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Agentic Interest Development

How Spanish- and English-Speaking Caregivers from Low-Income Communities Leverage STEM Programs to Support Their Family Goals and Interests

Scott Pattison, Smirla Ramos Montañez, Viviana López Burgos, Gina Svarovsky, Annie Douglass, Julie Allen, Catherine Wagner, Alicia Santiago, Nelda Reyes

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Summary

In the STEM interest literature, and the education field more broadly, families and caregivers are often portrayed as passive recipients of STEM engagement opportunities, and their interests are often assessed based on a narrow, researcher-centered perspective of what counts as STEM. However, equity scholars have highlighted the pressing need to expand perspectives on STEM engagement and center the voices and experiences of families—especially those from communities that have been institutionally and systemically marginalized in STEM education.

In this study, conducted in the context of an early childhood, family-focused informal engineering education program, we built on existing research on STEM agency to explore how caregivers leveraged the program to support their interests and those of their families, both related to STEM and more broadly. As part of a larger design-based implementation research (DBIR) study, we developed in-depth, longitudinal case studies with 12 English- and Spanish-speaking caregivers from low-income communities based on their experiences before, during, and up to 1 year after the program. All 12 caregivers described existing interests that motivated them to participate.

Qualitative analysis of the case studies revealed how these caregivers demonstrated agency in several ways:

- Leveraging the program to support their interests and those of their families
- Flexibly and creatively connecting the program with other interests as they learned more about the opportunities afforded by the program
- Navigating challenges external to the program to remain involved and support initial and emerging interest connections.

The findings highlight the need to rethink traditional, deficit-based perspectives on STEM interest and to explore new approaches for centering caregiver and family interests in the development and implementation of STEM learning programs.

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Introduction

A growing body of literature highlights the importance of interest for shaping how both children and adults engage in STEM inside and outside of school (Pattison, Ramos Montañez, & Svarovsky, 2022; Renninger et al., 2015).

We now understand more than ever that preparing the next generation for a STEM-rich world does not just involve facts and skills but also fostering a deep motivation and passion for learning about and engaging with STEM throughout our lives (Miller et al., 2018; National Research Council, 2009; Renninger & Hidi, 2020). It is this interest that motivates individuals to repeatedly reengage with an activity or topic, building skills, knowledge, and identities. Interest also helps individuals persist through challenges, supports ongoing engagement with STEM despite barriers or systemic inequities, and ultimately shapes our choices about STEM-related careers and hobbies (see literature review below).

Although interest has been an important topic of research in STEM education for many years, the growing attention to equity in the field has pointed to several challenges. For example, scholars have highlighted the pervasive deficit-based perspectives on youth and families that continue to shape education policy and practice (Ladson-Billings, 2007; Ramos Montañez, 2023; Russell et al., 2022; S. Wang et al., 2021). In the STEM interest literature, these perspectives have manifested in the ways that researchers discount or ignore the existing interests and practices of families and theorize interest development as something that is done "to" children and families rather than an active, ongoing process motivated by individuals themselves (Azevedo, 2013; Bevan et al., 2018). The primary metaphors that have shaped the research, including the notion of "sparking" or "developing" STEM-related interest, position individuals, and especially those from institutionally and systemically marginalized communities[1], as requiring intervention to support their engagement with these topics (Baldridge et al., 2024; Renninger & Hidi, 2020; Yosso, 2005). Measures of STEM-related interest are often based on narrow, research-centric perspectives of STEM that ignore the many ways that children and families engage with and practice STEM throughout their daily lives (Azevedo, 2013, 2015; Calabrese Barton et al., 2021; Kayumova & Dou, 2022; Pattison & Ramos Montañez, 2022).

Current Study

In this study, we aspired to move beyond these challenges by developing a more holistic, family-centered perspective on the ways that children and families shape their own interests, both related to STEM and more broadly. The work was conducted in the context of an early childhood, family-focused engineering education project integrated into a Head Start program serving low-income families with preschool-age children (3 to 5 years). Over the course of two school years, we worked with partners to engage 42 families with a series of multilingual engineering learning experiences. During and after these experiences, we built relationships with caregivers from each family and documented their evolving interests and perspectives through in-depth interviews and other data collection strategies. The stories that emerged from the caregivers highlighted the interests that they brought to the experience and the ways they demonstrated agency and resourcefulness in leveraging the program to support these interests.

