work before digital media use, or control access to mobile devices [5, 38]. For active mediation, parents would talk with their children to explain and discuss media content and usage, such as safety issues of Internet use and website reliability [12, 61]. Co-using is a form of mediation where parents share the media together and provide support when their children need help with understanding, such as teaching children something, collaborating on a project, and providing resources [2, 12, 51]. Scaffolding is an effective co-using strategy to support children's learning, which can help them achieve goals and solve problems that are slightly beyond their current competence [70, 67]. Yelland and Masters [71] summarized three scaffolding techniques in the information age: cognitive scaffolding (using tools like questions and modelling to promote children's understanding of concepts and procedures), technical scaffolding (strategies provided by the toolkit such as immediate feedback and predefined tasks), and affective scaffolding (providing encouragement for higher level of thinking and tasks).

In addition to concerns, parents perceive some benefits from their children's technology uses. For example, in a survey about parents' perspectives on children's play with Minecraft, Mavoa et al. [46] found parents valued the opportunities for creativity and problem-solving provided by digital play. Sobel et al. [61] pointed out that parents believed co-playing Pokémon Go with children was quality time between family members and contributed to family bonding. Additionally, some parents believe that digital games have the potential to provide learning opportunities for their children and promote their children's academic and social skills, such as numeracy, collaboration, and leadership [7, 50, 60].

Coding Kits for Young Children

As more and more people realize the importance of cultivating computational thinking in young children, various coding kits have been developed in academia and industry. Ehsan et al. [23] reviewed 12 apps that were designed to develop computational thinking in children aged 4 years old and up. They found all these apps could help promote certain computational thinking competencies. In a review paper about coding kits for young children, Yu and Roque [72] identified thirty computational kits and classified them into three categories: physical, virtual, and hybrid kits. They defined physical kits as kits whose components are tangible, such as Cubetto, which consists of a wooden robot, a set of directional command tiles, a control board to put the command tiles, and adventure maps to move the robot. Virtual kits are mobile or PC based applications without physical parts, such as ScratchJr [59], a mobile app for children to create interactive stories, animations, and art projects through block-based coding. Hybrid kits are kits that consist of both tangible and virtual parts, such as Coding Awbie, an iPad game where children create computer programs using tangible tiles to control virtual characters.

Overall, there is less research specifically focused on parents' roles and perspectives on their children's use of educational technologies at home, especially coding kits. Coding kits are different learning mediums from other playful technologies in the aforementioned literature because (1) coding kits claim to teach children coding skills, a skill set parents want their kids to acquire and many parents have encouraged or plan to encourage their kids to learn [66]; and (2) coding kits span across physical, virtual, and hybrid forms. Learning computational skills through playing with coding kits at home, where there are no well-structured activities or teachers to scaffold the learning experience, is different from classroom learning. In such an informal learning condition, how parents interact with their children and support the children's play with the kits needs more exploration and understanding. With the unique educational purpose and various forms of coding kits, we explore the following questions: what are parents expecting from their children's use of coding kits? How do parents mediate their children's play with coding kits? Will parents' concerns around other media uses, like screen time and cyber safety, persist with coding kits? What benefits do parents perceive from their children's play with coding kits? We describe the methods of this study in more depth in next section.

METHODS

We performed semi-structured interviews with parents (1) who had at least one child between 3-9 years old and (2) the child had experience playing with coding kits at home. We focused on parents with young children between 3-9 because parents play essential roles in children's development of social, emotional, and academic outcomes at this early age range [39, 25]. Additionally, many coding kits target young children within this age group [72]. For the second criterion about having coding kits at home, we wanted to focus on "experienced" parents whose children had multiple or ongoing play experiences with coding kits.

We recruited participants in three ways: (1) sharing recruitment posts on social media platforms; (2) sharing recruitment information to potential parents through groups and institutions that were in partnership with our research group, such as local public schools and libraries; and (3) snowball sampling, i.e., asking participants to recommend parents and share the recruitment information. The data collection included two parts: (1) a 5-10 minute survey to collect consent and the information about participants' backgrounds and their coding kits; and (2) a 30-45 minute online or phone interview with each participant. The interview included open-ended questions around the following topics: the coding kits participants had and their expectations, roles, perceived benefits as well as concerns regarding their children's use of the kits. In addition, we asked participants to describe the roles of other adult caregivers at home for their children's play with coding kits and give examples. The interviews were audio-recorded. After each interview, we provided the participant with a $20 Amazon Gift Card to compensate for their time.

Participants

We interviewed a total of eighteen parents. We transcribed and began data analysis of interviews as we conducted new interviews in parallel. After the fifteenth participant, the first and second authors did not notice new and emerging insights around our research questions. We did three more interviews and came to a consensus that there were no new themes in terms of parents' perspectives, roles, perceived benefits, and concerns. Therefore, we ended our participant interviews [27].

