8. Family Coding Days: Engaging Children and Parents in Creative Coding and Robotics

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Abstract: Various models for bringing families together to engage in coding activities have emerged in recent years, but few studies have explored the affordances of different coding technologies for fostering family engagement. This project examined family coding in early childhood with 2 different programming interfaces: the ScratchJr app (a graphical interface) and the KIBO robotics kit (a tangible interface). Data from parent surveys and facilitator observations were collected from informal coding workshops called "Family Coding Days," in which young children and their parents were invited to learn about the interface (either ScratchJr or KIBO), create a coding project together, and share their project with other families. Findings indicated no significant differences between ScratchJr and KIBO Family Days in regard to families' coding interest before and after the event, the nature of parent-child interactions, and children's engagement in key computational thinking skills. Study limitations, implications, and future directions for research and practice are discussed.

Introduction

Coding technologies, such as those that involve robotics or apps with programming languages, allow children to extend their learning in new ways by becoming producers, rather than consumers, of their own creative artifacts (Bers, 2018; Resnick & Silverman, 2005; Yu & Roque, 2018). Although coding in schools has increasingly become more popular with the adoption of K–12 computer science standards and frameworks (Code.org, 2020), schools often have limitations on the amount of time students can spend using coding technologies. Children's early coding experiences with family members may foster children's interest in coding and promote parent-child interactions (Roque, 2016).

Family-oriented programming has thus emerged as a fun, informal way for children and parents to come together and jointly engage in coding activities. Existing models of family-oriented programming include Family Creative Learning (Roque, 2016) and Family Code Night (Pearce & Borba, 2017), which enable children and parents to work together on creative computing projects or jointly play with coding software. Findings from these events indicate that these events are enjoyable for both parents and children and stimulate their interest in project-based tasks and creative problem solving.

Furthermore, family-oriented programming events conducted in informal settings such as libraries and afterschool programs function as connected learning environments (Ito et al., 2013). Ito and colleagues (2013) defined connected learning as "broadened access to learning that is socially embedded, interest-driven, and oriented toward educational, economic, or political opportunity" (p. 4). In the connected learning model, opportunities for children to connect learning across formal and informal settings can enhance children's social and academic competencies. Through coding together, parents can facilitate children's engagement in key computational thinking skills such as algorithmic thinking, debugging, and design process, which are important skills that can benefit children's learning in other areas (Bers, 2018; Martin, 2017).

However, different types of coding technologies may offer different types of user experiences. Graphical interfaces, such as tablet-based apps, use screens and visual elements such as icons, images, and windows to engage users, whereas tangible interfaces allow users to connect their digital environment to the physical world by manipulating objects (Sapounidis & Demetriadis, 2013). Studies comparing graphical versus tangible interfaces indicate that tangible

interfaces are better suited for sharing because they have multiple access points, or different ways for users to touch and engage with the interface (Shaer, 2009). Younger children also tend to find tangible interfaces more enjoyable, whereas older children who have had more experience with computers find graphical interfaces easier to navigate (Sapounidis & Demetriadis, 2013). Particularly in early childhood when parent involvement is crucial for promoting children's technology and media experiences (Donohue, 2016), how might families engage in coding activities with tangible versus graphical interfaces? Does the type of technology impact parent-child interactions during creative coding? This study sought to explore these questions.

Our research team piloted "Family Coding Day" workshops, one- to two-hour coding workshops for children ages 5–7 and their parents to jointly program using either the ScratchJr app, a graphical coding interface (Flannery et al., 2013), or the KIBO robotics kit, a tangible coding interface (Sullivan, Bers, & Mihm, 2017). Anecdotal evidence from pilot ScratchJr and KIBO Family Day workshops (including researcher observations and conversations with parents) indicated that the ways in which parents and children co-engage in coding activities may be directly influenced by the type of coding platform. However, little research has been done on comparing the affordances of different coding technologies for fostering family engagement. This study fills this gap by providing information on parents' perceptions before and immediately after the family coding workshops. In accordance with the connected learning model, we focused our comparison of ScratchJr and KIBO Family Days on three key constructs: (a) parents and children's coding interest before and after the event, (b) type of parent-child interaction during the event, and (c) children's engagement in key computational thinking skills.

