

## RESEARCH REPORT

# How Parents Support Children's Informal Learning Experiences with Robots

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**Abstract:** Coding and robotic technologies are becoming more prominent in early childhood STEM education. Parents, who are key facilitators of children's early educational experiences, are increasingly invited to engage with their children in collaborative robotics activities. Few studies have focused on the ways in which parents support young children's informal learning experiences involving robots. This paper presents two different approaches to exploring how parents support young children's engagement. Both studies involve KIBO, a screen-free robot programmed with tangible wooden blocks. The first approach brought together children ages 5-7 with their parents in small groups for 1-2-hour "KIBO Family Day" workshops. Findings from parent surveys (N = 51) indicated that these workshops significantly enhanced families' interest in coding. Parents also reported engaging as coaches, whereas children engaged as playmates and planners. To further explore the role of parents as coaches, three parent-child dyads were invited to participate in a 20-minute videotaped KIBO play session. Findings indicated that parents predominantly used cognitive scaffolding strategies, such as asking questions, offering suggestions, and verbally acknowledging their child's actions. Affective and technical scaffolding strategies were used less frequently. Study limitations and implications for practice and future research are discussed.

**Keywords:** Early childhood, robotics, collaborative learning, parents, scaffolding

## Introduction

Coding and robotic technologies are becoming more prominent in early childhood STEM education as a reflection of the importance of computer skills in today's society (Bers, 2018; K-12 Computer Science Framework Steering Committee, 2016). Programmable robots that are developmentally appropriate, such as the KIBO robotics kit, are well-suited to introducing young children to coding in both formal and informal learning settings (Albo-Canals et al., 2018; Bers 2018; Lee, Sullivan, & Bers, 2013).

Prior work has shown that parents are important facilitators of young children's learning in informal settings (Parker, Boak, Griffin, Ripple, & Peay, 1999). For example, parent-child reading interventions and home reading programs have been shown to improve children's linguistic and cognitive development (National Early Literacy Panel, 2008; Taylor, 1983). However, in contrast with family literacy initiatives, parents may have little or no experience with coding and may not have access to educational robotics tools. Thus, they may feel ill-prepared to introduce robotics to their children on their own (Dell'Antonia, 2014; The Toy Association, 2017). To address these issues, initiatives to bring families together to engage in creative coding and robotics activities have risen in popularity in the last several decades (Beals & Bers, 2006; Bers, 2007; Govind, Relkin, & Bers, 2020; Cuellar, Penalzoza, & Kato, 2013; Feng, Lin, & Liu, 2011; Lin & Liu, 2012; Pearce & Borba, 2017;

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Roque, 2016). Findings from these family coding events have demonstrated the benefits of parents and children engaging in collaborative computing activities. However, few studies have focused on young children and the ways in which parents support their informal learning experiences with robots.

This paper presents two different studies that brought parents and their young children together to engage collaboratively with the KIBO robotics kit, a screen-free robot programmed using tangible wooden blocks. The first study reports on findings from a series of five “KIBO Family Day” workshops that took place outside of school hours and enabled families to interact in semi-structured play sessions with the KIBO robot. The purpose of this study was to understand parents’ views on how these workshops impacted families’ interest in coding, as well as the kinds of roles assumed by children versus parents during the robotics activities. A second observational study examined the specific strategies used by parents to support children’s engagement with KIBO. Three parent-child dyads were videotaped during a 20-minute semi-structured play session with the KIBO robot. Together, findings from the two studies were used to answer the following research questions:

1. How did participating in a KIBO Family Day workshop impact parents’ views on their families’ interest in coding?
2. What kinds of roles did parents perceive themselves and their children engaging in while working together with KIBO?
3. What kinds of strategies do parents use to support children’s engagement with KIBO?

#### *Related Work*

There is some evidence that family coding events foster greater interest in coding among children and adults. These events have largely been conducted in informal community-oriented settings with multiple families. For example, Family Code Night (Pearce & Borba, 2017) provides event kits for schools to host large-scale family coding workshops using Code.org and unplugged activities. The Family Creative Learning model (Roque, 2016; Roque, Lin, & Liuzzi, 2014, 2016) brings together school-age children and families to create projects using the Makey Makey invention kit and the Scratch programming language. Another example is the organization Startups for Kids, which hosts free workshops to teach children and their families about coding in preparation for careers in tech (<https://startupforkids.fr>). Findings indicate that parents and children find programming more enjoyable after these family-oriented events and show increased interest in creative problem solving and project-based learning.