Participants' ages ranged from 29 to 56 years old with an average of 39.10. Thirteen were female and five were male. Fourteen participants self-reported as White, three as Asian, and one participant did not disclose their race. The participants reported 31 children in total between 3-9 years old. The average age of reported children was 6.02 years old; eighteen of them were girls and thirteen were boys. Three parents reported having one child and the remaining fifteen had two or more children. Sixteen participants were from the United States across six states, two were from the UK, and none of them were from the same family. Sixteen parents had a bachelor's degree or above, one attended some college, and one held a high school degree. Four parents had professional experience with computer programming, ten had some experience with HTML or block-based programming, and the remaining four had no programming experience. In addition, sixteen parents said that they would sometimes or frequently join in their

children's play with coding kits, while two parents reported seldom or never playing together (i.e. not playing active roles like collaborating or scaffolding).

Participants reported more than twenty different coding kits and the kits distributed across physical kits (e.g., Code-a-pillar [14], Cubetto, Cubelets [18]), virtual kits (e.g., ScratchJr, LightBot, Move the Turtle [48]), and hybrid kits (e.g., Coding Awbie, Dash & Dot [22]). Seven parents reported having one coding kit at home and the remaining eleven parents reported having two or more kits.

Data Analysis

We transcribed all interviews and analyzed the transcripts in batch after the conclusion of interviews four, ten, fifteen, and eighteen. During each of these batched analyses, two co-authors independently identified all segments in the new interview transcripts that reflected any of the four topics: parents' expectations, roles, perceived benefits, and concerns; relevant segments were largely clustered around specific questions from the interview protocol, but were sometimes also distributed through the transcripts. The two authors discussed any segment discrepancies until both authors agreed on the relevance of all segments to each topic. Note that any one segment might be counted as relevant to multiple topics.

Within the segments of each topic, the two authors coded the data following an iterative qualitative coding process to identify emergent themes and ideas in the tradition of thematic analysis [11]. For parent roles, our analysis was scaffolded by frameworks derived from related work [2, 32] and extended as appropriate for inductive analysis. We had a research assistant (external coder) code the role segments using the roles we identified (Table 1). We then checked the inter-rater reliability for the results between the external coder and us, achieving Cohen's Kappa scores at 0.729 ("substantial agreement" [42]). For the analysis of segments in other topics, we did not have categories derived from prior research; as such, all the codes were generated through inductive analysis. The two authors coded data independently and all authors met regularly to review the identified themes, address disagreements, and refine codes, ensuring the validity of the analysis [40, 44]. We undertook additional rounds of analysis for the topics of (1) parents' expectations, perceived benefits, and concerns, in which we clustered related codes into higher-level themes; and (2) parent roles, in which we analyzed the roles parents played in different mediation patterns and how parents' roles changed as their children got more familiar with coding kits.

FINDINGS

We report findings of how parents got coding kits for their children and how they learned about the kits. We also describe the main themes that emerged from the coding about parents' expectations, roles, perceived benefits, and concerns.

Getting Coding Kits

Among the eighteen participants, twelve parents reported they or their partners bought coding kits for their children, five parents said they got coding kits as a gift from relatives or friends, and one participant reported the child accidentally downloaded a coding app then started playing with it.

For the twelve parents who purchased or whose partners purchased coding kits, we further asked how they learned about the kits and found out three ways. First, six parents got to know coding kits because of their or their partners' occupations, such as being a STEM teacher in elementary school or pursuing professional careers with computer programming like software engineering. Second, four participants reported that they learned about coding kits through educational organizations or activities, such as STEM-related programs in their children's schools and coding summer camps. Third, two participants reported getting to know coding kits from friends or colleagues. As a mother of a nine-year-old girl (P3) shared, *"We learned about Cubetto because a friend had it, we tried it there."* These results align with the findings in a study about parents' perspectives on children's use of portable digital devices that parental occupations and schools are the major influences and sources of their educational-technology choices for children [60]. In addition, these findings, together with the demographic backgrounds of our participants, further highlight the inequality in computing education opportunities and resources. Therefore, we hypothesize that parents with occupations that have little to do with programming are less likely to know the existence of coding kits and parents from underrepresented groups, such as low-income and less-educated communities, are more likely to miss various computing learning opportunities for their kids. We would need to confirm this hypothesis in the future study.

Parents' Expectations

Expectations are what parents expected about their children's play with coding kits, which might have or have not happened when the interview happened. We identified three areas of parent expectations, including the expectations around play outcomes, children's interactions with a coding kit, and the design of a kit to support the interactions.

