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Caregivers' Roles in Supporting Children's Engagement in Engineering Activities at Home (Fundamental)

Dr. Kelli Paul, Indiana University-Bloomington

Dr. Kelli Paul is an Assistant Research Scientist at the Center for Research on Learning and Technology at Indiana University where her research focuses on the development of STEM interests, identity, and career aspirations in children and adolescents.

Lauren Penney, Indiana University-Bloomington
Dr. Adam Maltese, Indiana University-Bloomington

Professor of Science Education

Amber Simpson, State University of New York at Binghamton

Amber Simpson is an Associate Professor of Mathematics Education in the Teaching, Leaming and Educational Leadership Department at Binghamton University. Her research interests include (1) examining individual's identity(ies) in one or more STEM disciplines, (2) understanding the role of making a.11d tinkering in formal and informal learning environments, and (3) investigating family engagement in and interactions around STEM-related activities. Before joining BU, she completed a post-doctoral fellowship at Indiana University-Bloomington. She earned a Ph.D. in mathematics education from Clemson University.

Dr. Jungsun Kim, Indiana University-Bloomington

Jungsun Kim, Ph.D. is a research scientist at Indiana University at Bloomington. Her research focuses on how students can consistently develop their talent throughout their educational experiences and how parents, school, and community support students, s

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Abstract

We began this project with three goals: (1) engage families in engineering activities, (2) increase the awareness of kids and caregivers as to what engineering is, and (3) increase children' interest in engineering. We focused on caregivers and home environments because of the important role that at-home experiences with STEM play in triggering interest for many individuals who enter STEM professions. We created and distributed four different kits to families interested in engaging in STEM activities at home. Each kit included a challenge around engineering-related content (e.g., circuits, construction) and contained activity instructions (child) and a facilitation guide (caregivers). However, few instructions were given to caregivers about the expectations of their role while engaging with their children. This paper reports on the findings from family engagement in the Watercolor Bot kit. We sought to explore the roles enacted and behaviors utilized by caregivers as they supported their children during the activity. Our findings add to the conversation about how to define and conceptualize caregiver roles and how the home context/setting influences the types of supports caregivers provide. In contrast to emerging work on caregiver support, we argue that it may be more fruitful to think about the types of support (physical, verbal, content, and managerial) offered rather than defining specific roles (e.g., collaborator, project manager, etc.). We provide implications for designing kits and activities to include specific support for caregivers beyond simply providing project-specific instructions that address caregivers' needs.

Introduction/ Background

At-home experiences with STEM and engineering play an important role in triggering interest for many individuals who end up in STEM fields [1]. The home is an important context for learning. School-aged children spend around 19% of their time in school or other formal educational environments and the remaining 81% in informal settings [2]. While informal settings for education include institutions such as museums, libraries, and after-school centers, this study centers on what happens in the home during natural interactions "in the wild" [3]. The home environment is full of unique cultural practices and ways of interacting in the world and, specifically, with STEM. Family cultural practices shape children's beliefs, knowledge, interactions, and inquiry practices [4], [5], [6], [7]. Parents, grandparents, and other caregivers value STEM education [8] and play a large part in shaping their children's STEM experiences, dispositions, identities, interests, and practices [9], [10], [11], [12], [13]. As such, caregivers provide a valuable resource to their children and have the potential to bring unique contributions to the process of learning engineering, especially in the home context.

Caregivers serve as the "providers of experiences" for their children, such that their beliefs and perceptions about STEM and engineering influence not only which opportunities they provide to their children but the actions and behaviors they use while engaging in these activities with their children [10], [14], [15]. We draw upon the work of Eccles and colleagues to understand how caregiver values, beliefs, and socialization impacts their child's informal STEM experiences. Specifically, the expectancy value theory (EVT) framework describes ecological, psychological, and sociocultural influences on children's choices and performance in STEM activities, with socializers being one of the key factors for children. The model of parental socialization posits that parental beliefs and perceptions influence their subsequent actions and behavior, primary among these are the provision of activities and supports, encouraging their children, and actively engaging in activities together [16], [17].

While caregivers may engage in math and science more readily with their children in their daily lives (e.g., via cooking, budgeting, measuring for DIY projects), they are less likely to do so with engineering activities. This may be due, in part, to their knowledge of their child's interests and abilities and to their own misconceptions about engineering, lack of understanding of engineering concepts, and lack of confidence in their ability to help their children with these activities. The interplay of caregivers' knowledge, expertise, and their child(ren)'s interests influence what activities are engaged in [18] or whether caregivers avoid these activities altogether [10], [19], [20]. For example, if caregivers feel like they lack appropriate knowledge or skills to help their children, they may struggle with how best to teach or support them in STEM activities [19]. However, caregivers do not need to have technical or subject matter expertise to be able to engage with and support their children in STEM activities [21], [22].

