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Family Voices: Learning from Families with Preschool-Age Children from Historically Marginalized Communities to Expand our Vision of Engineering

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Family Voices: Learning from Families with Preschool-Age Children from Historically Marginalized Communities to Expand our Vision of Engineering (Work in Progress)

Over the last several decades, there are an increasing number of programs designed to engage preschool-age children and their families in engineering design [1], [2]. Creating learning opportunities for children at an early age is critical for supporting long-term engineering-related interest development and career pathways [3], [4]. Out-of-school, family-based engineering experiences can be powerful catalysts supporting young children's engagement with engineering design practices and the development of engineering-related interests and identities [5]–[8]. These experiences can also have an important influence on parents, including their motivation to create new engineering-related learning opportunities for their children and the ways they support children's engineering engagement during those experiences [3], [7].

To ensure that these efforts are successful, it is critical that programs directly connect with and support the interests and experiences of children and their families. Building on prior knowledge and interests and making learning experiences culturally relevant are fundamental tenants of successful STEM education and essential first steps in making the engineering field more accessible and relevant to diverse communities [9]–[11]. Unfortunately, the voices, perspectives, and practices of youth and families participating in these programs have been notably absent from the engineering education literature, especially for individuals from historically marginalized communities. Equity scholars have noted how educators and researchers have struggled to rethink the historically colonialist and hegemonic perspectives that have dominated the engineering education field and continue to serve as central barriers to diversifying engineering careers [12]–[16]. For example, scholars have advocated for the need to rethink what engineering practices are valued, who is and is not positioned as legitimate learners and doers of engineering across different learning settings, and how engineering as a discipline is defined in ways that exclude or devalue other forms of doing, thinking, and problem solving.

In the present study, we are working to elevate the voices of parents and young children from low-income Spanish- and English-speaking families in our community and better understand the ways that they connect engineering to their own interests, goals, and values. The study is part of an ongoing research project [17], in partnership with our local Head Start program, designed to develop engineering programs for preschool-aged children and their families and simultaneously study how these experiences shape families' long-term interests. Since 2016, we have engaged approximately 20 families per year in a 6-month family-focused engineering learning program that includes take-home engineering activities, in-person and virtual parent meetings, training for educators, online support resources, and more. Through ongoing collaboration with families and educators and embedded longitudinal data collection, such as in-depth interviews, video recordings, and photo documentation of family engagement, our bilingual (Spanish/English) and bicultural research team is developing case studies of family experiences with the program and the ways that both children and adults subsequently continue to think about and engage with engineering after the program ends.

Theoretical Framework

The family engineering program and our research approach were both guided by an *Asset-Based Family Learning Framework* [18], [19]. Grounded in sociocultural theories of learning [20]–[22] and building on both equity research in education [23]–[25] and prior studies on family learning in everyday contexts [26]–[28], the framework centers families as a primary learning context for children and highlights the unique nature of this learning compared to other educational settings.

For example, family learning is intergenerational, often involves children of multiple ages, is motivated by multiple family goals that are not constrained by formal assessment, and builds on the unique histories of families' experiences together [18], [29]. The framework also conceptualizes family learning through a systems lens [6], [30], highlights the unique roles of parents and other adult caregivers in supporting children's learning and development [31], [32], and acknowledges that family learning is a cultural practice that varies across families and communities [27], [33], [34]. In the current study, the Asset-based Family Learning Framework led us to choose the family as the unit of analysis when investigating early childhood engineering engagement. It also motivated us to take a broad perspective on engineering and engineering design, acknowledging the multiple ways families might perceive and connect with engineering and the prior knowledge and experiences they bring to engineering learning experiences.

Research Methods

The research described in this paper was part of the National Science Foundation-funded *Head Start on Engineering* (HSE) project in partnership with University of Notre Dame, Oregon Museum of Science and Industry (OMSI), and Mt. Hood Community College (MHCC) Head Start in a mid-sized metropolitan region in the Pacific Northwest [6], [35]. Head Start is a national program run by the US Department of Health and Human Services and designed to help low-income families with children birth through 5 years foster healthy development and school readiness. HSE is a family-focused, informal engineering education program for preschool-age children (ages 3 to 5 years) and their families with the goal of supporting family interests in the engineering design process and empowering families to use engineering to help their children thrive in a world where science and engineering are now ubiquitous. The 6-month program includes a series of bilingual (Spanish/English) family take-home activity kits, each with a storybook, activity materials, and a parent facilitation guide; parent workshops to introduce the take-home activity kits; videos and online resources, professional development for Head Start teachers and staff; home visits by Head Start staff members; classroom activities to complement engagement at home; and a culminating field trip to the local science center.