Method

Family Coding Day workshops were conducted by researchers as well as by individuals around the country who expressed interest in bringing coding to their institutions. These individuals (termed *facilitators*) received a detailed protocol with recruitment strategies, event tip sheets, sample agendas, activity prompts, and instructions for collecting data via parent and facilitator surveys.

Both ScratchJr and KIBO Family Days consisted of similar activities: *learning* about the technology, *co-creating* a coding project, and *sharing* projects with peers. First, children separately engaged in off-screen coding games while parents completed a pre-event survey and received a step-by-step ScratchJr or KIBO tutorial. Then, families were reunited to work together on an open-ended coding project. Researcher-facilitators provided families with sample prompts, such as "Program a ScratchJr character/KIBO robot to perform a dance, be an animal, or act out a scene from a favorite book or movie," but encouraged families to come up with their own creative ideas. As families worked collaboratively on their projects, researcher-facilitators would walk around to assist and encourage families to learn from one another and provide feedback on their projects. Finally, parents completed a postevent survey and joined their children as they shared their final projects.

Sample

Fourteen Family Coding Day workshops around the United States were conducted between Fall 2017 and Summer 2018, attracting more than 100 families with children primarily between 5 and 7 years old. Younger and older siblings were invited to attend, but the activities and survey items targeted this specific age range. Seven of the 109 families attended both ScratchJr and KIBO Family Days. In order to explore differences between independent samples, we removed these seven cases from analysis, resulting in our sample of N = 95 families (see Table 1 for participant demographics).

	ScratchJr (n = 52)	KIBO Robotics (n = 43)
Mean Child Age (years)	6.43	6.23
Parent Gender		
Mother	40	32
Father	12	11
Parent Education		
High school degree or equivalent	1	1
Some college, no degree	0	2
Associate degree	4	3
Bachelor's degree	15	14
Master's degree	18	12
Professional degree	11	7
Parent in STEM Profession		
Yes	22	11
No	27	27
Prior Experience with Coding Interface		
Yes, child only	23	7
Yes, adult only	2	1
Yes, both child and adult	3	0
No, neither child nor adult	24	35

Table 1. Family Coding Day participant demographics by condition.

Graphical condition. Nine ScratchJr Family Days were hosted by both researchers and external facilitators. A total of 52 families participated. Events were primarily held at elementary schools or children's museums after school or on weekend mornings. All families either brought their own tablet from home or borrowed a tablet to use for their ScratchJr project.

Tangible condition. Five KIBO Family Days were conducted, all of which were facilitated by researchers. A total of 43 families participated. Events were held in the local Boston area, either at the research university in a large open classroom space or in elementary schools where the researchers recruited co-facilitators to help recruit families to attend. For the open-ended projects, researcher-facilitators placed large bins of KIBO parts and tangible programming blocks in a central, easily accessible part of the room.

Data Collection and Analysis

Parents consented to research participation, which consisted of surveys before and after the event. Presurveys, completed by parents at the beginning of the workshop, included questions related to demographics and parents and children's prior experience and interest in coding. Postsurveys, completed at the end of the workshop, consisted of open-ended and Likert-type scale questions regarding parents and children's levels of engagement, collaboration, and learning during the event.

Statistical comparisons were drawn between the two conditions (ScratchJr vs. KIBO) to explore whether there were differences in parents' reported experiences. Specifically, the following dimensions related to the key principles of connected learning were examined: (a) parents and children's coding interest before and after the event, (b) type of parent-child interaction, and (c) children's engagement in key computational thinking skills. In order to account for the

risk of Type I error due to multiple comparison tests, the Bonferroni correction was applied, resulting in an adjusted alpha value for statistical significance of .006. In addition to quantitative data, this paper also presents qualitative observations from facilitators and excerpts of parents' open-ended survey responses to further illuminate families' experiences at Family Coding Days.