Prior research has begun to investigate the ways in which caregivers support their children in STEM projects during family workshops [11], [21], and at home [18], [23], [24]. These supports are categorized as "roles" caregivers enact. However, no clear consensus exists on what these roles are or how they are defined. For example, in 2009, [18] interviewed middle schoolers and their caregivers, identifying seven roles parents used to support their kids' creative technologically mediated activities: teacher, collaborator, resource provider, learning broker, non-tech consultant, employer, learner. In 2016, [21] applied these roles to their five-week family creative learning workshop, adding facilitator and gatekeeper to the list. In our own prior work examining roles in a five-month engineering workshop [11], we drew from [18]'s roles, adding and refining them throughout the coding process, resulting in 11 identified roles: teacher, collaborator, resource provider, learning broker, parallel collaborator, facilitator, project manager, quality engineer, lead engineer, observer, and outsider. While these roles are relatively consistent as they are all based on the same initial 2009 study, similar work by [23] identified roles differently, such as builder, designer, facilitator, cheerleader, and teacher. While much of this work attempts to categorize the roles enacted by caregivers, recent work has begun to focus less on identifying the specific roles and more on describing the actions and behaviors of caregivers. Specifically, [18] examined parental behaviors during school closures early in the

COVID-19 pandemic. They observed the ways parents engaged with and supported their children during online learning, observing that parents listened in on Zoom sessions, brokered access to resources, guided lessons, and provided technical support or assistance [18]. Across all these studies, whether described using behaviors or specific role categorizations, the types of support provided by caregivers tends to be fairly consistent, including physical support (builder, collaborator), verbal support (cheerleader, consultant), content support (teacher, learning broker), and managerial support (facilitator, project manager).

Research Questions

In this paper, we seek to address the following research question: What kinds of roles and behaviors do caregivers enact that support their child's learning and engagement in engineering activities at home? We anticipated that caregivers' roles and behaviors would be influenced by the home context and reflect caregivers' trying to balance responsibilities of being a parent/caregiver with their expectations of what it means to support or teach their child about a discipline with which they may be unfamiliar (e.g., engineering).

Methods

Study Context

The current study was conducted as part of an NSF-funded project to (1) engage kids and their caregivers in engineering, (2) increase the awareness of kids and caregivers as to what engineering is, and (3) increase kids' interest in engineering. We intentionally focused on caregivers and home environments because at-home experiences with STEM play an important role in triggering interest for many individuals who end up in STEM [1]. We created and distributed kits to families who wanted to engage in STEM. Each kit included a challenge around various engineering-related content (e.g., circuits, construction) [https://athomeengineers.com/]. The goal was for families to use the kits to spark initial or sustain existing interest in STEM.

We partnered with our local library by offering the kits as part of their annual summer reading challenge. The program was advertised as part of the library's upcoming events guide/brochure as well as on their website. We utilized the library's existing activity registration system to sign families up and their main branch for distribution of kits. Our team responded to all participant inquiries, provided weekly online Q&A sessions, and replenished used materials in the kits. We offered four separate kits to families: Roller Coaster, Squishy Circuits, Trendy Tennies, and Watercolor Bots. Registration was opened for each kit individually and was capped at 35 families per kit. Families checked out the kits and completed them at home.

This study focuses on the Watercolor Bot kit. Each kit contained a set of instructions (child), a facilitation guide (caregivers), video links that provided more information and examples, a variety of materials (e.g., Q-tips, cotton balls), two lithium coin cell batteries, and two 10mm vibrating disc motors. Instructions directed families to: design a motorized bot that "paints", build a body for their bot, connect the battery to the motor, attach the motor to the bot, test the bot on different surfaces, and redesign as needed. Limited guidance was given to caregivers about the expectations of their role while engaging with their children.

Participants

Families could register for and participate in a kit without participating in the research project. Each family who expressed interest in participating in the research study was provided with a unique Zoom link and asked to use the link to record their family whenever they engaged together in the activity. While nine families recorded videos of at least one kit activity, this paper focuses on the four families who worked on the Watercolor Bot kit. Approximately 3.5 hours of video data were collected across the four families. Families are described in the results below.

Analyses

We examined four caregiver/child dyads (and in one case a caregiver and two children) as they worked to complete the Watercolor Bot kit. While research exists on caregiver roles enacted during STEM activities, we chose not to use these roles as a starting point. Rather, we followed a grounded theory approach and utilized inductive open coding to illuminate the behaviors that caregivers utilized while interacting with their children [25], [26]. Two researchers coded the videos and noted the ways in which caregivers interacted with their child(ren), both verbally and non-verbally. In our codes, we described the nature of the interactions (e.g., caregiver asked the child questions, made design suggestions, helped attach the wires); however, at times we characterized the interaction by identifying a specific role (e.g., caregiver was behaving like a teacher or collaborator). After coding each video, the researchers discussed similarities and discrepancies in the codes, coding the next video only once they had reached consensus.

Results

Each family interacted with the watercolor kit in different ways. Below, we provide a brief overview of each family and their interactions as observed in their recordings, highlighting the multiple roles enacted by caregivers. Pseudonyms were used for all caregivers and children.

Harris Family

The Harris family consisted of Sally (Mom), Dan (Dad), and Ethan (age unknown). Sally helped Ethan get started on the activity but then left him to create on his own while she and Dan engaged in other activities nearby. At times, Ethan made bids that drew Sally and Dan into his exploration as he expressed his success, frustration, and ideas. Although Sally positioned herself as a novice, she continually checked on Ethan, asking him about his progress. However, when Ethan asked her a specific question about how the watercolor bot was supposed to work, she told him to "Ask Daddy" who then offered advice and referenced the materials provided in the kit. By the end of the recordings (two videos recorded the same day covering 64 minutes), Ethan's bot vibrated around on its Q-tip legs (Ethan never applied paint to the Q-tip feet during the video).