During the 2021–22 school year, we recruited seven families from the program to participate in case study research exploring their program experiences, their evolving ideas about engineering, and ongoing interests and engagement patterns that developed 6 to 12 months after the program ended. Participants were recruited from the broader program group of 20 families in collaboration with Head Start staff with the goals of balancing the group by language preference (Spanish and English), representing the diversity of the MHCC Head Start community, and ensuring that the research was feasible for families. Data collection spanned approximately 1 year and included in-depth qualitative interviews via phone or video before, in the middle, and at the end of the program and during the fall of the child's kindergarten year. Data collection also included observations of all program events, tracking of program participation, and documentation of other program artifacts, such as pictures, reflections, family communication, and meeting notes. Each case study family was assigned a research liaison that maintained ongoing contact with the family and spoke either Spanish or English, based on the family's preference. All data were collected and analyzed in the preferred language of participants by bilingual (Spanish/English) and bicultural team members.

Data analysis followed a case study approach [36], [37] and strategies from qualitative research [38], [39]. First, we synthesized data across all sources into an interest development narrative for each family, using a standardized template developed by the research team (e.g., overall description of participation, experience with the activities, family reflections on changing

ideas about engineering). These narratives were then updated after review by all team members. For the analysis reported in this paper, a new data representation was created focused on the ways families perceived engineering or connected their own interests, goals, and values to engineering, as characterized in the case study narratives. For each narrative, we created a spreadsheet with relevant parent quotes and data descriptions captured in separate rows. The team then coded these rows using an iterative, inductive grounded theory process, beginning with initial coding to identify emergent codes and followed by focused coding to apply the codes systematically to the data [39]. During both stages, at least two researchers coded each spreadsheet and discussed discrepancies. Throughout, we used a variety of strategies to support the analytic rigor and transparency, including regularly capturing emerging ideas and reflections through analytic memos, reviewing data and coding across multiple team members, member checking our assumptions and findings with Head Start families and staff, and continuously reflecting on how cultural values and assumptions influenced data collection and analysis.

Preliminary Findings

In their reflections, all seven families indicated they had deepened their understanding and broadened their appreciation of engineering. As one parent noted: *"In the beginning I had no idea what engineering was… I thought an engineer was a civil engineer or mechanical engineer… This opens me up to engineering of a playground, a landscape, solving a problem with rainwater that's puddling... It makes it more attainable—not out of reach and not just for the gifted"* (Family 58). Another parent agreed: *"Ahora sí, pienso que la ingeniería está en todo. Simplemente que uno piensa que cómo lo está aprendiendo en la calle y en la vida que no tiene ciencia."* (Family 51). [Now I think that engineering is in everything. It's just that you think because you learned it outside of school, during your everyday life, that it doesn't connect or it doesn't have as much value.] Through the preliminary analysis, several themes emerged from these case studies about the ways the families came to understand engineering through the program and how they connected this understanding to their own interests, beliefs, and values: (a) *everyday problem solving*, (b) *family relationship building*, (c) *child skill development*, and (d) *pathways to equity*. These themes highlight the broad ways that families interpreted engineering, the unique ways they connected their goals and values to the engineering program experience, and how these connections empowered families to continue to use and engage with engineering beyond the program.

Everyday problem solving—In the interviews and program discussions, families connected engineering to everyday problem solving or described ways they had leveraged engineering activities and engineering design practices to guide and support everyday experiences. All seven case study families connected with this theme, which was one of the most commonly coded across the data set.[1] For example, one parent described how they were incorporating the engineering design process into daily activities with their children: *"Before I thought engineering was only related to the project. The activities showed me the idea of relating engineering to playing—which I was not even considering before. Now they are using engineering in cooking or making a simple salad. They approach making a salad like a problem to solve. And the result is a salad that everyone is willing to eat."* (Family 46). Another family, when asked about connections between engineering and what families do every day, described the ways she saw engineering related to how she has to problem solve family routines as a

[1] Although we indicate the number of families coded for each theme to bring transparency to the analysis process, these numbers do not imply that the relative frequency of themes is meant to be generalizable.

mother: *"My youngest son has autism. I get up earlier to get them ready. The days that he doesn't go to school he asks why he doesn't have school. I have to plan for those days… Sometimes it doesn't come out as planned. I have to think about what to do. Things change, emergencies come up… I have a Plan A and Plan B just in case"* (Family 31).

Family relationship building—Another common theme across all seven families was parents perceiving and leveraging the engineering activities and engineering design practices to support family collaboration and build relationships among family members, including siblings, spouses, or extended family members. As one parent stated when reflecting on the most valuable aspect of the program: *"El tiempo juntos, aprender juntos uno del otro. Las ideas que tiene el otro. Cómo resolver ciertos problemas que tenemos ahí, como hacer las cosas. Más que nada trabajar en equipo"* (Family 37). [The time together, learning together from each other. The ideas that we each have. How to solve certain problems that we have, like how to do things. But more than anything, working as a team.] Many families such as this parent talked about how these experiences provided a unique opportunity for family members to practice collaboration and support their relationships as a family. Some of these families also reflected on how the engineering activities and engineering design process provided a unique context for practicing collaboration: "*It was fun to see them try different things and work together. If they asked for help, I tried to help. But in general, it was their ideas.… So many times, they argue. But with these activities they were able to play together without arguing"* (Family 31).

