Caregivers' Role-taking during the Use of Discussion Prompts in At-Home Engineering Kits

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Abstract: This study presents a video-based case study of families who used discussion prompts in the at-home engineering kits. We examine different roles that caregivers took on during the implementation of the prompts to organize families' engineering learning activities. Narrative accounts and transcriptions were analyzed to investigate the different roles that caregivers took. Three roles emerged: caregivers as *monitor*; caregivers as *mentor*; caregivers as *partner*. We further coded families' talks to investigate how three different caregivers' roles influenced families' engineering practices and caregiver-child talk types. Preliminary findings illustrate how three caregivers' roles enabled and constrained different types of engineering practices and caregiver-child talk types. Findings contribute to future considerations in designing discussion prompts for at-home engineering kits.

In response to COVID-19 pandemic, caregivers' engagement in their children's learning is an emerging priority. We provided at-home engineering kits, which included open-ended engineering challenges and discussion prompts to facilitate families' engagement in engineering practices at home. While research has examined the role of prompts in informal learning settings (e.g., Zimmerman, McKinley, Kim, & Grills, 2019), most studies are from contexts where facilitator support is available; less is known about how prompts can support caregivers to guide children's' learning at home. In this paper, we examine different roles that caregivers took on during the implementation of the discussion prompts to organize families' engineering learning activities.

Theoretical framework

We focus on families' social interaction and conversations by building on work that applies sociocultural theories to family learning (Dierking & Falk, 1994). In families' shared activity, caregivers can take on roles to structure families' participation and support negotiation of meanings (Rogoff, 2003). Prior research suggests that caregivers take on roles such as teachers, collaborators, and learning brokers (Barron, Martin, Takeuchi, & Fithian, 2009). Our conjecture is that caregivers' roles influence the degree of structure and formalness when using the prompts in the at-home engineering kits, which can consequentially influence families' engineering practices. Our work explores how caregivers organize families' engineering learning activities—through the configurations of interactional roles—during the use of at-home engineering kits.

We adopted Engineering is Elementary (EiE) model (ask-imagine-plan-create-improve) to guide our understanding of families' engineering practices (Cunningham, 2009). For younger learners (K-5), the engineering practices of asking is related to understanding the problem scope; imagining and planning relate to the idea generation; creating is concerned with the application of scientific and engineering knowledge to address the design problems; and improving is making optimization on their design (National Research Council, 2012).

Methodology

Our study is a qualitative case study of families with children (6-12 years) who used the at-home engineering kits. The unit of analysis was family members' engagement while utilizing one kit. If one family split up into two groups and used two kits separately, we considered them as two cases. The research team worked with Boys and Girls Clubs and public libraries that had existing relationships with economically disadvantaged families to recruit study participants. Eight families represented European American, Asian, and African American backgrounds. Out of 16 families (27 children) that completed one to five kits and recorded their interaction (230 hours of data), we focused on eight family cases that completed the same kit. The kit included an instruction card and craft materials to construct a package for delivery, out of pasta, that can travel along a zipline to deliver a package to a friend 30 feet away. Four discussion prompts contained questions: 1) prompt 1: What is the function of each container? What kinds of shapes form a good container? What material will you use? Explain your choice of material; 2) prompt 2: Is your container sturdy enough? How do you know? How might the type of pasta make a difference? Is the size and depth of the container appropriate?; 3) Prompt 3: Why do you need a handle and a hook?; 4) prompt 4: Construct a zipline and test your design. Explain how you attached the zipline. Why is your design working or not working? How can you improve your design?

We conducted interaction analysis (Jordan & Henderson, 1995) in two phases. First, we created content logs to identify episodes where families utilized the prompts. When the families' video-records did not provide clear evidence of revoicing the prompts, we did not engage in further data analysis to prevent from making ungrounded assumptions. As such, two family cases were excluded. For each case, we created a narrative account with a summary of how many prompts were implemented and transcribed families' talk that resulted from the implementation of the prompts with screenshots and timestamps from the video-records to provide a "thick description." We further examined the narrative accounts by conducting a thematic analysis to explore the different roles that caregivers took during the implementation of the prompts. Three themes emerged: caregivers as *monitor*; caregivers as *mentor*; caregivers as *partner*. In the second phase, to investigate how three different caregivers' roles influenced families' engineering talks, we coded families' talks at the level of individual's utterances, defined as a turn of speech by a speaker, with atlas.ti. using the coding scheme by Cardella et al. (2013) with three elements: 1) engineering practices (problem scoping, planning, modeling, evaluation/testing), 2) caregiver-child talk types (asking, affirmation, disagreement, explanation), and 3) interest (excitement, frustration). The codes for the engineering practices aligned with the EiE practices. We refined the codebook until there was a consensus on the codes. Consequently, sub-codes were added (e.g., kit revoicing, asking questions to express uncertainty). Coding results were compared and contrasted within and across three different groups. We acknowledge that the study sample in each participant structure is not sufficient to provide generalizability.