Play Outcomes

Parents reported two high-level expectations about the outcomes of their children's learning with coding kits. First, fourteen out of eighteen parents expected that playing with coding kits could help their children understand coding, become more competent in technical skills, and get more prepared for the future. Because these parents believed coding would be an essential skill for the future and perceived coding as a second language that their children needed to master. A mother with 4 children (P8) shared, *"Programming is almost another language you need to know... you need to understand at least the concept of programming, no matter what you go into."*

Second, four parents mentioned that they hoped their children to get comfortable with technology and programming by playing with coding kits. A father with two girls (4 years old and 7 years old, P10) noted, *"Programming shouldn't be something that she should be afraid of, she should feel comfortable doing it."* Such parents did not hold the belief that their children must master coding skill or make a living based on the skill in the future. Instead, they wanted their children to feel confident about technologies and get a sense of what is programming and how it works. In other words, parents' expectations about

the play benefits centered around learning coding skills and not being afraid of technology.

Interactions with Coding Kits

Parents consistently reported wanting their children to play with coding kits in meaningful ways rather than randomly pressing buttons or passively watching the screen of a kit. For example, sixteen parents wanted their children to do planning and coding activities with the kits, and to think about the cause-and-effect between coding and a robot's or game character's reactions. A mother with a 3.5-year-old son (P4) recounted, *"[I want him to] be able to program something to where he knows what he's doing, where he knows how to get it from A to B."* Eight parents also wanted their children to be creative and try new things with coding kits. When playing with Dash & Dot, a mother with two young boys (P2), would love her 5-year-old son to *"come up with new ways to use the tool, new creative projects he wants to do."*

Another common parent expectation is to have fun with coding kits. Nine parents wanted their children to enjoy the play and viewed having fun as an important aspect for playing with the kits. When talking about expectations, P1, a mother with two girls (ages 4 and 7), commented, *"My hope is that they have fun with it."* Another mother with a 4-year-old son (P6) said, *"I expect him to enjoy what he is doing... I'm not really into forcing him to do things he doesn't want to do."* In addition, parents expected their children to be able to play with coding kits independently and also collaborate with siblings. As to independent play, parents hoped the children could play with coding kits by themselves. As P4 put it, *"I expect him to be able to be on activity by himself without my intervention or assistance."* We identified two reasons for this expectation: sometimes parents were busy and could not always be available to offer help when their children were stuck; and some parents who had little to no programming experience did not know how to help with coding. On the other hand, parents who had two or more children expected collaborations within siblings. Parents reported that siblings sometimes fought over coding kits because they all wanted to take charge, had different ideas about playing, or were just in a bad mood. P13, a mother with two children (ages 5 and 8), said, *"They tend to fight when they play sometimes... if they can play together and learn to work together in a way like non-combative, that works well for me."* In short, parents' expectations about play activities centered around playing in meaningful ways, having fun, and being able to play both independently and collaboratively with siblings.

Coding Kit Design

Fourteen participants hoped coding kits could maintain their children's interest and engagement. P4 noted that when looking for new coding toys, *"he [the child] needs to be passionate about it... It has to be something he wants to pursue on his own."* However, seven parents reported that coding kits were not their children's top choice for play and would seldom ask for them. As P2 put it, *"he [a 5-year-old boy] occasionally remembers about Dash [a coding kit]... It is not something he constantly asks for."*

Nine parents expected more structures from a coding kit to scaffold children's play because they believed coding was not something easy to learn and wanted their children to feel empowered to do coding. These features include providing more tasks, challenges, and tutorials, rather than just giving children a toy and letting them explore it by themselves. P3 shared, *"coding toys are something that needs more hand-holding."* P10 wanted more scaffolding features in coding kits so that his 7-year-old girl could have more autonomy instead of frequently asking for help: *"[I hope] there's stuff built into the toys that help her discover the features or discover what she can do."*

Five participants explicitly mentioned that a coding kit should support a range of activities and age groups. When talking about the kind of coding kits she wanted, P15 was expecting *"something with a range [of possibilities] instead of something they use for a while, and then they are done."* For P7, a mother with two girls (ages 7 and 8), an ideal coding kit would be something where *"there's a lot of different levels and there's a lot of different things you can do."* In other words, parents' expectations about the coding-kit design were about being attractive for children, providing more built-in features to scaffold children's play, and supporting a range of activities.

Parent Roles

We summarized ten different roles parents played for their children's interaction with coding kits, including being a spectator, scaffolder, bystander, logistics supporter, enforcer, gatekeeper, and four co-play roles (i.e., teacher, collaborator, executor, and dominator). Among the ten roles, spectator, teacher, bystander, and collaborator were identified from previous studies [2, 32]. Scaffolder, logistics supporter, and gatekeeper overlap with some roles in [2, 32], such as coach, resource provider, and learning broker. We used these roles to more precisely describe what parents did in children's play with coding kits. We also named some new roles, including enforcer, executor, and dominator. The descriptions and examples of these roles are presented in Table 1. In addition, we connected these roles to the roles or parent-child interaction patterns identified in literature.