Prior Literature

STEM Interest Development in Early Childhood

Our work on interest development and agency is situated in the context of early childhood STEM learning experiences with families outside of school (Pattison et al., 2020, 2023; Pattison, Ramos Montañez, & Svarovsky, 2022; Pattison & Dierking, 2018; Pattison & Ramos Montañez, 2022). From birth, young children are motivated to explore the natural, physical, and social worlds around them (IM & NRC, 2012; NRC, 2000). Researchers have documented the ways young children practice STEM skills in their everyday lives (Bierman et al., 2024; Callanan et al., 2021; McHugh et al., 2024; McWayne & Melzi, 2023), talk about STEM topics with others (Castañeda et al., 2022; Haden et al., 2023; Kelly et al., 2024; Rigney & Callanan, 2011), and begin to cultivate their own interests and identities related to STEM (Alexander et al., 2012; Edmonds et al., 2022; Fisher et al., 2012; Mantzicopoulos et al., 2008). As children enter preschool, they are developing an increasingly robust set of skills, knowledge, and dispositions to engage deeply in STEM learning experiences (Bjorklund & Causey, 2018; McClure et al., 2017; Zimmerman & Klahr, 2018). Specific to engineering, a growing body of literature has highlighted how preschool-age children are interested in and capable of engaging in engineering design inside and outside of school, building on their natural motivation to create, test, and problem solve (Acosta & Haden, 2023; English & Moore, 2018; Pattison et al., 2020; Simpson & Knox, 2022; Wagner et al., 2023).

Through these early learning experiences, young children create the foundations of STEM-related interests that can have long-term impacts on learning and engagement (Cohen et al., 2021; Dou et al., 2019; Gottfried et al., 2016; Maltese & Tai, 2010).

Many preschool children have already developed strong and persistent interests related to STEM topics or activities (Alexander et al., 2012; DeLoache et al., 2007; Fisher et al., 2012; Leibham et al., 2013; Patrick et al., 2008). While these children may not initially be able to articulate their interests, by the time they enter kindergarten, research has demonstrated that they can provide reliable reports of their STEM-related interests and preferences (Mantzicopoulos et al., 2008; Oppermann et al., 2017; Zhang et al., 2020). At this age, children are also developing ideas about who does and does not engage with specific topics, including gender stereotypes about STEM (Cohen et al., 2021; Leibham et al., 2013; Rogers et al., 2024). These early interests and perceptions, in turn, shape how children continue to engage with STEM as they enter school and how they come to see themselves, or not, as STEM learners (Gossen & Ivey, 2023; Pattison, Ramos Montañez, & Svarovsky, 2022). In interviews with STEM professionals or STEM-related hobbyists, adults frequently report that early learning experiences were instrumental in shaping their lifelong engagement with STEM (Crowley et al., 2015; Hecht et al., 2019; Maltese et al., 2014; Tai et al., 2006).

Across these experiences, parents, caregivers, and other family members[2] play a fundamental role in supporting interest development (Alexandre et al., 2022; Dou et al., 2019; Ennes et al., 2023; Gossen & Ivey, 2023; Vivante & Vedder-Weiss, 2025). Caregivers are instrumental in creating these learning opportunities, sometimes motivated by their own goals and interests and sometimes in response to the interests they perceive in their children (Crowley et al., 2015; National Academies of Sciences, Engineering, and Medicine, 2016; Pattison, Ramos Montañez, & Svarovsky, 2022; Pattison & Ramos Montañez, 2022).

Within specific interactions, adults help facilitate children's learning, thus creating positive, engaging learning experiences that set the stage for long-term interest development (Callanan et al., 2020; Joy et al., 2021; NASEM, 2016; Vygotsky, 1978). Children's expressions of interests and preferences also motivate caregivers to provide new resources and learning opportunities (Ainley & Ainley, 2015; P. Bell et al., 2013; Leibham et al., 2005; Pezoa et al., 2019). Similarly, caregivers' own interests, preferences, and attitudes also play a critical role in influencing their children's interests (Cheung et al., 2018; Colliver, 2018; Dabney et al., 2013; Monroe et al., 2024).