Research constructs. We asked parents in both the pre- and postsurveys to report their and their children's coding interest using a 1–5 Likert-type scale from "1 = not at all interested" to "5 = very interested." In the postsurvey, parents reported the type of parent-child interaction during the event as child directed, adult directed, or collaborative. Child- or adult-directed interactions were defined as the child or adult "leading the majority of the discussion and activity," whereas a collaborative interaction was defined as one in which "adults and children shared initiation of the discussion and activity." Children's engagement in key computational thinking skills focused on three skills: *algorithms*, defined as "coding with a logical sequence of steps," *debugging*, defined as "finding and correcting errors; troubleshooting," and *design process*, defined by six iterative steps: "ask, imagine, plan, create, test and improve, and share." Parents reported their children's engagement in these three skills during the event using a 1–5 Likert-type scale. Because computational thinking skills are often difficult to assess, even by professionals of assessment and teaching, the survey items included specific indicators for the 1, 3, and 5 markers, 5 being the highest level of engagement.

Results

Coding Interest

Independent sample *t*-tests indicated that parents and children's reported coding interest before and after the event did not differ significantly by interface (ScratchJr vs. KIBO), all *p*'s > .05. Dependent sample *t*-tests indicated that parents' coding interest increased significantly after participating in a Family Coding Day, $t(82) = 6.20$, $p < .001$. Parents also reported significantly higher coding interest among children after the event, $t(84) = 7.36$, $p < .001$ (see Figure 1).

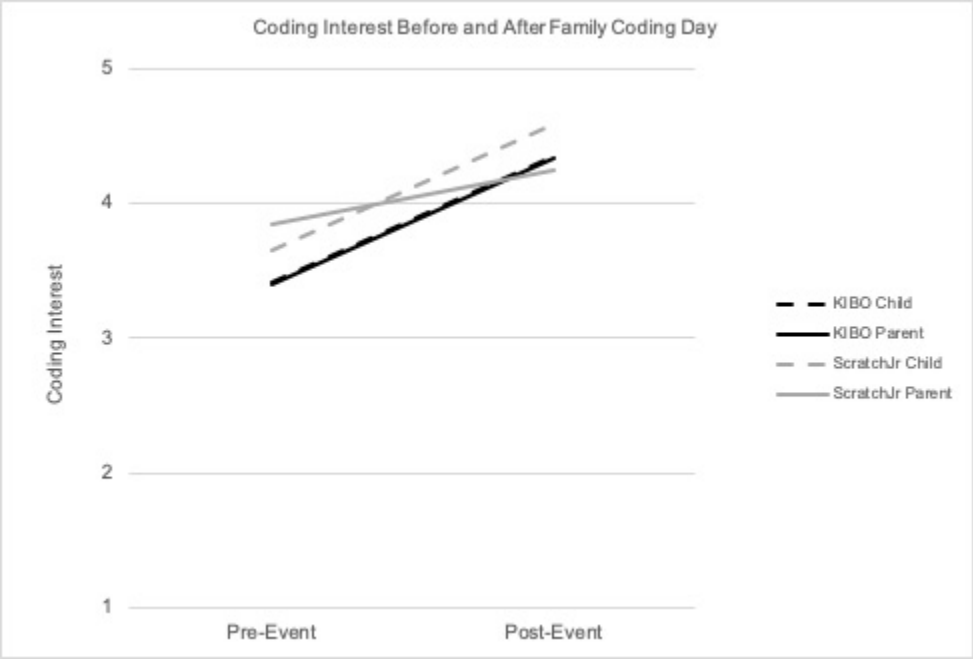

Figure 1. Parents and children's coding interest increased significantly after participation in a Family Coding Day event.

Parents and children were generally enthusiastic about learning to code and eager to showcase their creations at the end of the event. One parent from a ScratchJr Family Day reported, "Before this I knew nothing about coding, but it has piqued my interest to take a class in this, so later on I would be able to do this with my daughter when it becomes more advanced." Parents were also pleasantly surprised by how much children enjoyed their introduction to coding. One parent from a KIBO Family Day reported, "Our son was very interested. He frequently complains of being bored and has a hard time focusing on activities for longer periods of time, but he was very engaged in this and wanted to continue doing it." Another parent wrote, "This activity sparked an interest in my children (and myself) to enroll them in more coding activities and to acquire simple robots for them to code at home." These comments suggest these one-time coding workshops may encourage parents to seek additional opportunities to continue fostering children's interest in coding.