Roles for Mediation

Using the parental mediation framework [12], we analyzed parent roles for different mediation patterns (i.e. active mediation, restrictive mediation, and co-using). This analysis helps understand why parents took on different roles and how these roles were enacted. Two parent roles, namely bystander and dominator, do not fit into this framework because either parents or children were not involved in the play within the two roles. With coding kits, we see parents' interaction behaviors such as providing encouragement and asking questions to scaffold children's learning experience as active mediation, which were mainly reflected in the roles of spectator and scaffolder. Parents actively mediated as a scaffolder when they wanted their kids to play in meaningful ways (e.g. planning and doing problem-solving through coding) and try new ideas with coding kits. For example, P12, a father of two young children (ages 3 and 5), noted that *"because they tend to start a very basic thing and then repeat the same thing, I try to force*

Table 1. Parent Roles in Children's Use of Coding Kits

Roles	Description	Examples	Connections
Spectator	Parents act as an audience, provide encouragement, and are available when children need help	*"She'll experiment with something and then I become her audience for demonstrating what she has made and accomplished."*	*"Spectator"*[32], [58]
Scaffolder	Parents suggest a child to try different ways of playing, or ask questions to scaffold the play	*"I'll suggest, 'what would it look like if you were to try this other thing?' Or 'have you thought about whatever?'"*	*"Coach"*[32], [58]
Bystander	Parents know their children are playing with a coding kit but not involving in the play	*"He is pretty hands-off... that's kind of their private time... So we leave them alone, for the most part."*	*"Bystander"*[32]
Logistics supporter	Parents help with logistics of children's play, such as setting up a kit and changing batteries	*"If he [a child] is having trouble making it work, like the batteries or if it's getting low on charge, he'll ask me to help him."*	*"Resource provider"*[2], [58]
Enforcer	Parents mediate the conflicts between siblings, remind siblings to take turns, remind children of the time limit, etc.	*"They don't like to step away, and they lose track of time. All of these warning signs, you need to intervene."*	[61]
Gatekeeper	Parents test a coding kit before introducing it to children or decide which toy, when, or where to play	*"My husband went through it [a coding kit] first to see if this is something that would be beneficial for her [the child]... Then he exposed her to it."*	*"Learning broker"*[2]
	Co-play roles:		
Teacher	Parents teach children how to use a coding kit, how to create a code, and help debug the code	*"For the whole play process, the beginning is 95% showing them [children] how to make it [a coding kit] work and stuff like that."*	*"Teacher"*[2], [58]
Collaborator	Parents and children come up with ideas together, or take turns with a kit	*"Often one of us will come up with the challenge and the other will program the robot the turtle... and [we] will take turns."*	*"Collaborator"*[2], *"Teammate"* [32], [58]
Executor	Children boss parents to do something for them, such as passing tiles and building obstacles for the play	*"He [a child] bosses me around a lot, so I'm the worker bee and they really like to be in charge and tell me what I need to do."*	[62]
Dominator	Parents take over the play and take away from children's participation	*"He [a father] gets excited about them [coding kits] but sometimes that can take away from her [a child] participation."*	[62], [33], [58]

them into a more difficult problem." As a spectator, parents would actively mediate when their children got frustrated or showcased their codes and projects. P5, a mother of two young children (ages 3 and 6), said she and her husband would step in and redirect the frustration when her 6-year-old girl got depressed with coding kits.

For restrictive mediation, we examined parents' behaviors that regulated or restricted their children's interactions with coding kits, which were mainly reflected in the roles of enforcer and gatekeeper. When children began to fight with each other or lost track of play time, parents would intervene as a enforcer to calm the children down or stop their play. P5 shared that when her boy and girl started fighting about coding toys, she would usually ask the children to *"take a break from the toy and figure out why [they were] fighting."* In addition, parents would do restrictive mediation as a gatekeeper when their children asked for permission for playing with coding kits, such as setting limits on play time and location. For example, P13 said she tried to limit the children's time with electronics. When the children wanted to play with OSMO Coding Awbie, she told them, *"You have 30 minutes to do OSMO and don't go outside."*

As to co-using, we looked for parents' interactions where they taught their kids how to use a coding kit, collaborated on projects, and provided resources to support the kids' play, which were mainly reflected in the roles of teacher, collaborator, logistics supporter, and executor. When just getting a new coding kit, parents tended to be a teacher where they learned and taught their children how to use the kit, like creating a code. P3 shared that her girl did not like reading and she had to read the play instruction for the girl to *"help her figure out what and how she can do [with the kit]."* As a collaborator, parents joined in children's play as a co-player, such as coming up with play ideas together and taking turns. For example, P10 often played coding kits with his two daughters and stated, *"One of us will come up with the challenge and the other will program the robot."* In addition, parents would act as a logistics supporter for their children's play, such as setting up play scenes and charging the kits. P8 shared that it was usually her and her husband helping set up their children's play with the kit Sphero [63], such as taking it out and opening the coding app on iPad, so that the kids were able to use it. The last co-using parent role is executor. Sometimes children would take complete charge of the play and bossed their parents to do things for them. P7 recalled, *"They [two girls] sometimes*

make me do the work they do not want to do, like getting an object for the robot to hit."