Current Perspectives on STEM Interest

While much is known about STEM-related interests in early childhood, questions remain about the mechanisms and processes that shape interests at this age and the educational experiences and resources that can support families in developing their children's early STEM-related interests (Pattison, Ramos Montañez, & Svarovsky, 2022). Furthermore, equity-focused scholarship has highlighted the need to rethink traditional perspectives on STEM interest that contribute to deficit-based perspectives on families from institutionally and systemically marginalized communities, thus perpetuating inequities within the STEM education system (Kirchgasler, 2024; Ladson-Billings, 2007; Mejia et al., 2018; Ramos Montañez, 2023; Yosso, 2005).

The concept of interest emerged from the field of psychology as a powerful lens for understanding how motivation shapes engagement and learning (Bell et al., 2019; Harackiewicz et al., 2016; Renninger & Hidi, 2020). In their influential work, Renninger and Hidi defined interest as both the heightened emotional state that motivates us to engage in a particular moment, as well as the predisposition to reengage with a particular object, event, or topic over time (Ainley, 2019; Hidi & Renninger, 2006; Renninger & Hidi, 2011, 2020). In specific learning moments, heightened interest is linked to a variety of engagement and learning indicators, such as focused attention, increased comprehension, perseverance during complex and challenging tasks, and buffering against unfavorable learning conditions (Kang et al., 2010; Lewalter & Scholta, 2009; NRC, 2000; Renninger & Hidi, 2016; Renninger & Su, 2012). Over time, repeated interest-related experiences create more enduring patterns of motivation that become increasingly self-directed and shape our individual choices about learning and education inside and outside of school (Azevedo, 2015; Crowley et al., 2015; Renninger & Hidi, 2016). In STEM education, individual interests have been correlated with STEM engagement across settings, selection of and persistence in STEM classes and degrees, and long-term involvement in STEM-related careers and hobbies (Azevedo, 2015; Caspi et al., 2019; Gottfried et al., 2016; Hecht et al., 2019).

This research has provided important insights into STEM interest and interest development. Current perspectives are also limited in several ways. Much of the existing literature focuses on sparking "new" STEM-related interests in children and youth, often failing to recognize the existing knowledge, interests, and experiences of individuals, families and communities (McWayne & Melzi, 2023; Ramos Montañez, 2023; Solis & Callanan, 2016; S. Wang et al., 2021).

Similarly, the frameworks and measures of STEM-related interest often rely on narrow definitions of STEM skills and practices, thus limiting our understanding of the diversity of interests that may relate to STEM and devaluing how individuals and communities already engage with STEM in their everyday lives (Azevedo, 2013, 2015; Calabrese Barton et al., 2021; Kayumova & Dou, 2022; Pattison & Ramos Montañez, 2022). As a construct from psychology, interest is often studied at the

individual level. Yet, a growing body of research highlights the importance of thinking about interest development within systems, including the role of caregivers and families, as part of broader social and cultural contexts (Azevedo, 2011; Dou & Cian, 2021; Pattison et al., 2020; Pattison, Ramos Montañez, & Svarovsky, 2022).

In the current study, we were inspired by the ways caregivers from participating families articulated the existing interests that they brought with them to early childhood engineering program and how the interactions between caregiver interests and the program shaped the unique interest patterns they described throughout our conversations. These stories countered the typically narrow conceptualization of STEM interests and the ways that individuals and families are often situated as passive recipients of STEM learning experiences in the literature. To further explore this broader understanding of interest and elevate the experiences and perspectives of families, we turned to the literature on agency.