Furthermore, these opportunities enable parents and children to assume and develop a variety of roles as they collaborate and learn from one another. Unlike traditional roles of child as novice and parent as expert, new technologies often bring about varying role dynamics and interactions (Barron, Martin, Takeuchi, & Fithian, 2009; Roque, Lin, & Liuzzi, 2016). For example, parents may serve as learning brokers and non-technical consultants (Barron et al., 2009) or become their children’s co-designers and assistants (Armon, 1997; Feng, Lin, & Liu, 2011; Lin and Liu, 2012; Roque, Lin & Liuzzi, 2016). In addition, museum studies involving young children and their parents and grandparents have found participants engaging in similar roles such as planner, observer, teacher, coach, and playmate (Sanford, Knutson, & Crowley, 2007; Swartz & Crowley, 2004). Although the role names differ slightly across disciplines, the strategies that parents use to peripherally assist children and encourage them to drive their own learning are best summarized by the literature on scaffolding.

Scaffolding is defined as the “process that enables a child or a novice to solve a problem, carry out a task, or achieve a goal which would be beyond [her] unassisted efforts” (Wood, Bruner, & Ross, 1976). Research on scaffolding indicates that parents assume a variety of positive supportive behaviors that promote children’s early learning (Neumann, 2017; Wood et al., 2016). Yelland and Masters (2007) identified three types of scaffolding behaviors used by teachers to encourage student learning within computer-based environments. The first, cognitive scaffolding, denoted behaviors that promoted conceptual and procedural understandings, such as asking questions, assisting with making plans, and encouraging collaboration (i.e., social cognition). The second, affective scaffolding, consisted of behaviors that promoted staying on task and using positive encouragement to promote

higher levels of thinking. Lastly, technical scaffolding referred to features of the computer technology that teachers could highlight to facilitate learning.

In this paper we use this classification scheme to understand the types of strategies parents use to promote children's engagement with robotics, specifically the KIBO robotics kit. The KIBO robotics kit (Bers, 2018) is a developmentally appropriate platform designed to teach coding to children between four and seven years of age. It has been subjected to extensive testing and use in a variety of educational settings. Prior research has found KIBO not only effective for teaching young children foundational coding and computational thinking concepts, but also for encouraging problem solving, creativity, and social interactions (Elkin, Sullivan, & Bers, 2016; Sullivan, Bers, & Mihm, 2017).

The screen-free KIBO robot (see Figure 1) is programmed using tangible wooden blocks. Children connect wooden programming blocks into a syntactically correct sequence and then scan the blocks using a barcode scanner contained within the robot. Each block represents one instruction step. KIBO was designed with a "low floor, high ceiling" (Resnick & Silverman, 2005) principle, meaning the robot is simple enough for a novice to use but sufficiently adaptable to challenge a more advanced child programmer. The KIBO robotics kit has sensors, modules, and extensions that attach to the KIBO body and enable children to artistically design and personalize their robot creatively, as well as respond to stimuli from the environment, such as light, sound, and distance.



Figure 1. KIBO Robotics Kit.

The left image shows the KIBO robot, programming blocks, and add-on parts, and the right image shows the robot sensors and other modules.

This paper, which presents two different studies involving parents and children co-engaging with the KIBO robotics kit, builds upon prior work in several ways. First, we add to the existing literature on family coding, specifically focusing on young children in order to fill the early childhood gap. Educational robotics kits are increasingly popular play tools for young children, so this work will prove useful for understanding how parents and children interact when co-engaging with these tangible tools. Second, this work was conducted in two different types of settings using different methodologies. The first study, KIBO Family Days, involved community-oriented events that took place in informal settings, and data were collected directly from parents in order to understand their perspectives. The second study, Parent-Child Interactions, involved a more experimental approach and took place in a lab setting. Data were collected through close observation of parent-child dyads and analysis of parent behaviors. Taken together, both studies provide insight into how parents support young children's informal learning experiences with the KIBO robotics kit.

## Method

### *Study 1: KIBO Family Days*

*Recruitment.* Five KIBO Family Day events took place between October 2017 and July 2018.

As part of the recruitment and outreach plan, two additional events were hosted by individuals who were not part of the research team. Because data from parent attendees were not collected during these two events, we have not included these events in our analyses. We recruited families using our research group's mailing lists and social media platforms, event flyers, and word-of-mouth. The event was advertised as a free family coding workshop for children ages 5-7 and any of their family members. Although recruitment methods reached individuals around the world, all five events were conducted in the New England area and facilitated by one or more of the authors of this paper.