Sally and Dan both seemed comfortable with Ethan working independently. Ethan also seemed content to work on his own until he was unsure what to do or how to do it or when he wanted to show his parents his success at various parts of the design. For the majority of the video recordings, both Sally and Dan were off camera as they were engaged in their own activities (e.g., doing dishes, playing guitar) while Ethan completed the activity primarily on his own. Dan was not aware of the activity until after Ethan had already begun. Sally helped Ethan get started and expressed frustration with the lack of instructions, materials, and support provided with the kit. From the beginning, she made it clear that she probably would not be able to help Ethan with the project but she did periodically check in on Ethan's progress. She positioned the project as Ethan's and when he asked her for physical help, she constantly revoiced and confirmed what he asked her to do to ensure that she did it the way he wanted it done. When Ethan asked Sally questions, she often told him to ask his Dad, who had experience with circuits and projects similar to this, as evidenced by a conversation when Ethan asked Dan if they could solder the battery to the motor. While Sally positioned herself as less knowledgeable, she provided critical support helping Ethan move through obstacles. At one point Ethan struggled to get his design to work and said, "I might have to give up on this." Sally came over and gave him a few suggestions, which he tried, then broke into a huge smile when her ideas worked. Ethan showed persistence and resilience by saying things like "The next time I do one of these…" and "I finally got it to work with my own idea!"

Sally and Dan demonstrated interest and investment in Ethan's ultimate success in the activity, celebrating his ideas and when his bot worked, gave him a high five and said, "I'm proud of you, Ethan!" While it may have appeared that Sally and Dan were not involved in the activity as they typically were off camera and engaged in other activities, they seemed to be watching Ethan and paying attention to what he was doing, providing help when Ethan asked for it. This pattern of interaction with Ethan working independently and his parents occasionally checking in, and all of them celebrating successes was smooth and seamless.

Throughout the 64 minutes of video recording during this project, Ethan's parents were aware of but not integrally involved in Ethan's work. They were outside observers of the project until Ethan made moves to involve them in bigger supporting roles. Ethan sought Dan's help several times to talk through problems or to show off his work. Dan provided verbal support, asking questions, pointing to kit resources, and sharing his knowledge of circuits. Sally provided physical support when asked, like when Ethan struggled with the tape or rubber bands, acting as his hands and physically manipulating the materials in ways he could not. She also provided verbal support through encouragement and asking Ethan questions about his work and possible solutions when he ran into problems he did not know how to work through. The few times Ethan seemed ready to give up or lose focus Sally provided some managerial support by helping him move to the next step. Throughout this project, Sally played mostly the role of a project manager, though at times also acted as a collaborator, teacher, learning broker, observer, and material provider. Dan's limited participation was as a teacher and cheerleader.

Williams Family

The Williams family consisted of Helen (Mom), Edward (Dad), Bella (6 years), and Charlotte (9 years). The video begins with Helen noting that, "We're going to work on our water bot again today", which suggests that they have already begun to design bots prior to the start of the video. Initially, both girls were engaged in the watercolor bot activity. However, when Bella switched to painting on her own (rather than building her bot to do it), Helen turned her focus to collaborating with Charlotte who was redesigning her bot. Helen demonstrated her knowledge of circuits and balance by suggesting ideas to Charlotte. Helen also celebrated successes, calling Edward over to see their bot. Edward provided knowledge of electrical circuits when Charlotte struggled to maintain the connection between the battery and vibrating motor wires. All three worked together to theorize why the bot was not moving, wondering if there was too much friction, too much watercolor paint on it, or the vibration was not happening in the right place. By the end of the recording (one 38-minute video), the bot vibrated the tinfoil across their floor. Helen engaged with her two children in different ways, which appeared to be based on the children's ages and Helen's knowledge of their abilities and the types of support they needed. With her younger daughter, Helen seemed to direct more of the activity, trying to keep her on task while still letting Bella be in charge of the activity and bot design. Helen helped Bella get set up for the activity, prompted her to think about the activity and made sure they had the resources and supplies they needed. At one point, she asked Bella to think about the previous design and how they could improve on it. She suggested ideas and made observations, but Helen positioned Bella as being in charge and took direction from her and supported her design choices. When Bella encountered a problem (i.e., the bot moved on aluminum foil but not on the paper), Helen seemed to know what the problem was, but asked Bella questions to get her to try and figure it out. When Helen provided a suggestion and Bella disagreed, she asked Bella for her ideas. Helen helped facilitate progress by pointing out the next steps in the process. Once they opened the watercolors, Bella began exploring color mixing, and Helen adapted their activity from the bot building to allow Bella to focus on painting and exploring colors.