Parent-Child Interaction Type

A chi-square test of independence indicated that the type of reported parent-child interaction was not significantly associated with the interface used (ScratchJr vs. KIBO), $X2$ (2, N = 95) = 4.35, p = .11. Of the 95 parents, 54.7% (n = 52) reported their interactions with children as collaborative, 38.9% (n = 37) as child directed, and 6.3% (n = 6) as adult directed.

Family Coding Days were predominantly viewed as collaborative coding events. Most parents left positive feedback for event facilitators, remarking, "This was a great activity to do together with my child." Some families divided tasks during the coding project. For instance, one parent reported, "My child led the first part of the coding session with the easier coding and then I led the more complex pieces (if/then statements) but with collaboration throughout." Parents also engaged as coaches and encouraged their children to explore new concepts. One parent from a ScratchJr Family Day reported, "My daughter was most interested in designing her own scenes and characters. She was not as interested in making them move, but when coached she did become more engaged, and she really liked adding her voice."

Children's Computational Thinking Engagement

Parents reported that their children did engage in key computational thinking skills during Family Coding Days. The three skills explored in this study—algorithms (M = 3.22, SD = 1.05), debugging (M = 3.26, SD = 1.37), and design process (M = 3.69, SD = 1.14)—were positively and moderately correlated, with Pearson's r ranging from .54 to .60, p < .001. Independent sample t-tests indicated that children's reported engagement in these three skills did not differ significantly by interface (ScratchJr vs. KIBO), all p's > .05.

All families succeeded in creating a project to share with others at the end of the event. Whereas some families had decorated KIBO robots with various crafts materials or had personalized characters and backgrounds for their ScratchJr projects, other families chose to focus on the programming aspect and created complex codes with repeat loops or conditionals. One parent from a ScratchJr Family Day commented on her child's engagement in iterative design and algorithmic thinking, remarking, "It was great seeing my daughter create and re-create stories using different algorithms."

Discussion

This study examined families' experiences at informal "Family Coding Day" events, in which young children and parents learned about coding, worked together on an open-ended project, and shared their creations with fellow participants. The purpose of the study was to explore whether parents' perceptions of their experiences at Family Coding Days differed based on the type of coding platform they engaged with, either the ScratchJr programming app (a graphical interface) or the KIBO robotics kit (a tangible interface). Our analyses revealed no significant differences between ScratchJr and KIBO Family Days in regard to families' coding interest before and after the event, the nature of parent-child interactions during the event, and children's engagement in computational thinking skills during the joint coding activity.

Both parents and children's coding interest increased significantly after participating in a Family Coding Day. This finding supports ScratchJr and KIBO as accessible and engaging coding platforms for learners of all ages. Furthermore, this finding suggests that framing coding as a creative and engaging activity for families to do together can promote their engagement and interest in coding overall. Regardless of interface, parent-child interactions during Family Coding Days were predominantly identified as collaborative. This finding is interesting because the two interfaces offer very different user experiences. ScratchJr, as a single-touch interface, enables only one user to interact with the app at any given time. Conversely, the KIBO robotics kit comes with many interlocking blocks and detachable parts, offering multiple access points for users. However, during ScratchJr Family Days, families would position themselves so that both the child and parent could view the screen or take turns clicking on the various icons. Parents also offered suggestions verbally or pointed to the various ScratchJr features while their children physically operated the app. This form of "joint media engagement" (Takeuchi & Stevens, 2011) permitted ScratchJr families to have a collaborative coding experience. Finally, children did engage in computational thinking during the course of designing and revising their coding projects with the assistance of their parents. Future work should explore the extent to which children's engagement in computational thinking skills is dependent on parent involvement, as well as the specific ways in which children's computational thinking can be enhanced through family coding.