*Participants.* The five KIBO Family Day events attracted a total of 70 parents, who consented to participate in research surveys before and after the event, along with a total of 99 children. We present in this paper the findings from  $N = 51$  survey participants who completed both pre- and post-surveys (see Figure 2 for study flow diagram). No significant family demographic differences were found between parents who completed one survey versus parents who completed both. All 51 survey participants identified as the parents of the children that attended the event.

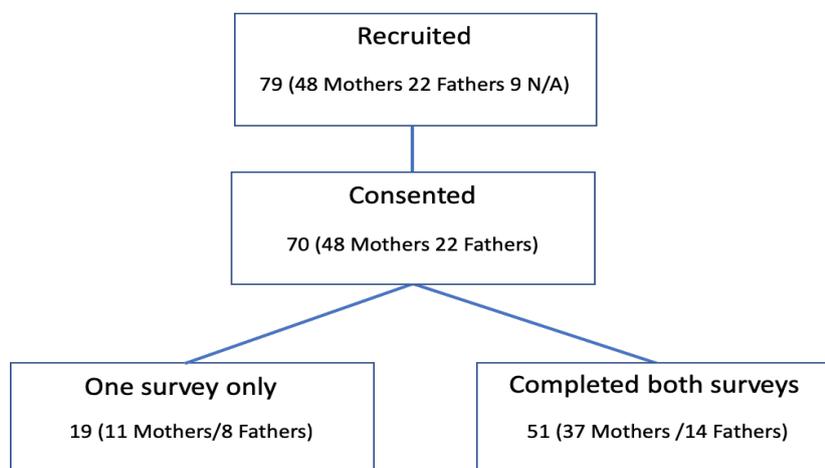


Figure 2. Study Flow Diagram for KIBO Family Day

Of the 51 parents, 37 (73%) identified as female, and 14 (27%) identified as male. These participants brought a total of  $N = 56$  children with them. The mean age of all children was five years. 45% of parents reported that their children had prior coding experience before the event (31% ScratchJr, 24% KIBO, 8% Scratch, 5% LEGO WeDo, 21% other). Parents' educational attainment varied, but the majority of participants (90%) held at least a bachelor's degree (37% bachelor's degree, 33% master's degree, 20% professional degree). In addition, 29.4% of parents in this sample reported their profession was related to STEM (Science, Technology, Engineering, and Math). Examples of reported STEM professions included software engineering, healthcare, and graphic design. Examples of non-STEM professions included merchandising, architecture, and compliance. 29% of parents reported that they had some level of coding experience themselves prior to this event. 16% of parents identified as "coding frequently and being a coding expert."

*Procedure.* Facilitators followed a step-by-step KIBO Family Day protocol. The protocol included a facilitator script, sample agendas, suggested coding activities, parent tip sheet, and activity sheets for children. Depending on the number of families who signed up, each event was led by 2-4 facilitators. All five events lasted between 1.5-2 hours and involved a maximum of 25 children and their families at a time. The events took place during after-school hours in two adjacent classrooms. The first large classroom had ample floor space and contained the KIBO robotics kits and decorative craft materials. In the second classroom, facilitators set up tablets with surveys for parents to complete before and after the workshop. All adults provided informed consent under the terms approved by the university's institutional review board.

Each event followed a similar agenda. For the first part of the event, children engaged in interactive games and a hands-on introduction to the KIBO robot while parents completed consent forms and pre-surveys. After 20-30 minutes, parents joined their children to work together on a creative coding project with KIBO. Families either followed the provided activity prompts (“create a robot dance” or “create a robot animal”) or came up with an idea of their own. While families worked on their projects, facilitators monitored the room and encouraged families to share tips and ideas with one another. At the end of the workshop, families gathered in a circle to share their coding projects with one another. Parents completed post-surveys as children assisted the facilitators with cleaning up.

*Data collection and analysis.* Parents/legal guardians were asked to complete optional research surveys before and after the event. Surveys consisted of multiple-choice, Likert-type scale items, and open-ended responses. Some items such as coding interest were included in pre- and post-surveys in order to assess the impact of the KIBO Family Day event. Other items such as parents’ views of roles assumed by children and parents were included only in the post-survey.