With her older daughter, Helen again positioned the project as belonging to Charlotte and supported her design decisions, continually asking Charlotte what she thought or what she wanted to do next. Helen and Charlotte worked together, physically hands-on to construct the bot (e.g., one held while the other taped) and talked through ideas and suggestions. While most of the time Helen let Charlotte direct the activity, at one point Charlotte became frustrated and asked if she could paint with her sister. Helen recognized that Charlotte needed a break and said yes, she could paint. However, almost immediately Helen made a comment about the battery being dead and Charlotte was drawn back into the activity and continued to work on the bot with Helen . Soon after that they got the bot vibrating. Helen called for Edward to come see and celebrate their success. As Helen explained what they had been doing to Edward, Charlotte said "Aw man… the thing fell off." Helen, Edward, and Charlotte then discussed what happened and why. Helen knew a little about electrical circuits and how they work, but Edward explained in more depth how circuits work and what might be happening. All three provided suggestions and ideas as to why the bot worked on some surfaces more than others. All three worked together, often varying who directly worked on the bot. Helen and Edward both collaborated with and provided help to Charlotte, but they positioned the activity as Charlotte's project. They did not attempt to change her design for their own reasons; they helped make Charlotte's design work. Both Helen and Edward reminded girls to be careful not to get paint everywhere, not to put the bots directly on the floor, and to not grab things that do not belong to them. They also recognized their daughters' limits, allowing Bella to go paint when she lost interest and for Charlotte to take a break when she got frustrated.

Throughout this project, Helen was an active participant in the activity while Edward arrived at the very end. Helen supported both girls with hands-on help and facilitated their process of making and testing. She was a collaborative partner, providing her daughters with physical support, verbal support, and managerial support while creating and troubleshooting the design of the bots and the vibrating movement. Helen recognized when Bella was no longer interested in the Bot activity, and Helen provided different levels of support to Charlotte and Bella, but played the same roles for both as a project manager, facilitator, resource provider, teacher, collaborator, and cheerleader. Edward was only present for the end and mainly supported Charlotte as a teacher and collaborator. He offered physical and verbal support as he demonstrated how to create a more secure and stable connection between the battery and motor. Helen and Edward also both played parental roles, as when Helen facilitated Bella's transition from the Bot activity to painting with watercolors when her attention waned, or when Edward warned Charlotte not to put the bot on the carpet or asked Bella why she touched her sister's project.

Cadshaw Family

The Cadshaw family consisted of Betty (Mom), Rick (Dad), Harper (age unknown), and baby brother. Betty helped Harper get set up and start the activity. Betty provided resources (e.g., read text from the guide), referenced informational videos, and asked questions to guide Harper in the planning, design, and creation of the watercolor bot. Multiple times across the series of videos (3 sessions, two different days, recorded 65 minutes), Betty redirected Harper to focus attention on the questions she was asking her or rebuked Harper for her behavior, even stopping the recording at one point. When Betty asked Harper questions from the materials, Harper slumped in her chair and did not respond. Throughout the activity, Betty was simultaneously caring for baby brother and balancing other family obligations (e.g., friends arrived to drop off dinner), even making this clear to Harper by saying, "At some point I need to go get something else done besides this." Betty acknowledged her limited understanding of circuits and how to connect the battery and motor, noting that they would have to figure that out. Harper brainstormed many creative ideas to generate "more pressure" to connect the wires to the battery to get the bot to vibrate. Eventually, Betty stripped plastic coating off the wires to help make a better connection. The recordings ended with Harper having a watercolor bot that was able to paint a small amount but still had stability and vibration troubles.

Betty's interactions and support varied across the three recordings, seemingly influenced by the context and competing parental responsibilities. In the first video as Harper began, Betty was sitting at the table with her, but was holding her infant son. While Betty did not offer physical help, she asked Harper about the needed materials, explained what a motor does, helped read through instructions, and monitored progress by asking check-in questions periodically. Betty called out Harper for her behavior, asking her if she wanted to continue or not. Betty positioned Harper as in charge, but Harper often looked to Betty as if to check whether she was doing things correctly. Betty pointed out when Harper had not read or followed the instructions or told her to stop and rethink what she was doing before continuing down that path. In these moments, Harper was leading the activity and working independently while Betty watched and provided input. At other times, Betty and Harper worked together more closely, such as when they tried to get the battery and motor to work. Betty made comments such as, "I don't know how to do this stuff" or "We'll have to figure it out", followed by moments of working together during which both made suggestions, tried out ideas, or looked for additional information in the instructions and resources provided. Both seem to constantly attempt to balance who is in charge of the activity, with Harper wanting to be in charge but needing support to do so. Towards the end of the first video, Betty went off-camera to talk to Rick and do other activities. The second video occurred on a different day and showed Harper working entirely on her own. The third video began with Harper asking Betty for help. In this video, Betty did not have her infant son with her (he was napping), and as a result, Betty worked with Harper in a more hands-on way. Betty emphasized that they would need to work together to figure it out, but also shared her knowledge of conductivity as she explained to Harper why she wanted to remove plastic from the ends of the motor wires to expose more metal. They alternated who was more hands-on, both worked to get the motor to vibrate, and both were excited when it did. At times, Betty worked to get Harper on task, and at other times provided explanations for why things did/did not work. Near the end of the recording, Betty stated, "At some point, I need to go get something done besides this", which indicated a shift towards finishing up the activity. Harper asked if she could try one more time but instead Betty asked Harper questions about the bot design and how she might change it to make it better. As Betty continued to ask Harper more questions, Harper slumped away from the table and looked away from her Mom and the project. Betty and Rick (who was off-camera) note that it is time for a nap. Harper agreed to be done with the project, the video ended, and there are no more recordings of this project from this family.