Altogether, these findings suggest that the affordances of graphical versus tangible tools may not matter as much as having informal, open-ended opportunities for young children and parents to engage in creative programming. Regardless of interface, ScratchJr and KIBO Family Day events have shown themselves to be enriching spaces for families to engage in connected learning (TeachThought, 2018). These events are *interest-powered* and *production-centered*, inviting parents to co-design robotic creations or digital stories that are personally meaningful and interesting to their young children. These events are also *peer-supported* and have a *shared purpose*, welcoming various opportunities for collaboration, feedback, and community building. Finally, these events are *academically oriented* and *openly networked*, offering children the opportunity to learn new skills and connect their learning across different settings. As family coding workshops expand in coming years, future research should continue to explore how families' experiences are shaped by different kinds of coding technologies.

Limitations

There were several limitations to this work. One was that both child and parent survey data were reported by parents themselves. Self-reported survey responses are prone to some level of bias, particularly social desirability bias, in which parents may over-report socially desirable traits and under-report undesirable traits. Future work should employ validated observation measures to supplement parent reports and collection of data directly from children to understand their perceptions of coding alongside their parents. In addition to response bias, another limitation of this work is self-selection bias, which limits generalizability. Families self-selected to attend ScratchJr and KIBO

Family Day events and participate in pre- and postsurveys for research purposes. Although recruitment methods varied among events, the analytic sample for this study comprised highly educated parents from middle to high socioeconomic backgrounds. Future research should explore whether families that do not belong to these demographic characteristics report similar family coding experiences.

Another study limitation is facilitator resources. Event facilitators require a large space for families to come together, as well as access to the technologies themselves (i.e., tablets and KIBO robotic kits). Although ScratchJr is a freely downloadable app, KIBO robotic kits are more expensive. These possible logistical and financial obstacles may be why KIBO Family Day events were hosted solely by the research team. Future research might explore how access to resources may affect the nature of families' experiences at Family Coding Days. More important, individuals and organizations seeking to bring coding to their respective communities should seek adequate funding and resources to ensure positive experiences for families.

Practical Implications

In the larger conversation of the graphical versus tangible debate and which might be considered more suitable for different settings, this work suggests that both ScratchJr and KIBO foster positive experiences for young children and parents to jointly engage in creative computing activities. Parents, educators, and practitioners seeking to promote family-oriented coding opportunities for young children should keep the following considerations in mind. By programming stories on ScratchJr or creating robotic artifacts with KIBO, children not only engage with advanced technological tools, but also learn how to produce creative artifacts. Facilitators should encourage families to create projects that are meaningful and personal to them. Similar to when reading a book or playing a board game with their children, parents can play an important role in facilitating children's creativity, personal expression, and problem-solving skills through the activity of coding together.

In addition, the ways in which parents and children engage with different kinds of coding tools depend on the availability of resources, such as time, space, number of tablets or robotic kits, and facilitators. Family Coding Days should be long enough to allow families to successfully complete a coding project but concise enough to keep families fully engaged. Events should also ensure that the environment offers adequate tools and appropriate spaces for both children and parents to easily access the interface and collaborate with one another. Facilitators should be trained on how to use the interface and to offer scaffolding strategies to encourage families to problem solve on their own before asking facilitators for assistance. Taking these considerations into account will benefit both facilitators and families.

Conclusion

As coding becomes an increasingly important priority in schools and other formal learning settings, connecting children's learning of coding outside of school through family engagement will also become increasingly salient. This study was the first to explore family-oriented coding in early childhood in informal settings using different types of coding technologies. More than 100 families participated in Family Coding Days, which were informal coding workshops conducted in settings such as afterschool programs, museums, and community centers. Findings from parent surveys and facilitator observations indicated that families' experiences at Family Coding Days did not differ based on the type of coding platform they engaged with, either the ScratchJr programming app (a graphical interface) or the KIBO robotics kit (a tangible interface). These findings may serve to position creative coding as an engaging family-oriented activity and propel future research on parent-child interactions at family coding events.

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Acknowledgments

We are deeply grateful to the families and facilitators who participated in this research. We also thank members of the DevTech Research Group for their assistance with data collection. This work was generously supported by the Scratch Foundation and the National Science Foundation (NSF DRL-1118664).