To answer the first research question, “How did participating in a KIBO Family Day workshop impact parents’ views on their families’ interest in coding?”, we analyzed parents’ responses to the coding interest items in the pre- and post-surveys. Parents reported on their own level of coding interest, as well as their perceptions of children’s coding interest, on a 5-point Likert-type scale. Related samples t-tests were used to test the significance of differences between coding interest before and after the event.

To answer the second research question, “What kinds of roles did parents perceive themselves and their children engaging in while working collaboratively with KIBO?”, we analyzed parents’ responses to the post-survey items pertaining to parent and child role engagement. We used the five major roles (planner, observer, teacher, coach, and playmate) identified from the literature and asked parents to rate the extent to which they and their child engaged in each role on a 5-point Likert-type scale. Related samples t-tests were used to test the significance of differences between parent and child roles. Due to running multiple comparison tests, which increases the risk of Type I error, the Bonferroni correction was applied, and the resulting alpha value for determining statistical significance was determined to be .007.

A brief description was provided for each of the five roles:

- Planner: planned out project topic and delegated tasks to others
- Observer: let others guide project creation and did not contribute to coding activities
- Teacher: explained some of the coding topics to the group
- Coach: encouraged and supported the group and offered suggestions
- Playmate: shared the fun, enjoyable parts of the coding activities

Parents were also asked about the extent to which their experience was collaborative (meaning that the majority of discussion and activities were shared) or predominantly led by either an adult or child. Chi-square tests were used to compare differences in the frequencies of responses.

### *Study 2: Parent-child interactions*

*Recruitment.* For the second observational study, we recruited families via mailing lists, word-of-mouth advertising, and prior KIBO Family Day event attendance lists. Inclusion criteria for study participation were that the child must be between five and seven years old, the parent must be able to complete surveys in English, and both the child and parent should be able to converse comfortably in English.

*Participants.* This sample consisted of three parent-child dyads, all consisting of a child who participated with their mother. Each participant’s name has been replaced by a pseudonym to maintain confidentiality. The first parent-child dyad included Thomas (age 6), who had no prior experience with KIBO, and his mother Maria (age 40), who worked in a STEM profession, held a master’s degree, and had coding experience using statistical software. The second dyad included Sarah (age 6), who had prior experience with KIBO, and her mother Andrea (age 42), who worked in a non-STEM profession, held a master’s degree, and had no prior coding experience. The third dyad

included Jordan (age 5), who had prior experience with KIBO, and his mother, Caroline (age 50), who worked in a non-STEM profession, held a master's degree, and had no prior coding experience. We acknowledge that these three case studies are not fully representative of all families who previously attended KIBO Family Day workshops or have co-engaged with KIBO in other informal settings. However, these case studies were still meaningful in unpacking the specific strategies used by parents to support their children during collaborative robotics activities.

*Procedure.* We conducted this study in a closed room connected to an observation booth, separated by a one-way-view mirror. The room included a center table with four surrounding chairs, a sofa on the back wall, a side table for displaying a visual timer and decorative craft materials (e.g., construction paper, tape, scissors, and markers). One KIBO robotics kit was placed on top of the center table. The adjacent observation booth had a built-in audio and video system, and an additional tripod was set up inside the room. In addition to videotaping play sessions, 1-2 researchers observed and took live field notes from the observation booth.

The parent-child dyad first entered the testing room with the primary researcher and was permitted to sit anywhere they felt comfortable. The parent then completed a brief demographic survey while the researcher allowed the child to freely explore KIBO. After the parent completed the survey, the researcher provided a brief interface tutorial and explained to the dyad that they would have 20 minutes to play with the interface and create their own coding project. The prompts for the coding project were similar to those provided during the KIBO Family Day events. In order to make the setting feel as naturalistic as possible, the researcher asked parents to engage with their child as they would during any other activity. If the parent or child needed any assistance during the KIBO play session, a researcher would be outside the room and could assist them at any point. After 20 minutes, the researcher came back into the testing room, and the dyad shared their coding project. Parents also participated in a semi-structured interview and post-survey about the joint programming experience; however, these data are not presented in this paper.

*Data collection and analysis.* To answer the third research question, "What kinds of strategies do parents use to support children's engagement with KIBO?", we transcribed the three 20-minute play sessions and identified the total number of talk turns for each parent. We defined a parental talk turn as a full statement or set of statements that expressed a complete thought or action. If the researcher came into the room to assist the dyad during the 20-minute play session, we omitted from our analysis parental talk turns that took place during the researcher's presence in the room.