Findings

The occurrences of talk demonstrated that families' conversations sparked by the discussion prompts were predominantly related to the engineering practices of planning, followed by equal occurrences of problem scoping and modeling and evaluation/testing (Figure 1). Explanation, asking questions, and providing affirmation/ encouragement were the most frequent talk types. When occurrences of talk were compared across three groups, caregivers as *monitor* utilized all four prompts and the other families used 1 to 3 prompts. The families' talk related to engineering practices and caregiver-child talk types had nuanced differences across three groups. Notably, families with caregivers as *monitor* engaged in more planning talk while families with caregivers as *partner* engaged in more problem scoping talk. Talks related to asking questions to express uncertainty or having conflicts were only evident in families with caregivers who took on the role of *monitor*.

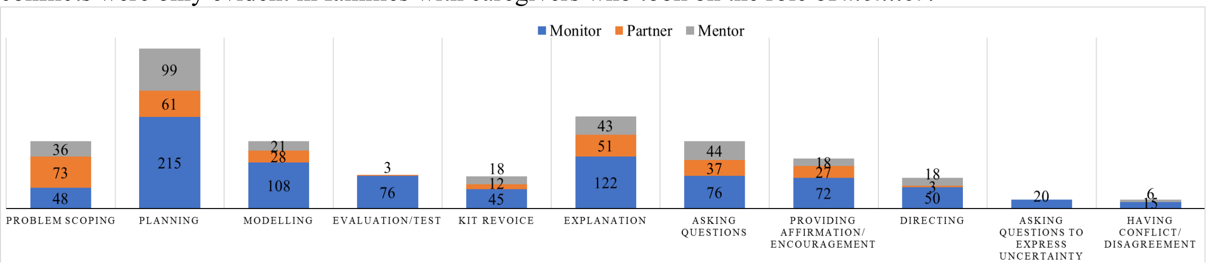

Figure 1. The graph represents occurrences of talk at the level of individual's utterances related to engineering practices and talk types in three groups (caregivers as monitor, caregivers as partner, caregivers as mentor).

Caregivers monitor the design process with faithful implementation of the prompts

Caregivers took on the role of *monitor* by faithfully revoicing all four prompts, which supported families' engagement in all four engineering practices. Edward and Roberto's families that had caregivers taking the role of *monitor* were the two cases that revoiced prompt 2 to test the sturdiness and the appropriate size of the containers. As such, these two families were able to also engage in engineering practice of evaluation and testing, which most families did not engage in (Figure 1). Families' engagement was characterized by product-driven approach—towards constructing a complete prototype that addresses the function—as highlighted in higher occurrences of planning and evaluation/testing talk.

Analysis of families' interaction showed that caregivers used the prompts to provide executive directions on what to do next or provide approval to the child's responses, as demonstrated in the excerpt from Edward's family below. Edward's family discussed what the function of the container would be after revoicing prompt 1. Initially, Edward suggested that the container be easy to use and deliver the package fast. The caregiver disagreed and emphasized to focus on keeping the package secure inside the container. Afterwards, the family did not engage in further discussion to reach a consensus on the function or discuss different ways to add safety features to the container. The episode starts as the caregiver observes Edward making the container.

01 Caregiver: ((shakes head)) You are gonna hurt it, you are gonna hurt it. No, mm-mm (negative)…
02 Edward: ((moments passed; the plastic figure is put inside the container))

03 Caregiver: Ok. I don't think it's the best way, but it's what you wanna do…I am thinking if I had to put you
04 in one of these and sent you across the way, would you want to be in here?
05 Edward: ((frowns)) No!
06 Caregiver: Think about it. Ok. We need to make something that's safer.

The caregiver expressed uncertainty and disapproval towards Edward's design approach (line 1). She expressed disagreement even after Edward successfully put the figure in the container (line 3) since the container did not look safe and secure (lines 4, 6) to address the function that she had emphasized previously. Findings showed that caregivers who took on the role of *monitor* faithfully implemented the prompts to monitor the design process, but also questioned the appropriateness of the child's approach and shifted their design trajectory towards implementing approaches that caregivers perceived as important.

Caregivers mentor to mitigate challenges through on-the-fly use of the prompts

An additional role that caregivers took on was that of *mentor*. In Sara and Eden's families, caregivers mentored their children by utilizing the prompts on-the-fly to mitigate challenges experienced by the children. Sara and Eden were part of the same family, but each worked with different caregivers. (Therefore, two separate video-records were created.) Sara, being the older sibling, independently worked on the engineering challenge without much challenges by using the instruction card. Eden, on the other hand, experienced difficulties understanding the engineering challenge and the constraints, although the caregiver had previously utilized the discussion prompt 1 to discuss them. After discussing prompt 1, the caregiver left to do chores. When the caregiver started observing Eden after she finished her work, Eden stated: "I have no idea what I am doing." The caregiver then helped Eden to construct the container. The episode starts after the caregiver reads the discussion prompt 4 to brainstorm ways to attach the container to the zipline.