Child skill development—Six of the families also talked about how they valued the engineering activities and engineering as a way to support broader skill development for their children. This included comments or reflections about the skills, abilities, or dispositions supported by the program or engineering activities (e.g., independence, creativity, imagination, flexible thinking, and socioemotional skills), as well as how the program or engineering activities provided parents the opportunity to observe and learn about their children's development. Related to the first theme above, one family reflected on how they see the engineering process as relevant to their everyday activities and how these experiences allow them to help their daughter practice dealing with frustration: *"Con ella yo creo que utilizamos el proceso [de la ingeniería] con cualquier cosa del día. Tiene 4 años y está aprendiendo cómo funcionan las cosas. Es impaciente, se frustra, y pregunta por qué no está haciendo las cosas bien. Quiere hacer las cosas sola. Ya sea al ponerse la ropa, la chamarra, quiere estar segura de hacerlo bien"* (Family 40). [With our daughter, I think we use the engineering process every day. She is 4 years old, and she's learning how things work. She's impatient, she gets frustrated, and she asks why things aren't coming out the way she wants. She wants to do things herself. Whether it's putting on her clothes or coat, she wants to make sure she is doing things right.] Another mother, when asked about how her views of engineering had changed throughout the program, focused on "character building" for her children: *"I would add character building… Because I was able to see their strengths… It kind of changed the little one's point of view and way of seeing things and how competition is not always the solution."* (Family 46).

Pathways to equity—This theme was only coded for one family. However, for this family (Family 58), it was an extremely important part of the experience and the value they saw in engineering for their children, their family, and other members of their community. For these parents, engineering and other STEM learning experiences are a way to create new opportunities for their children that were not available when they were growing up: *"I'm a first-generation college student. No brothers or sisters in higher education. We don't want these kids to follow that. We want them to understand education is important early on and to receive training in*

today's jobs that pay livable wages. Engineering, mathematics, and science. I don't want them to be factory workers. I hope they can stay creative and focus on getting jobs to solve problems." Motivated by these goals, this family described the ways they were working to extend the engineering activities and resources to support equity and systemic change in their community: *"We are organizing to do it ourselves if the program isn't available… We were fortunate to have this, and we want to pass it on for the next year. We are inviting 10 friends… to interact with the same exercises. There is very limited focus on engineering, math, and science in our community. We decided that's all going to change with us."* Although this theme only emerged from one family in this case study group, we believe it may be important to other families and is a potential avenue for future analysis across the broader dataset.

Discussion

Through these long-term connections with families and in-depth case study analysis, we were able to surface a rich understanding of the ways that families understood and connected with engineering through their experience in a family-based engineering education program. Across the group, families reported broadening their ideas about engineering and its value for children. They also saw engineering as something relevant to their lives, identified ways their own skills and experiences could be applied to engineering, and described how they felt empowered to use engineering in a variety of ways. There were many common themes across the group, but each family also made unique connections to engineering that in turn motivated unique and ongoing patterns of engagement and interest development [40], [41]. The broad and inclusive approach to engineering presented in the program appeared to be critical for helping families make these connections, see the relevance and value of engineering, and integrate engineering into their lives in diverse ways [6]. In ongoing analysis, we are continuing to explore how other aspects of the program design may have also contributed to the themes shared by families.

The themes identified in this preliminary analysis help to shed new light on public perceptions and values related engineering and the ways that educators and researchers can learn from families in order to make engineering outreach efforts more relevant and successful. Framing engineering within these broader goals, values, and skills has the potential to both enrich the engineering practices that families engage in and broaden the appeal of engineering as a field [42]. These findings can also help guide efforts to expand engineering education beyond the technical aspects and reorient towards broader social and community goals—thus helping us rethink what counts as engineering and what is valued in engineering education [9], [43], [44].

Studies such as this can also elucidate the knowledge and assets that families from historically marginalized communities bring to their engagement with engineering, inside and outside of school, and counter the deficit-based narratives that pervade the literature [45], [46]. Many scholars have highlighted the need for the engineering education field to focus more on youth, family, and community assets [12], [44]. Equity-oriented researchers have identified the powerful but often overlooked engineering-related knowledge, skills, and assets that already exist within historically marginalized communities such as the low-income Spanish- and English-speaking families we work with, including (but not limited to) empathy, care, and perspective-taking skills [47], [48]; tinkering, problem-solving skills, and everyday ingenuity [9], [48]; and aspirations and goals for self, family, and the community [44]. These assets serve not just as connection points for engineering education efforts but can inform the critical need to rethink and broaden our understanding of engineering knowledge and practices. The voices from families and parents highlighted in this study provide one important set of perspectives that can help us as researchers and educators achieve this much-needed broader vision.

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