After identifying the parental talk turns, we coded every talk turn using the cognitive, affective, and technical scaffolding (CATs) coding system and sub-categorized the talk turns by specific behaviors. Eleven codes were identified in total (see Table 1 for code descriptions). After one researcher coded all of the talk turns for the three dyads, a second trained researcher coded a randomly selected 25% of the transcripts to establish inter-coder reliability. Initial percentage agreement was 77%. After discussing discrepancies, both coders collaboratively refined the coding system for greater clarity and came to 96-98% percentage agreement per dyad. The second coder then re-analyzed the other 75% of the transcripts using the refined codebook.

Table 1.  
Codebook for parental scaffolding strategies

Code	Description
<i>Cognitive scaffolding</i>	
Asking questions	Parent asks the child a question about the project or about KIBO
Modeling	Parent provides an example to help child come up with an idea or demonstrates effective design thinking
Offering suggestions	Parent suggests ideas to the child or offers an idea as a statement or question
Encouraging collaboration	Parent asks or encourages child to work together
Verbal acknowledgement	Parent either verbalizes part of the code or KIBO's action, or parent repeats something the child says
<i>Affective scaffolding</i>	
Encouraging or praising	Parent encourages or praises child
Relieving stress/frustration	Parent provides encouragement if child is stressed or frustrated
Redirecting to task	Parent redirects child to stay on task
Being playful	Parent acts playfully with child
<i>Technical scaffolding</i>	
Physically assisting	Parent physically helps operate KIBO
Verbally instructing	Parent provides verbal instructions on how to use KIBO

**Results**

*Study 1: KIBO Family Days*

*Coding interest.* Parents reported that their interest in coding and that of their children increased significantly following the KIBO Family Day events (see Table 2). Children's coding interest started at a mean of 3.52/5, SD =1.15 and increased to 4.41/5 SD=.805. Adult coding interest averaged 3.38/5 SD=1.18 initially and increased to 4.39/5 SD=.75 after the coding event.

Table 2.  
Parent-reported coding interest before and after KIBO Family Day

Survey Question	Responses: Mean (red) +/- SD (black)	Significance
Child Coding Interest n = 44 "Please rate your child(ren)'s level of interest in coding:"		t(43) = 4.65, p < .001
Adult Coding Interest n = 42 "Please rate your level of interest in coding:"		t(41) = 6.53, p < .001

*Collaboration.* The majority of parents considered the event to be collaborative (n = 28, 54.9%),

some thought it was child-directed ( $n = 18, 35.3\%$ ) and only a few parents ( $n = 5, 9.8\%$ ) reported the experience was adult-directed. Prior experience with KIBO did not significantly affect parents' ratings of the collaborative nature of the Family Days activities. Mothers were more likely to report that the activity was collaborative, whereas fathers were more likely to report the event as child-directed. The relation between parent gender and nature of collaboration was significant,  $\chi^2(2) = 8.99, p = .011$  (see Table 3).

Table 3.

*Classification of coding experience stratified by parent gender in Study 1*

	Adult-directed	Child-directed	Collaborative
<b>Mother (n = 38)</b>	4 (10.5%)	9 (23.7%)	25 (65.8%)
<b>Father (n = 13)</b>	1 (7.7%)	9 (69.2%)	3 (23%)

*Parent versus child role engagement.* Parents reported engaging more as coaches compared to their children,  $t(77.15) = 2.99, p = .004$ . Children engaged more as planners,  $t(85) = 6.60, p < .001$ , and as playmates,  $t(62.90) = 2.95, p = .004$  (see Figure 3).