Throughout this project, Betty provides mainly managerial support and verbal support, though she also steps in to provide physical support several times. She is mostly a project manager and facilitator, keeping Harper moving through the project while also balancing home life management. While Harper is still designing her bot, Betty collaborates in parallel as she attempts to figure out how to connect the battery and motor. Betty's managerial support is partly project related, partly behavior related, and partly family life related. Betty's involvement and support is interrupted by friends visiting, dinner plans, baby brother, and other household tasks. While Betty is present for much of the activity, she is off screen and mostly hands-off but very tuned to her daughter's behavior and the act of recording their project work.

Gupta Family

The Gupta family consisted of Amara (Mom), Arnav (7 years), and Priya (10 years). Both children worked on their own individual watercolor bots for the whole session (a sequence of two videos, 48 minutes). Amara sat at the table with the children the entire time, providing hands-on help to both children when they struggled with the available materials. Arnav finished his design first but struggled with and was unable to attach the battery and vibrating motor to his bot body. All three worked together to get the motor to vibrate using available resources (e.g., kit guides, videos, internet) and trial-and-error to manipulate the motor, wires, and battery. They wondered aloud, offering suggestions, ideas, and questions, as they built their knowledge together. After more than ten minutes of problem solving attempts, Amara suggested, "Why don't we stop this video and try to figure out how to connect and then we can come back to it?" The second video began with Amara announcing they had figured out the connection and held the vibrating motor up to the camera as both children exclaimed in awe. Amara continued to provide hands-on help to both children, responding to their requests when they ran into issues. Their recordings ended after successfully testing their watercolor bots on various surfaces. Amara 's interactions differed between Arnav and Priya. Amara paid more attention to Arnav throughout the sessions, possibly because Priya at one point emphasized that she wanted to do her project on her own. Amara provided direct hands-on help to both children, but in different ways. She would give Priya an extra pair of hands to hold her work or would give a quick demonstration of how to do something and then step back and let Priya do the work herself. Amara and Arnav alternated who was hands-on, such that Amara recognized Arnav's limits when it came to physically assembling the bot and took over the activity in those moments. When Arnav struggled with his design or materials Amara provided more complete and thorough help by taking his materials and manipulating them for him to achieve what he had intended. However, while she was physically assembling the parts, Arnav continued to direct the project by watching and providing feedback to Amara as she worked on it, at one point telling her, "Don't damage the wires!" When Amara noticed that Arnav was becoming disengaged when she was hands-on, she pulled him back into the activity with a comment, question, or noting, "I'm doing most of your work for you!"

Amara seamlessly switched her focus back and forth as needed between the kids, paying attention to both even while her primary focus was on Arnav. Working together appeared to be a natural activity for them, as they all seemed comfortable asking questions, making suggestions, brainstorming ideas, looking for resources, and talking about how best to proceed. Amara provided content support by asking questions, providing suggestions, and referring to the resources provided. When they struggled to attach the wires, they worked together as a team, using trial-and-error, suggesting ideas, and referring to resources (e.g., watching the provided videos, searching YouTube). Once they resolved the battery connection, they worked together to get the bots to vibrate and move on the paper. They shifted fluidly between who was actively hands-on with the project and who was actively observing and commenting, with the unspoken recognition that Arnav and Priya were the lead decision-makers on the project designs. Not only did all three work together throughout, but they also became excited and celebrated together when the bots successfully vibrated (even if only for a moment) and moved across the paper. Across this activity, Amara provided physical, verbal, content, and managerial support to both Arnav and Priya. Amara recognized the difficulty in manipulating the materials and provided light scaffolded physical help to Priya and heavier physical support to Arnav. She asked questions, sought resources, and guided her children through the activity, acting in ways that could be construed as a project manager, a teacher, a co-learner, cheerleader, and consultant.

Discussion

We initially began this study looking for specific, defined roles (e.g., Facilitator, Project Manager) enacted by caregivers when supporting their children in STEM activities in the home environment. However, we found it challenging to cleanly distinguish between specific roles as they often overlapped or co-occurred, as evidenced by the fluidity with which caregivers shifted between roles as they supported their child(ren) during the micro-moments within a singular activity. Unlike previous research, we found it more useful to describe generalized categories of parental/caregiver support. We did observe some "roles" across the four categories of support provided: physical support (builder, collaborator), verbal support (cheerleader, consultant), content support (teacher, learning broker), and managerial support (facilitator, project manager).

Our goal was to identify the types of roles or supports caregivers provide while engaged in engineering activities at home. We anticipated that the home context would influence these supports in a variety of ways, especially as caregivers sought to balance responsibilities of being a caregiver with their expectations of what it means to support their child in an activity or discipline in which they are unfamiliar (e.g., engineering). Previous literature has examined supports utilized in caregiver/child interactions in workshops [11] or in informal settings outside of the home (e.g., museums or community science events) [22]. Researchers have interviewed caregivers about their home support [18], [23], but few have observed home interactions with caregivers themselves choosing when to record their activities. Below, we highlight four ways in which we found the home context influences caregiver support.