Connecting Interest and Agency

Agency provides a powerful lens for expanding traditional ideas about STEM interest. Although rarely used in conjunction with the concept of interest, it has been an important framework for researchers studying STEM identity in both formal and informal learning environments (Gutiérrez & Calabrese Barton, 2015; Rahm, 2021; Varelas, Settlage, et al., 2015). Many STEM education researchers in this area trace their work to Holland and colleagues (1998). In their foundational writings, these scholars described agency as a way of understanding how individuals are not only shaped by culture and society but also are able to take purposeful action to change their behaviors, environments, and the systems that surround them through their interactions within socially and culturally constructed worlds. From this initial theorization, STEM identity scholars have leveraged the concept of agency to bring attention to the dynamic interplay of agency and structure in STEM education, the ways learners navigate these tensions to construct their own identities, and the transformative potential when this process is supported (e.g., Bajaj, 2019; Calabrese Barton & Tan, 2010; Carlone et al., 2015; Gutiérrez & Calabrese Barton, 2015; Miller et al., 2018; Rahm, 2021; Schenkel & Calabrese Barton, 2020).

From an equity perspective, the concept of agency sheds new light on our understanding of STEM learning and the positioning of individuals and communities in both research and practice (Ishimaru & Takahashi, 2017; Kotler et al., 2024; Schenkel et al., 2019; Varelas, Settlage, et al., 2015). Deficit-based perspectives on STEM education locate the "problems" of STEM learning with communities and perpetuate assimilationist or "access" approaches to STEM education (Barajas-López & Ishimaru, 2020; Ladson-Billings, 2007; McWayne et al., 2022; Quintos et al., 2019; Stoehr & Civil, 2022). In contrast, the notion of agency highlights the resourcefulness and ingenuity of learners and the communities in which they are situated, illuminates systemic factors that are at the root of STEM inequities, broadens our ideas about what it means to do STEM or be a STEM learner, and legitimizes the goals and outcomes valued by learners and communities (Gutiérrez & Calabrese Barton, 2015; Keilty et al., 2022; Kotler et al., 2024; Schenkel et al., 2019).

Research on agency has also highlighted the importance of supporting agency and autonomy for learners in order to foster long-term engagement and persistence in STEM fields (Secules et al., 2018; Svarovsky et al., 2018).

Within STEM education specifically, critical science agency has emerged as an important framework for integrating these concepts into the ways that researchers and educators understand and support learning (Basu et al., 2009; Harris & Ballard, 2021; Schenkel et al., 2019). Originally developed by Basu and colleagues (2009) based on the work of

Turner and Font (2003) on critical mathematics agency, the concept has been further developed by Schenkel and colleagues (Schenkel et al., 2019; Schenkel & Calabrese Barton, 2020) and expanded in the field of environmental science by Ballard and colleagues (Ballard et al., 2018; Harris & Ballard, 2021). Schenkel defined critical science agency as using "the knowledge and practice of science in conjunction with various other forms of expertise to take action on critical issues in one's life and society" (Schenkel et al., 2019, p. 310). Their work highlights how individuals and groups leverage and adapt science knowledge and tools to support their own goals, interests, and challenges and to address issues of injustice within their communities. They have also explored the factors that afford and constrain this agency, such as historic power imbalances within learning contexts, and strategies that researchers and educators can use to support critical science agency, including shifting power dynamics and recognizing diverse ways of knowing and being (Calabrese Barton et al., 2021; Schenkel et al., 2019; Schenkel & Calabrese Barton, 2020).

To date, the concept of agency has rarely been linked to the study of STEM interest. One exception is the work of Ballard and Harris (Ballard et al., 2018; Harris & Ballard, 2021). Within the context of environmental education, they linked critical science agency to interest development by drawing on Azevedo's notion of "lines of practice" (Azevedo, 2011). Following the experiences of elementary students with science learning opportunities across formal and informal learning settings, they focused on the ways students' "outward pursuits of their interests allow us to select and analyze specific moments of student agency or performances of identity in practice" (Harris & Ballard, 2021, p. 910). In documenting these interests, they explored "practices that (1) clustered around repeated engagement across contexts, (2) were prominently reported parts of practice reported by an individual and corroborated by peers, and (3) were continuous with past and future activities" (p. 910). In other words, the researchers both used reported and observed interests and interest-driven engagement as evidence of the youth's agency and applied agency as a lens for highlighting the creative and resourceful ways that the youth pursued their interests despite challenges in different learning contexts.