Shifting Roles

Parent roles changed as children became more familiar with a coding kit. We noticed that parents played more as a teacher, collaborator, and logistics supporter in their children's early play when they just got a coding kit. Parents consistently reported that they first learned to use a coding kit, then taught their children how to use it. When getting a micro:bit [47] for her children (ages 4, 7, and 10), P9 and her husband *"looked at some YouTube videos or Googled what some other people did [with micro:bit]."* Then they showed their children how to play with it. Parents would also engage more as a collaborator and provide logistical support at this early stage. P7 helped to set their Dash robot by downloading the app and putting batteries into Dash. P13 mentioned that she, her husband, and her two children played Coding Awbie as a family at first and usually took turns because they wanted to *"show the kids that anybody can play with it, with any kind of background."*

As children got more familiar with a coding kit, parents tended to step back a little bit and acted more as a spectator, scaffolder, and enforcer. As aforementioned, parents wanted their children to learn with coding kits, such as knowing the cause-and-effect, planning, and doing problem-solving. Therefore, parents would often ask children questions to guide them to think about the logic of a play and do problem-solving. During her 5-year-old son's play, P2 noted that she would be *"suggesting what he does, like 'why don't you do in this way?' or 'no, no, no, don't pick it up, try to do it using the remote control [app].'"* When siblings began to fight during the play or lose track of playtime, parents would become an enforcer. P7 would consistently remind her children's playtime and told them *"you have 10 minutes left, you 5 minutes left."* In other words, as children got more experience with a coding kit, parents' roles would shift from more being a teacher, logistics supporter, and collaborator to a scaffolder, spectator, and enforcer.

Perceived Benefits

Perceived benefits are what parents believed coding kits had brought to their children, themselves, and their families. Investigating the benefits helps understand some unique characteristics of coding kits and highlights the important roles coding kits play in supporting children's learning of computational thinking. Parents reported various benefits, including shifting parents' perceptions of coding, building relationship among family members, and helping kids learn new ideas and skills.

Changing Parents' Perceptions of Coding

Nine parents reported that coding kits shifted their perceptions of coding from something that seemed complex and inaccessible to something everyone could understand and engage in. A mother with one 5-year-old boy and 9-year-old girl (P16) stated, *"I thought coding was all on the computers. I didn't understand that it could be more basic in a toy fashion, could be simplified."* Four parents highlighted coding as a problem-solving process. As P13 put it, *"It [coding] is problem-solving because if it doesn't work, you have to solve the problem as to why it's broken."* Three parents thought about teaching children computer programming differently from traditional text-based programmings like JavaScript and Python. P18, a father with three children, reflected that coding kits encouraged him to think about what programming was and what would be the best way to teach a young kid programming.

Building Relationships

First, eight parents reported coding kits as a medium for family bonding, particularly for families where there was a member pursuing professional computer programming as a career. As a software engineer, P5 said, *"They [coding kits] get the kids interested in what I do... so the coding toys are a bit of a personal connection to me."* Second, six parents reported that coding kits created a space for family time. A father with one nine-year-old girl (P17) said that there were more times they interacted with coding kits as a family instead of letting the girl play by herself. Third, three parents reported that coding kits helped facilitate collaboration within siblings. As mentioned by P1, P11 (a father with 3 children), and P13, the younger kids might seek assistance from older kids when there was a problem with their code.

Learning Benefits

Parents reported a set of learning benefits their children got out of from playing with coding kits. Ten parents believed their children were learning computational thinking skills, such as planning and problem-solving. As P5 put it, *"Trying to plan head, understand what consequences can result, and then especially trying again if they don't get the right result. I think those are all stuff that my kids have learned."* For six parents, playing with coding kits helped demystify technology for their children and encourage the children to think about the mechanisms behind computers and technologies. For example, P3 said, *"I think it [coding kit] changed her experience, she has more appreciation for how much [work] and the hidden things of so many programs and apps."* Three parents mentioned playing with coding kits helped their children learn to handle emotions. P12 mentioned that among all the toys they had, *"the coding toys are the only toys that allow them to face real frustrations that they need to overcome."* Parents also reported some other learning experiences, such as developing numeracy skills by counting steps for a robot/sprite, promoting verbal skills by storytelling, as well as supporting children's creativity by allowing different activities.