01 Caregiver: How will we ((looks at the prompt)) attach this zipline? ((rephrases the same question again))
02 Eden: You just use another pipe cleaner ((attaches to the container)) but then it would…
03 Caregiver: What other materials do we have in here?
04 ((Eden mentions fishing line, scissors, paper clips, rubber bands.))
05 So, let's think about what might….let's… you wanna feel this ((passes the fishing line))?
06 Eden: ((feels the fishing line))
07 Caregiver: What might slide along there very easily?
08 Eden: ((takes paper clip))

The caregiver utilized the discussion prompt and asked questions to help Eden notice a material that might slide easily along the zipline (lines 1–2). As Eden was unable to notice the material property of the paper clip, the caregiver asked Eden to feel the fishing line (line 5) and find a material that might slide down the fishing line (line 7). As highlighted in the episode, the caregiver positioned herself as the mentor who would step in to mitigate challenges experienced by the child—by utilizing questioning to strategically guide the child find ways to address the engineering challenge. While the caregiver continued to encourage the child to brainstorm and design the prototype, it was often challenging for Eden to figure out ways to construct the container or address challenges on his own. As such, the caregiver had to step in to provide strategic questioning and explanations to co-construct the container and the zipline. Later, Eden and the caregiver successfully constructed a zipline that delivered a package by adopting a pulley system. However, Eden expressed a lack of ownership over the design as the caregiver initiated many ideas: "I think I am copying Sara (his sister)." Without opportunities for the child to make sense of and resolve his inquiry steps, as the caregiver stepped in to deliver suggestions, the feeling of accomplishment at the end of the engineering challenge was low for Eden.

Caregivers partner with the children through equal usage of the prompts

The last role that caregivers took was that of *partner*. In two family cases (Billy, Abby), caregivers and children worked as partners by posing questions and suggestions while equally utilizing the prompts. A notable difference in this group was high occurrences of problem scoping talk (Figure 1). Billy's family discussed how long 30 feet is; Abby's family discussed which toy to send to estimate the size of the container. We note that similar type of problem scoping was not evident in other cases. Another notable difference was the level of caregivers' participation. The caregivers engaged as partners alongside the children who also questioned, shared uncertainty, and proposed ideas throughout the engineering design process instead of only voicing opinions when challenges emerged as an outsider. We present an episode to illustrate how caregivers took on the role of *partner*. Prior to the episode, Billy read aloud prompt 1 and began to sketch out his plan for the container. The caregiver revisited the prompt and questioned how the container could travel back and forth to deliver a package.

01 Caregiver: In the olden days…you could pull the clothing line towards you and then it would go back out.
02 Billy: Yes, but that's…we can do that, Mom. ((notices)) There's fishing, fishing line!
03 Caregiver: Do we want to use gravity or do we want use more like pull?

04 Billy: Pull.
05 Caregiver: Because why?
06 Billy: Because gravity would be hard.
07 Caregiver: If it was gravity, it would only be able to go to, let's say to Lia's house. But we couldn't get it back…

The caregiver continued to inquire different possibilities for creating the delivery system by suggesting a pulley (lines 2) and gravity (line 3) to deliver the package. When Billy quickly dismissed the possibility of using gravity (line 10), the caregiver continued to question whether gravity would be an appropriate option given that creating a different height between departure and arrival points, thus using gravity, would only work in one direction (line 7). After this episode, Billy resisted to inquire about this topic further as he emphasized sketching out their plans first to complete the challenge. As illustrated in the episode, the caregivers who took on the role of *partner* engaged in the engineering activity with genuine interest to construct a working solution by posing questions and suggestions. However, in two family cases, an opportunity for further inquiry was often constrained by the child's intellectual values on the completion of tasks.

Discussion and conclusion

Our preliminary findings from six family cases illustrate forms of guided participation (Rogoff, 2003) that caregivers took on to organize families' engineering learning activities at home. Barron et al. (2009) have shown that caregivers support children's technology engagement by taking different roles as their learning partners. Our case study findings demonstrate that caregivers took on roles as *monitor, mentor, and partner* which both enabled and constrained different types of engineering practices and caregiver-child talk types. While faithful implementation of the prompts by caregivers who took on the role of *monitor* was supportive towards engagement in engineering practices, the asymmetric relationship in which the caregiver was positioned as the knowledge validator seemed to echo the rhetoric of hierarchy. Caregivers who took on the role of *mentor*, as highlighted in Eden's case, demonstrated that moments of learning opportunities that emerge from the child's inquiries may not be taken up *just-in-time*. The on-the-fly support from the caregiver in Eden's case enabled the family to co-construct a working prototype; however, questions remain as to whether the caregiver's support also enabled Eden to take ownership of their prototype. Caregivers that took on the roles of *partner* demonstrated that caregivers' active participation to learn and motivation to guide their children in inquiry process can be hindered when children's motivation and goals are not aligned with that of the caregivers. One possible solution that can be embedded in the discussion prompts is to communicate the importance of taking up one another's ideas, questions, warrants—however small they may be. It may be necessary to first support family members to understand that the informal engineering learning activity as an opportunity to construct and evaluate knowledge rather than simply completing the challenge. In future, we hope to investigate further how different design elements in the at-home engineering kits, including the prompts, can provide learners to embody engineering ways of thinking without the presence of a facilitator, while considering the role of family members.

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