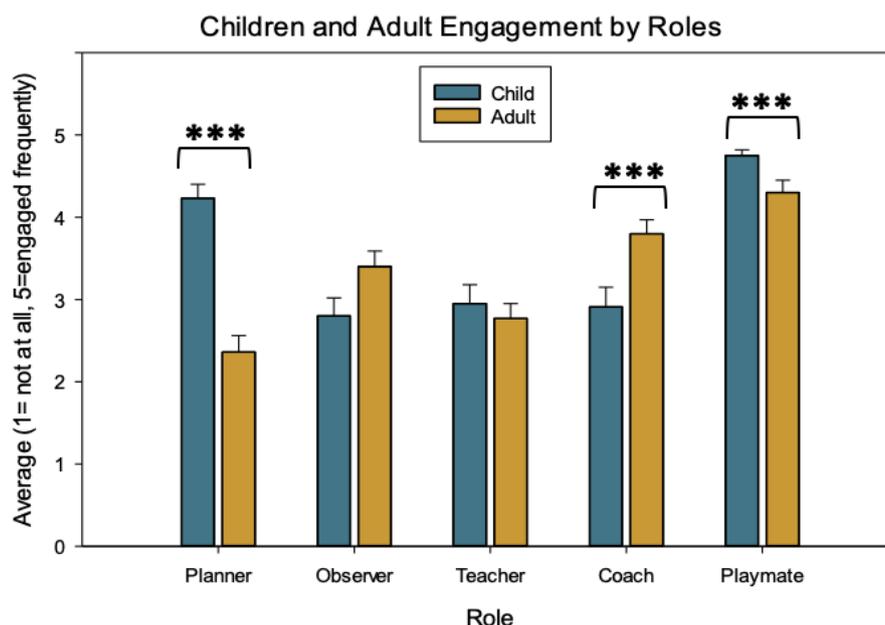


Figure 3. Parent-Reported Role Engagement during KIBO Family Day.

Parents reported engaging more as coaches, whereas they reported children engaging more as playmates and planners.

#### *Study 2: Parent-child interactions*

We first present a summary description of our three case studies and the KIBO projects they co-created. Then, in order to ground the quantitative findings from Study 1 and further explore parents' perceived roles as coaches, we describe the specific strategies we observed parents in our three case studies using to support their children's engagement with KIBO.

*Dyad 1: Thomas (child) and Maria (parent).* In this play session, Thomas creates a "KIBO hotel" project, beginning by showing his mother, Maria, how to scan the blocks. After testing the program together and realizing that KIBO is not performing all of the actions in the program, Thomas calls the researcher in to help. Thomas and Maria figure out that they probably missed some blocks while they were scanning and that they forgot to record a sound using KIBO's Sound Recorder module. Maria continues to encourage Thomas to explore KIBO and helps Thomas scan the new program he

has made. The program runs successfully this time, and Thomas eagerly calls the researcher back in to showcase the new program. The dyad starts to make a new project, and Thomas decides to let his mother take a turn to make her own project. Thomas allows Maria to plan the project by herself, while remaining fully engaged in helping her assemble the blocks and offering encouraging words.

*Dyad 2: Sarah (child) and Andrea (parent).* Sarah, having had extensive experience with KIBO, immediately starts assembling a KIBO program. After testing it once, Sarah asks Andrea if she wants to change the program. Andrea replies by asking for assistance with creating the program and Sarah teaches her mother about start and end blocks. While Andrea begins to create a program, Sarah abruptly shifts her attention to decorating KIBO and asks to make a rainbow. Sarah decides that she will make the “baby rainbow,” then gives Andrea instructions on how to cut out the “momma rainbow.” Andrea offers Sarah assistance with taping the rainbow onto the platform piece several times, but Sarah refuses each time. Andrea cuts out a pink heart after Sarah tells her to make something else for the project. Andrea watches and worries about Sarah’s safety as Sarah insists on independently cutting out holes in the heart using the scissors. After finishing the decorations, Sarah and Andrea only have five minutes remaining and return to programming.

*Dyad 3: Jordan (child) and Caroline (parent).* Jordan decides that he wants to program KIBO as a tiger and Caroline lets him take the lead, beginning with the decorations. Caroline starts drawing a face on the tiger and prompts Jordan with questions to tell her about what the tiger should look like. Jordan becomes more engaged as Caroline draws and works with his mother to tape the orange paper around KIBO. Jordan and Caroline bounce ideas off of each other to make the decorations more sturdy. They begin to program KIBO after they run out of tape and Caroline asks Jordan for suggestions on what to make for their program. Jordan is distracted at first, but then becomes engaged. He purposefully chooses blocks, records tiger growling sounds, and scans the whole program independently. Caroline shows her excitement when they finally run their program.

Table 4 displays the frequencies of parental scaffolding behaviors for the three dyads. On average, parents exhibited 71.8% cognitive, 22.8% affective, and 5.5% technical scaffolding behaviors. We next describe qualitative examples of these behaviors.