Goals for STEM kits

First, caregivers influence the access that their child(ren) have to STEM activities, often serving as a gatekeeper in deciding whether these activities are introduced at all. The goals may be similar whether the activity occurs in the home or in a workshop class, museum, or extracurricular activity. However, activities outside the home often include a facilitator or external adult support while inside the home it is typically just internal family caregivers. When they do choose to engage in such activities at home, caregivers often vary in their reasons for doing so, ranging from providing enrichment beyond what their child receives in school to providing an activity that is of interest to their child to providing an activity that serves to occupy their child while they get something else done around the house. These goals necessitate the provision of different types of support (or no support at all). For example, caregivers whose goal is to engage as a family in a STEM kit (e.g., the Williams family) provide more collaborative physical, verbal, content, and managerial support than caregivers who use STEM kits as an activity to occupy their child while they do other things (e.g., Harris family).

Knowledge of child

Second, caregivers possess a unique knowledge of their child that most others rarely have (though teachers do get to know their students quite closely). This knowledge spans not only the child's abilities and interests but also their child's behaviors and personality. For example, caregivers often are very aware of the ability level of their children, especially when it comes to knowing their child's physical limits (e.g., can they use a hot glue gun by themselves?). We saw this exemplified in the Gupta family where Amara physically helped Arnav throughout the project but did not provide similar hands-on support to Priya who seemed to possess the motor skills needed to manipulate the materials. In the Harris family, Sally knew that Ethan was capable of working on the activity independently, and busied herself with other tasks while he worked. Caregivers also notice subtle shifts in their child's behaviors and personality that others less familiar with their child might not see. Cues such as being cranky or not paying attention are much more noticeable to caregivers, who are quick to shift their support to accommodate these behaviors accordingly. For example, in the Cadshaw family, Betty noticed when Harper's attention wavered and when her attitude became more negative, noting that it might be time for a short break or a nap. Similarly, in the Williams family, when Bella became distracted by the watercolors, Sally did not insist Bella work on the watercolor bot and instead provided her the tools and space to paint with the watercolors and explore color mixing. When caregivers note these cues from their child, they easily and fluidly shift their types of support and interactions to "respond to the situation and what they believe their children need" [21, p. 667].

Parent familiarity with engineering

A third influence on the types of support provided by caregivers is their own knowledge or familiarity with engineering and STEM. Often, caregivers feel that they lack appropriate knowledge or skills to help their children. As such, they struggle with how to support their children in STEM activities [19], if they provide such activities at all. In our study, we saw an example of this in the Harris family when Sally explicitly noted that she would not be able to help Ethan, distancing herself from the activity and more or less leaving Ethan to complete it on his own. However, despite recognizing her own limits, she still supported Ethan by telling him where to find help ("Go ask your Dad"). Contrary to the beliefs of caregivers, technical or subject matter expertise is not necessary in order to support children in STEM activities [21]. Instead, lack of caregiver knowledge and the presence of an "expert" at home (as compared to at workshops or in museums) lead families to explore topics and find information and solutions together. We saw this in the Gupta family where Amara, Arnav, and Priya struggled to figure out how to connect the wires. Both Amara and her children utilized a variety of behaviors and supports as they worked together to figure out a solution, ranging from brainstorming ideas, to physical trial and error, to looking to external resources for additional information in the absence of a more knowledgeable "expert" to help them (e.g., watching videos of other "pseudo-experts" completing similar activities). Working with their child(ren) in such activities can even lead to increases in caregiver's self-confidence with engineering and STEM activities [27].

Uniqueness of home context

Finally, the unique context of the home environment influences the types of supports caregivers provide during STEM activities. Unlike research that has examined caregiver roles outside of the home (e.g., workshops, museums) where the sole focus is the activity, the home environment includes various distractions and other tasks that shape when and how caregivers provide support to their children. Fitting STEM activities in with the other tasks that need to get completed (e.g., laundry, cooking dinner) posed a challenge to caregivers, who had to adjust their support to accommodate these other tasks. We saw multiple examples of this in our study. First, in the Cadshaw family, multiple aspects of the home environment shape the types of help Betty provides. First, Betty is holding Harper's baby brother during the first video, which restricts the amount of physical help that Betty can provide. As a result, Betty provides more verbal support by asking multiple questions and providing observations and suggestions. In contrast, in the third video, baby brother seems to be down for a nap, allowing Betty to provide more hands-on support than in the first video. The home environment also imposes time restrictions, such that caregivers provide support in order to finish an activity by a certain time. Again, we see this in the Cadshaw family where Betty indicates that friends will be coming over soon to bring dinner to the family. As the friends' arrival time nears, Harper struggles to get her bot to stay together with tape. Rather than provide support to complete the activity, Betty suggests being done for now, effectively ending the activity until another time. We also see this in the Gupta family. While they do not seem to feel the pressure of time, they do exhibit pressure to complete the activity successfully for the video. As a result, Amara provides various support (verbal, physical, content, and managerial) as they seek to solve the problem (i.e., connecting the wires) and complete a working bot. Finally, the home environment provides multiple distractions that often must be tended to in the moment, drawing caregivers away from the activity. We saw this in the Cadshaw family when Betty was pulled away to answer questions from Rick and to care for Harper's baby brother and in the Harris family when Sally and Dan were busy doing their own activities (e.g., Dan was playing guitar, Sally was doing household tasks like laundry and dishes).

Limitations

The current study examined four families engaged in one activity. While similarities were observed, the four families varied in the roles enacted; a larger sample of families and/or observing families over multiple activities over time may provide a clearer picture of the roles caregivers take on. Additionally, the current activity involved working with electrical circuits. Caregiver interactions and roles may differ in activities that vary in the types of materials used (e.g., paper roller coaster kit uses paper and tape) and technical knowledge or skills needed (e.g., rain gauge kit involves electrical circuits and hot glue gun).