Parents' Concerns

Understanding parents' concerns can inspire coding kit designs that address the issues parents care about. Five parents self-reported not having any concern about their children's play with coding kits because they believed coding kits were educational and beneficial for their children, especially in families with physical coding kits. As P15 put it, *"I really don't have any concerns about it because it's really just about learning."* The remaining thirteen parents reported some concerns around the kit design and their children's play with the kits.

Concerns around Coding Kits

First, parents pointed out that the sound generated by some kits like Code-a-pillar was noisy and annoying even though the sound might be good at attracting children's attention. For

example, P4 said, *"I don't actually enjoy playing with Code-a-pillar. . . The music is kind of annoying."* Such parents also worried that noise would disturb other people at home. Second, seven parents mentioned coding kits were expensive and four of them worried that their children might break the toy. P8 kept track of how her four children played with the kit Sphero because *"it is expensive so they [the children] can't get mad and break it on accident."* Other concerns reported around the kits include the durability of a kit (e.g., battery life and Bluetooth connection) and the advertisements embedded into the kit, especially for coding apps.

Concerns around Play Activities

More concerns were reported around children's interactions with coding kits. Two unique concerns parents had were centered around learning and not being personally helpful sometimes. Eight parents were concerned that their children were not learning with coding kits because they wanted their children to have meaningful interactions with the kits while the children were often observed not doing coding or problem-solving. P14, a mother of two children (ages 4 and 8), was concerned about how her young boy played with coding kits sometimes and shared, *"He doesn't use it for coding. . . he just likes to hold it and go around with it. . . he doesn't always use it for the intended purpose."* Four parents reported that they had the concern that they were not helpful enough for their children's play because they did not know much about coding and how to assist the children with code, especially with kits that had a more advanced programming environment like Sphero. As one mother noted (P8), *"I don't always have the knowledge to help them when the kit is not working right."* In addition, like the use of many other toys and apps, parents reported concerns around screen time for coding apps (e.g. excessive screen time and children might get addicted to screenplay), Internet, and social media (e.g. a coding app might link children to other websites and expose them to inappropriate information).

DISCUSSION

The above findings provide insights into parents' expectations, roles, perceived benefits, and concerns regarding their young children's use of coding kits at home. In this section, we discuss how these insights connect to and are different from existing literature, as well as how these insights may inform new coding kit designs that consider the important roles and perspectives of parents in supporting young children as they play and learn with the kits.

Parent Roles

Even though only a few coding kits specifically considered group activities and parents' roles in their activity design [72], our study highlights that parents are playing important roles in supporting their children's interactions with coding kits, such as guiding children to do coding and problem-solving activities. We summarized ten different roles that parents took on to help their kids take advantage of these kits, seven of which were derived from parent roles identified in prior literature (i.e. [2, 32, 58]), including spectator, scaffolder, bystander, teacher, logistics supporter, collaborator, and gatekeeper. This finding adds to the evidence that these seven parent roles are common patterns in parent-child interactions with technology and media use. We also identified three new parent roles, including (1) enforcer, in which parents mediated the conflicts between siblings, reminded siblings to take turns, or kept track of their play time; (2) executor, in which children ordered parents to do something for their play such as passing coding tiles and building obstacles; and (3) dominator, in which parents took over the play experience from their children. It is worth noting that even though we name the three roles, similar interaction patterns have already been reported in literature. For example, parents would remind their children to take turns or set play time limit when co-playing *Pokémon GO* [61], which is an "enforcer" role in our paper but the authors did not name the interaction. Similarly, the interaction patterns of "executor" and "dominator" align with the intervention techniques in [33]. Sobel et al. [62] described such interactions as *"intervention and co-play."* Among the three roles, enforcer is a frequent parent role in families with multiple children, because when siblings play together, it is not uncommon that various conflicts emerge, such as being reluctant to take turns and competing for play ideas [28]. As such, parents would intervene as a enforcer to help resolve the conflicts. The low-frequency of executor and dominator might attribute to (1) some parents were more knowledgeable in using coding kits than their young children and acted more as a teacher, (2) some parents wanted their children to take charge and learn programming from the play, and (3) some parents were not interested in the play. We further compare the new roles with those in [2, 32, 58] and believe that the new roles did not emerge in the past studies probably due to the differences in study goals, methods, and participants. For example, [2] focused on parents' roles in their middle-school children's learning of technological skills, [32] performed an observational lab study to explore the differences in parent-child interactions with digital and analog play, [58] investigated parent-child interaction patterns in co-making activities, and none of them looked into siblings' interactions.