Table 4.  
*Frequencies of parental scaffolding behaviors in Study 2*

<b>Dyad</b>	1	2	3
Child has prior experience with KIBO	no	yes	yes
<i>Cognitive scaffolding</i>	<b>48</b>	<b>48</b>	<b>49</b>
1. Asking questions	22	20	17
2. Modeling	8	1	3
3. Offering suggestions	4	13	15
4. Encouraging collaboration	2	9	5
5. Verbal acknowledgement	12	5	9
<i>Affective scaffolding</i>	<b>13</b>	<b>15</b>	<b>18</b>
6. Encouraging or praising	8	3	5
7. Relieving stress/frustration	0	8	0
8. Redirecting to task	0	2	10
9. Being playful	5	2	3
<i>Technical scaffolding</i>	<b>10</b>	<b>1</b>	<b>0</b>
10. Physically assisting	6	0	0
11. Verbally instructing	4	1	0

*Cognitive Scaffolding Behaviors.* Among the three categories of scaffolding behaviors, cognitive was most prevalent, with asking questions and offering suggestions as the most common types of cognitive scaffolding. Parents asked questions in an effort to understand their child’s design process, figure out how they could assist, and move the project along towards completion. If children were stuck or indecisive, parents would assist by reading aloud the character or block names. For example,

when Thomas (Dyad 1) was deciding which blocks to use for their KIBO program, his mother Maria offered to read aloud the names of the different blocks, asking, “Do you want me to explain what all the blocks say on them? That way, you can understand your options.”

*Affective Scaffolding Behaviors.* All three parents provided words of encouragement or praise throughout the play session. For instance, parents complimented their children for thinking creatively (“Your ideas are so original”) and for problem-solving (“I knew you’d figure it out”). Parents would also often praise or encourage their child’s effort to complete a task (“Nicely done” or “Good job”). This type of praise was particularly evident when a task was completed solely by the child. A parent would also redirect their child’s attention back to the project if the child was distracted by other things in the room (e.g., the automated lights turning off, the mirror covering the one-way-view, the crafting materials, etc.). Redirection strategies included asking the child to look at the KIBO blocks together, reminding the child of behavioral expectations, or noting how much time they had left to work on their project.

*Technical Scaffolding Behaviors.* The level of parental technical support varied depending on whether the child had previous experience with KIBO. For instance, Jordan (Dyad 3) had extensive classroom experience with KIBO and thus required no technical assistance or parental instruction. Conversely, Thomas (Dyad 1) had no prior coding experience and was struggling to scan the blocks using the KIBO robot’s embedded barcode scanner. His mother suggested holding the KIBO robot from different angles and positions, which improved his scanning accuracy.

## Discussion

Coding is being introduced into early elementary school curricula in the United States and elsewhere in the world with increasing frequency (Code.org, 2020). However, there has been relatively little attention paid to family-inclusive coding experiences for young children. This study examined two approaches for bringing family members together in an informal environment designed to make learning to code with the KIBO robotics kit an enriching and collaborative experience. Although technology training in the classroom is invaluable, the involvement of parents and other family members in an extracurricular learning setting can potentially amplify benefits. The interaction of a parent and child can foster a higher level of engagement than may come about from a child’s interaction with an unrelated individual (Piazza et al., 2020). By the age of eight, children’s thoughts and perceptions about robotics are already heavily influenced by their parents (Druga, 2018). Our findings suggest that KIBO Family Day events provide open-ended and collaborative opportunities for families to learn about and become interested in robotics together.

Parents reported an overall high level of engagement and interest in coding after participating in KIBO Family Day events. This finding is consistent with previous studies that highlight the success of collaborative coding experiences for children and families (Pearce & Borba, 2017; Roque, 2016; Roque, Lin, & Liuzzi, 2014, 2016). In addition, children were observed to take the initiative to a considerable degree in planning their coding projects, whereas adults more frequently saw themselves in a coaching role. This finding reinforces the respective child and parent roles of “driver” and “reviewer” described by Lin and Liu (2012).

The significant gender difference in parents’ classification of the event as collaborative, adult-directed, or child-directed is an interesting finding that was not anticipated prior to the study. The source of this difference is not clear but could reflect a generic difference in how mothers and fathers view play with their children rather than a specific outcome of the coding event. For instance, Bers (2007) found that fathers tended to be more controlling as compared to mothers when collaboratively coding using LEGO Mindstorms.

The participants in this study had varied educational attainment, occupations, and levels of past coding experience. It seems noteworthy that regardless of these differences in backgrounds, almost all participants reported high engagement during the event and expressed an increased interest in coding in the aftermath. In fact, no adult participants reported less interest in coding after

taking part in the event. Three out of 43 children were reported to show less interest after the event. However, no further information was provided to explain reasoning for the decline in those cases. The overall high satisfaction level of adults and children participating in this event suggests that Family Day Coding events may be an effective way to enhance interest in coding in young children and their family members.