Unlike much of the existing literature that has examined caregiver roles over many weeks or multiple activities, our study focused on families engaged in one activity across a single or multiple sessions but only video recorded for between 38 to 66 minutes per family. We found it challenging to identify roles within the often brief micro-moments that occurred within a singular activity. Examining the same families at a more macro-level across multiple activities might provide a better sense of roles that caregivers enact.

Finally, while families engaged in the kit activity in their own homes, we recognize that the setting may not have been “natural”, especially in the sense that they were asked to record their engagement in the activity. It was apparent that caregivers were very aware of turning on and off the camera for the research project, often commenting on this when videos began or ended. Additionally, families’ awareness of the camera was apparent when caregivers in a few families announced to other family members that they were being recorded (e.g., to curtail unrelated conversations). Finally, as apparent in the Cadshaw families, the act of being recorded seemed to make Betty more aware of her daughter’s behavior (or perceived mis-behavior) during the activity. This context of engaging in the activity as part of research may have influenced the types of roles observed. Additionally, the “end” of the activity seemed artificial and differed between the families as to how they defined being done or achieving success. Families may have continued interacting with the activity after ending the recording. As such, we may have missed unrecorded moments; we only were able to observe what the families chose to show us.

Conclusion

This study was exploratory in nature and reflects our attempts to examine the roles enacted and types of support caregivers provide in an at-home context while engaged in an open-ended engineering-related activity. We focused on the home context as it provided the opportunity to examine caregiver/child interactions “in the wild”, namely in the home environment with all its accompanying nuances and distractions. Understanding how these supports play out in this environment, where families engage in unique cultural practices and ways of interacting, is important for the development of learning and STEM activities designed to be completed in the home. Our findings add to the conversation about how to define and conceptualize caregiver roles and how the context/setting influences the types of supports caregivers provide. In contrast to emerging work on caregiver support, we argue that it may be more fruitful to think about the types of support (physical, verbal, content, and managerial) offered rather than defining specific roles (e.g., collaborator, project manager, etc.). The fluidity with which caregivers provide multiple types of support while engaging in open-ended projects with their child(ren) poses challenges to identifying specific roles. Specific types of support provided are more easily identified and can inform the design of STEM/engineering kits and activities so that caregivers feel that they have the assistance and support that they need during these activities.

Providing engineering/STEM activities to families to engage in together at home is not as easy as it might seem. Multiple factors influence whether families will choose to participate in such activities at all, and with no guarantee that they will engage in them together. Families vary in their goals for engaging with STEM kits (e.g., together or independently, for fun or for enrichment), the STEM or engineering knowledge that they bring with them to the activity, and the unique aspects of their individual home environments. Looming over all these is a factor common to almost all families – time (or the lack thereof). Given the multitude of activities that compete for the attention of children and caregivers, incorporating STEM/engineering kits into these activities adds “one more thing” to often already-full family schedules. This begs the question of how to best support families to engage in these activities together at home.

Kits and activities should be designed to include specific support for caregivers beyond simply providing project-specific instructions that address caregivers needs. For example, caregivers may need different types of support depending on their reasons for selecting and engaging with STEM/engineering kits. The types of support needed by a child working independently on a kit activity will be quite different from support needed when caregivers and children engage together. Kits should provide information and guidance to caregivers to support the different ways in which they might use the kit. The STEM/engineering kits present children and their caregivers with a challenge to complete an open-ended activity that does not contain step-by-step instructions. Parents may not be familiar with how best to support their child(ren) through such an ill-structured activity, so additional scaffolding for parents is necessary. For example, caregivers may need suggestions for how to support their child(ren) through moments of productive struggle such that they foster forward progress without their child(ren) becoming so frustrated that they lose interest entirely. Finally, we need to be intentional about how we advertise and present these types of STEM/engineering kits to families so as to manage their expectations. Caregivers often serve as gatekeepers for choosing which activities to introduce to their child(ren), often choosing not to engage in activities deemed too time consuming, too messy, or requiring too much caregiver help. When describing STEM/engineering kits, we need to be realistic with families about the nature of the activity and caregiver support needed, but we also need to encourage caregivers to be open to engaging in these activities and reassure them that sufficient support for them is also included.

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References

[1] A.V. Maltese, C.S. Melki, & H.L. Wiebke, “The nature of experiences responsible for the generation and maintenance of interest in STEM,” *Science Education*, *98*(6), 937-962., 2014.