We also notice some discrepancies between parents' expectations and roles. When talking about expectations, some parents mentioned that they wanted their children to be able to play independently without their intervention. This expectation aligns with the findings from [60, 68, 17] that when looking for educational apps for young children, parents consider children's independent play and entertainment to be important aspects. While in real-world interactions, parents often acted as a scaffolder and teacher to structure or direct their children's experience because they wanted the children to engage with coding kits in meaningful ways. This discrepancy between parents' expectations and roles raises the question of the extent to which parents are willing and able to scaffold their children's play with coding kits and other educational technologies. More empirical studies are needed to help designers of learning technologies figure out ways that can balance children's need for parental support and parents' expectation for children to be independent learners and players.

Parents' Expectations, Perceived Benefits, and Concerns

Prior literature such as [5, 38, 46, 61, 24] has examined parents' perspectives on their children's use of other forms of

technology and media, such as video games and social media. This study provides insights into parents' perspectives on a type of STEM-focused learning technology and highlights parents' desire for their children to learn the basics of coding and get more prepared for the future through playing with coding kits. This finding aligns with prior findings that parents believe technology is an inevitable and intertwined aspect in their children's future [55], and that parents believe STEM skills are important for their children's career and future opportunities [30, 66]. Overall, parents expected coding kits to support their children's fluency and confidence in coding and technology, as well as to engage them in problem-solving, creative thinking and expressing ideas intentionally with coding.

In practice, not all parents found that coding kits met these expectations. Many coding kits examined in [72] claim to be designed for young children ages 3 and up. However, participants whose children were around 4 years old consistently reported uncertainty in their children's meaningful interactions with the kits, observing their children randomly pressing buttons rather than making explicit cause-and-effect actions between their code and robot motions. While some might say that computational thinking concepts and practices might be advanced for young children, studies of young children in classroom settings show promising practices for engaging young children in these coding kits [3, 10, 21]. Compared to the home context, classroom settings may have professional educators, curricula, and other resources specially designed for a younger age group to engage them with coding [52, 64]. Therefore, when designing coding kits and other learning technologies for home use, it is important to consider design features and activity strategies that can engage children in meaningful ways even without the presence of professional educators to scaffold the learning experience.

Even though some parents' expectations were not met, parents were able to experience and observe benefits in engaging with their kids and coding kits. For example, some parents reported strengthened family bonds as the benefits parents perceived from their children's playful technology use [61] and family co-making activities [55]. Other parents shared how they found coding to be more accessible and less intimidating. Parents' positive attitudes can influence their children's attitudes in computing. It's possible that these parents' positive perceptions of coding could increase their children's interests and confidence in creating more complex computer programs. Parents also reported observing various learning outcomes for their children, such as coding and planning. We see opportunities to help parents understand and recognize their children's learning experiences. In classroom settings, teachers have the training to observe learning in action and their curricula might include rubrics, tasks, and other assessment tools to help them understand their students' learning [9, 21]. With coding kits, parents might see their children "randomly pressing buttons," but children might be "experimenting and iterating," a computational practice identified by Brennan and Resnick that can support their computational design process [8]. Therefore, we see opportunities for further study of what and how children are learning from these coding kits as well as design opportunities to make these learning moves and outcomes more visible to parents and children.

Finally, parents' concerns about coding kits primarily depended on the medium. Unlike other media based on digital devices such as games or videos, coding kits span across physical, virtual, or hybrid media. Parents' concerns with digitally-based kits, like other digital technologies, revolved around screen time and cyber safety [5, 38, 46, 61, 24]. Parents expressed less or no concerns for physical kits like Cubetto and Robot Turtles. With regard to sound effects in coding kits, some parents' belief that sound could attract children's attention aligns with the argument in [34] that sound effects might be appealing to a child. However, Hirsh-Pasek and colleagues [34] also argue that sound effects would *"not add to the child's understanding of the primary content"* because they disrupt a child's cohesive learning experience and engagement. Therefore, it is important to balance when, where, and what sounds to include in a coding kit so that the kit can both be appealing to children and not disrupt them from learning. Overall, parents' concerns with coding kits were limited compared to other media like video games because parents immediately saw coding kits as educational activities and beneficial for their children's development. Parents' remaining concerns were directed at themselves, wondering how they might be able to support their children with their limited expertise. Like our recommendations based on parents expectations and perceived benefits, we see opportunities for coding kits to include resources to help parents support their children.

Design Implications

The findings and discussion above shed light on a variety of design implications for coding kits, such as making learning more visible and allowing parents to customize play goals and time for their kids. In this section, we highlight three implications: supporting parents as scaffolders, adding engaging features, and supporting sibling play. Even though these suggestions are directed at coding kits, some are applicable to designing other learning technologies for home use.