Findings from our second study showed that cognitive scaffolding was the most prevalent type across the three dyads, with asking questions and offering suggestions as the most frequently coded behaviors. This finding is not surprising considering that we identified five categories of cognitive scaffolding compared to only four affective and two technical scaffolding categories. However, this finding may still prove useful for understanding the relative importance parents place on cognitive development with educational robotics, as opposed to socio-emotional learning or fine motor skills. In addition, it may be likely that parents use similar strategies in other types of play-based learning activities with their children and have transferred those behaviors into this coding activity. For instance, one parent commented in the post-interview, “[We] do everything together. We play together, we grocery shop together...so this was no different.”

Affective and technical scaffolding behaviors were observed less frequently. Affective scaffolding behaviors were present in roughly equal frequencies across the three play sessions. Parents used affective scaffolding to encourage their child in various ways, such as helping their child stay on task (“Alright before we do that, we should complete the program, no?”) and praising their child’s actions (“Oh there you go! Knew you’d figure it out”). Technical scaffolding was used by parents to physically assist or instruct their child in creating their program. For example, in a KIBO session, the parent pointed out to the child, “Yeah so that’s light. It seems like these are all like different sounds KIBO can make...this is singing, this is a beep beep, this is play one.” The relatively low frequency of technical scaffolding may relate to two of the three children being familiar with KIBO and thus requiring little technical support from parents.

### **Limitations and Future Directions**

The data in Study 1 were collected exclusively from parent surveys. A strong correlation between levels of interest of the adult and child was observed, raising the possibility that the parent projected their own level of interest on the child. However, past studies focusing on parent reports of children’s engagement suggest that parent assessments tend to be accurate (Hughes, Wikeley, & Nash, 1994). Prior work has shown that the KIBO robot can foster a high level of interest and excitement about programming and robotics in young children (Sullivan & Bers, 2018; Bers, 2018). We found that parents also report a significant increase in both their children’s and their own coding interest after engaging with KIBO.

In order to maintain an informal, naturalistic environment, we did not interview, formally observe, or directly survey the participating children during KIBO Family Day workshops. Some studies have shown that lab-based play can provide a reasonable model of behaviors in more naturalistic environments (Rideout, 2017). Thus, we used a closed laboratory setting for the second observational study. However, we acknowledge that families may interact differently in laboratory settings as opposed to natural home environments and informal learning spaces such as museums and afterschool programs.

Likewise, families were not formally evaluated on their coding abilities after attending this event. Although assessment may be helpful in understanding what kinds of learning children and adults gain from these collaborative coding experiences, a brief intervention such as a single KIBO Family Day event only introduces families to basic coding principles. A series of such events combined with classroom instruction may be more likely to yield measurable improvements in coding ability. As such, this study focused specifically on parents’ perceptions of children’s coding interest rather than objective skill measures.

Despite the use of a protocol designed to standardize events, each KIBO Family Day was conducted slightly differently. The number of KIBO kits and participants at each event were not identical, and the need to share robots may have impacted (positively or negatively) the nature of

collaboration and other outcomes. Available space may also have influenced study outcomes, as space was limited at some of the events and participants were confined to relatively small work spaces that may have detracted from their enjoyment of the experience.

We originally intended to have educators from outside of our research program collect survey data. Although we received over 60 inquiries from educators around the world expressing interest, no outside facilitators contributed survey data. The event required at least two facilitators to collect survey data in accordance with the protocol, which may have created too much of a burden on outside facilitators. Future studies of family coding events might employ simplified protocols that reduce personnel requirements.

Both studies also utilized convenience sampling techniques. In Study 1, approximately 30% of participants reported a background in STEM-related areas, and many had high levels of educational attainment. Study 2 included a small number of families within the network of recruitment efforts who self-selected to participate. The three dyads consisted of mothers who were highly educated from middle-to-high socioeconomic backgrounds. Future research should employ a larger and more diverse sample size and explore the possible effects of parent and child gender, age, prior coding experience, and socioeconomic status to increase generalizability.

## Conclusion

This work explored how parents support children's informal learning experiences with the KIBO robotics kit. Overall, KIBO Family Day events were well-regarded by parents, who reported that the events increased coding interest in their children and themselves. Most parents reported that the event provided a collaborative experience in which adults and children took on different roles. Parents supported their young children's exploration of new technologies by the use of cognitive, affective, and technical scaffolding strategies. The model of using programmable robots in informal group settings that include parents and other family members has merit as a means of introducing young children to the valuable skill of coding.

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