[2] J. A. Banks, et al., “Learning in and out of school in diverse environments: Life-Long, Life-Wide, Life-Deep,” UW Center for Multicultural Education & The LIFE Center, Seattle, WA, USA, 2007. [online] Available:

https://education.uw.edu/sites/default/files/cme/docs/LEARNING%20LIFE%20REPORT.pdf
[3] E. Hutchins, *Cognition in the Wild*. MIT press, 1995.
[4] J. Bempechat & D. J. Shernoff, "Parental influences on achievement motivation and student engagement," in *Handbook of research on student engagement*, 315-342, 2012.
[5] L. C. Moll, C. Amanti, D. Neff, & N. Gonzalez, "Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms," *Theory into Practice*, 31(2), 132–141, Mar. 1992.
[6] M. H. Goodwin, "Occasioned knowledge exploration in family interaction," *Discourse & Society*, 18(1), 93–110, Jan. 2007.
[7] D. T. Keifert, "Family culture as context for learning through inquiry," *Cognition and instruction*, 39(3), 242-274, Jul. 2021.
[8] Z. H. Wan, Y. Jiang, & Y. Zhan, "STEM education in early childhood: A review of empirical studies," *Early Education and Development*, 32(7), 940-962, Oct. 2021.
[9] L. Salvatierra & V. M. Cabello, V. M. "Starting at Home: What Does the Literature Indicate about Parental Involvement in Early Childhood STEM Education?," *Education Sciences*, 12(3), 218, Mar. 2022.
[10] M. Šimunović & T. Babarović, "The role of parents' beliefs in students' motivation, achievement, and choices in the STEM domain: a review and directions for future research," *Social Psychology of Education*, 23, 701-719, Jul. 2020.
[11] A. Simpson, J. Yang, P. N. Knox, & A. V. Maltese, "Caregivers' Multiple Roles in Supporting their Child through an Engineering Design Project," in *American Society for Engineering Education*, Jan. 2021.
[12] Ing, M, "Can parents influence children's mathematics achievement and persistence in STEM careers?," *Journal of Career Development,* 41(2), 87-103, Apr. 2014.
[13] S. D. Simpkins, C. D. Price, & K. Garcia, "Parental support and high school students' motivation in biology, chemistry, and physics: Understanding differences among Latino and Caucasian boys and girls," *Journal of Research in Science Teaching*, 52(10), 1386-1407, Dec. 2015.
[14] J.S. Eccles, J. S., "Gendered socialization of STEM interests in the family," *International Journal of Gender, Science and Technology, 7*(2), 116-132, 2015.
[15] K.M. Jodl, A. Michael, O. Malanchuk, J.S. Eccles, & A. Samerof, "Parents' roles in shaping early adolescents' occupational aspirations," *Child Development, 72*(4), 1247–1265, 2001.
[16] J.S. Eccles & A. Wigfield, "From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation," *Contemporary Educational Psychology, 61*, 101859, 2020.
[17] S.D. Simpkins, J. Fredricks, & J.S. Eccles, "The role of parents in the ontogeny of achievement-related motivation and behavioral choices," *Monographs of the Society for the Study of Child Development, 80*(2), 1–22, 2015.
[18] B. Barron, C. K. Martin, L. Takeuchi, and R. Fithian, "Parents as learning partners in the development of technological fluency," *International Journal of Learning and Media*, vol. 1, no. 2, pp. 55-77, May 2009.
[19] E.R. McClure, L. Guernsey, D.H. Clements, S.N. Bales, J. Nichols, N. Kendall-Taylor, & M.H. Levine, "STEM Starts Early: Grounding Science, Technology, Engineering, and Math Education in Early Childhood." In *Joan Ganz Cooney Center at Sesame Workshop*.

Joan Ganz Cooney Center at Sesame Workshop. 1900 Broadway, New York, NY 10023., 2017. https://files.eric.ed.gov/fulltext/ED574402.pdf
[20] J. Thomas, J. Utley, S-Y. Hong, H. Korkmaz, & G. Nugent, "Parent involvement and its influence on children's STEM learning," in *Handbook of Research on STEM Education,* C.C. Johnson, M.J. Mohr-Schroder, T.J.Moore, & L.D. English (Eds.), Routledge, 2020, pp. 323-333.
[21] R. Roque, K. Lin, & R. Liuzzi, "I'm not just a mom: Parents developing multiple roles in creative computing," in *Proc. International Society of the Learning Sciences,* Singapore, 2016, pp. 663-670, 2016.
[22] N. Tuttle, G.A. Mentzer, L. Strickler, D. Bloomquist, S. Hapgood, S., S. Molitor, J. Kaderavek, & C.M. Czerniak, "Exploring How Families Do Science Together: Adult-Child Interactions at Community Science Events," *School Science and Mathematics*, *117*(5), 175-182, 2017.
[23] M. Dickens, S. S. Jordan, & M. Lande, "Parents and roles in informal making education: Informing and implications for making in museums," in *Proc. of the 123rd annual American Society of Engineering Education*, New Orleans, LA, USA, June 26-29, 2016.
[24] J. Yu, C. Bai, and R. Roque, "Considering parents in coding kit design: Understanding parents' perspectives and roles," in *Proc. of the 2020 CHI Conference on Human Factors in Computing Systems*, Honolulu, HI, USA, April 25-30, 2020.
[25] J. Corbin and A. Strauss, "Grounded theory research: Procedures, canons, and evaluative criteria," *Qual. Sociology.,* vol. 1, pp. 3-21, 1990.
[26] A. Strauss and J. Corbin, *Basics of Qualitative Research*. Thousand Oaks, CA: Sage Publications, 1990.
[27] P. Knox, K. Paul, J. Kim, J. Yang, S. Werfelli, A. Simpson, & A. Maltese, "Parental perspectives: Examining caregiver experiences and perceptions of growth and learning within an out-of-school elementary engineering program," In *American Society for Engineering Education*, January 2022.