Supporting Parents as Scaffolders

We recommend adding features in coding kits that support parents as scaffolders and empower them as teachers, two common roles parents played during children's interaction with coding kits. Most coding kits examined in [72] provide predefined tasks and challenges to structure children's learning experience, which is technical scaffolding following Yelland and Masters's framework [71]. Whereas there are few, if any, design features that specifically support parents as a scaffolder. Our findings show that parents usually follow a cognitive scaffolding approach (e.g, asking questions). How can we better support parents to guide their children to do coding activities and address their concerns about meaningful interactions with coding kits? First of all, many parents themselves may have little understanding of coding concepts (e.g., sequences, loops, and debugging [8]) and how these concepts can be achieved through a coding kit. Therefore, a coding kit should consider parents as learners, help them grasp coding concepts quickly, or even support family co-learning. For example, a kit can provide parents with tip-sheet style materials that illustrate

different concepts, suggest related activities, and encourage parents and children to come up with their own ideas, such as small cards with activity prompts (e.g., teach the robot to dance!) on one side and relevant coding concepts (e.g., loops for playing music and sequences for moving) on the other side so that parents can be more capable of directing their children into meaningful play. Second, such scaffolding features should balance children's need for parents' support with coding and parents' desire for children's independent but meaningful play. However, negotiating this balance between scaffolding and independence needs more exploration in future work.

Adding Engaging Features

Seven parents mentioned that coding kits were not their kid's top toy choices and the kids would not actively ask for the kits. In our participant-recruitment survey, thirteen participants reported that it was usually not the children initiating the play with coding kits but adult caregivers. This result resonates with the finding documented in [60] that educational games are less attractive and relaxing for young children than non-educational games. To make a coding kit more engaging for kids, we recommend involving kids' personal qualities (e.g., body motion, voice, and self-image) in the activity design. For example, P4 reported her son frequently used ScratchJr's sound-recording function in coding, which brought much fun to the child himself and the family when hearing the boy's voice. The use of children's voices and self-images in other forms of children's technology is also reported to be highly engaging for both children and parents [9, 57].

We also see two other approaches to increasing children's interest in a coding kit: (1) promoting their connection to a kit, such as including design features that lead children to treat a coding kit as a pet, or incorporating affective behaviors like hugging and smiling into the play. Studies show the use of robotic pets can contribute to decreased stress and anxiety as well as increased affective behaviors in people [1, 53]; (2) giving more priority to tangible forms, because parents reported less concerns about physical kits and that tangible kits were much more engaging for their young children, which aligns with the findings that tangible coding interfaces are more attractive for kids [36] and parents prefer traditional forms over digital play [37].

Designing for Sibling Play

Fifteen parents reported having more than one child and sibling interactions with coding kits. These parents expected siblings to collaborate or take turns with the kits. Therefore, it is important to consider collaborative play with a coding kit. Following Go et al.'s design suggestions for sibling interactions [28], we recommend that (1) given the ability differences within siblings of different ages, a kit should balance different levels of difficulty while still making fun challenges for children of different ages, such as including multiple pathways or entry points into a kit; (2) to address issues of conflicts and dominance between siblings, a kit can design systems or play mechanisms to avoid common sources of conflicts, such as including multiple controllers and mechanisms to force turn-taking [65]. For example, one child can design coding challenges for the other child so that everyone can have a role in a shared coding experience; and (3) since siblings often act as scaffolders for each other [28], a future design can include play mechanisms that support siblings acting as scaffolders for each other, such as giving hints or passing resources between siblings.

Limitations & Future Work

The major limitation of this work is the representativeness of participants. The majority of participants were white and well-educated people. However, our recruitment information had reached out to a diverse group of parents because several public elementary schools and children's play centers helped send out the recruitment information through both email lists and posters. Therefore, the recruiting result raises questions about what groups of parents are aware of coding kits as well as the affordability and accessibility of the kits. Future studies should attempt to recruit parents from more diverse backgrounds to confirm the generalizability of our results. Give that the data in this paper were based on parents' memory, future work can focus on an observational study of how parents support their children's play with coding kits. Additionally, parents frequently mentioned the interactions between siblings, it will be meaningful to explore sibling collaboration with coding kits in the future.

CONCLUSIONS

In this study, we performed semi-structured interviews with eighteen parents whose young child(ren) had experiences with coding kit(s) at home. The findings provide insights into parents' expectations, roles, perceived benefits, and concerns around their children's learning and play with coding kits. In supporting children's interaction with the kits, parents took on various roles, mostly acting as spectators, scaffolders, and teachers. Some new roles were also identified, such as being an enforcer, executor, and dominator. We further reflect on implications for coding kit design based on parents' perspectives and roles, such as including design features to support parents' roles and sibling play. This work not only expands the understanding of parent-child interaction in children's use of educational technologies but also can inspire coding kit designs that consider the important roles and perspectives of parents to better support children's exploration with computational thinking.

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