Research Questions

In the current study, we were interested in exploring how the agency literature could provide new insights into our work with families with preschool-age children and the ways that their STEM-related interests are expressed and evolve over time. Our previous research has highlighted how families develop long-term, unique patterns of engagement around topics, activities, materials, or contexts through STEM learning experiences (Pattison et al., 2020, 2022; Pattison & Dierking, 2018; Pattison & Ramos Montañez, 2022). One approach to understanding this interest development process is examining the ways that the STEM learning experiences "cause" or "spark" these emerging interests and what factors subsequently shape their nature, direction, and persistence, as defined by researchers and educators. However, integrating a critical science agency perspective elevates the importance of understanding the existing interests that families bring with them to the STEM learning experiences and how caregivers leverage these experiences, including STEM content, practices, and resources, to further their interests and those of other family members—or, as Schenkel and colleagues (2020) described it, take action to address the critical issues relevant to their lives.

In the current study, we integrated perspectives on agency with research on early childhood STEM-related interest to explore the following research questions:

1) What existing interests did caregivers and families bring with them to the program?
2) How did caregivers leverage the program to support their interests and those of other family members?

By sensitizing ourselves to an agency perspective, we hoped to contribute to a deeper understanding of STEM-related interest development in early childhood, elevate the voices and perspectives of families from systemically marginalized communities in the STEM education literature, and provide insights to inform the design and implementation of early child and family STEM learning programs that center the perspectives and experiences of participants.

Research Methods

To address the research questions, we conducted a multiple case study investigation (Stake, 2006; Yin, 2018) embedded within a larger design-based implementation research (DBIR) study (Fishman et al., 2013; LeMahieu et al., 2017). The data included in the analysis reported in this article were collected during the 2020–21 and 2021–22 school years, as well as follow-up data collected during the fall of 2022 and spring of 2023. The data collection methods and instruments were developed as part of the DBIR study, which focused on (a) iteratively testing and refining an early childhood family engineering program to be effective and sustainable and serve as an innovative model for other communities around the country and (b) advancing knowledge about family engineering interest development systems and how these can be supported by ongoing, cross-context learning experiences. The more specific research questions above, the analyses outlined below, and the findings reported in this article emerged during the project as one part of the DBIR study.

Team Positionality

Throughout the research process, we aspired to acknowledge ourselves as researchers and continuously reflect on the ways that our experiences, identities, and positionalities influenced the study (Secules et al., 2021). Professionally, the project team included education researchers, engineering content experts, early childhood educators, program developers, and community engagement specialists. We also represent a diversity of ethnic, racial, cultural, and linguistic backgrounds. As a team, we have been partnering with Head Start teachers and families for over a decade or more. Several project team members are native Spanish speakers and identify as bilingual and bicultural, with lived experiences similar to those of many research participants. Many of us are also parents, and we draw from these experiences to guide our work with families and reflect on the differences between our own perspectives and those of study participants. All team members included as authors on this article were intimately involved in the DBIR process, including planning and implementing research and program activities, reviewing data, making iterative changes to the program, and identifying theoretical insights emerging from the process.

In addition to our identities, we also acknowledge that the research was informed by our commitments to equity and social justice. Our motivation to work with low-income Spanish- and English-speaking families is rooted in the cultural and linguistic connections shared with these communities, our relationships with these communities through our collaborating partners, and our commitment to addressing the institutional and systemic marginalization of communities in STEM education.

We place great importance on families in our work, and we believe that challenging the deficit-based perspectives on families is crucial for transforming STEM education systems (Ishimaru, 2020; Ramos Montañez, 2023). In the broader informal engineering education project in which this work was situated, these commitments were articulated through two overarching equity principles: (a) working with families and educators in new ways to transform historic power inequities in STEM education and (b) re-envisioning STEM disciplines by broadening our understanding of engineering and authentically incorporating the assets, goals, perspectives, and values of families. Although this article does not focus on the ways that families shaped the ongoing implementation and refinement of the program, through the DBIR study the team worked to center family voices and perspectives; to minimize power hierarchies between researchers, educators, and families; and to reflect on the ways these power dynamics persisted despite team efforts (see Discussion).

Program Context

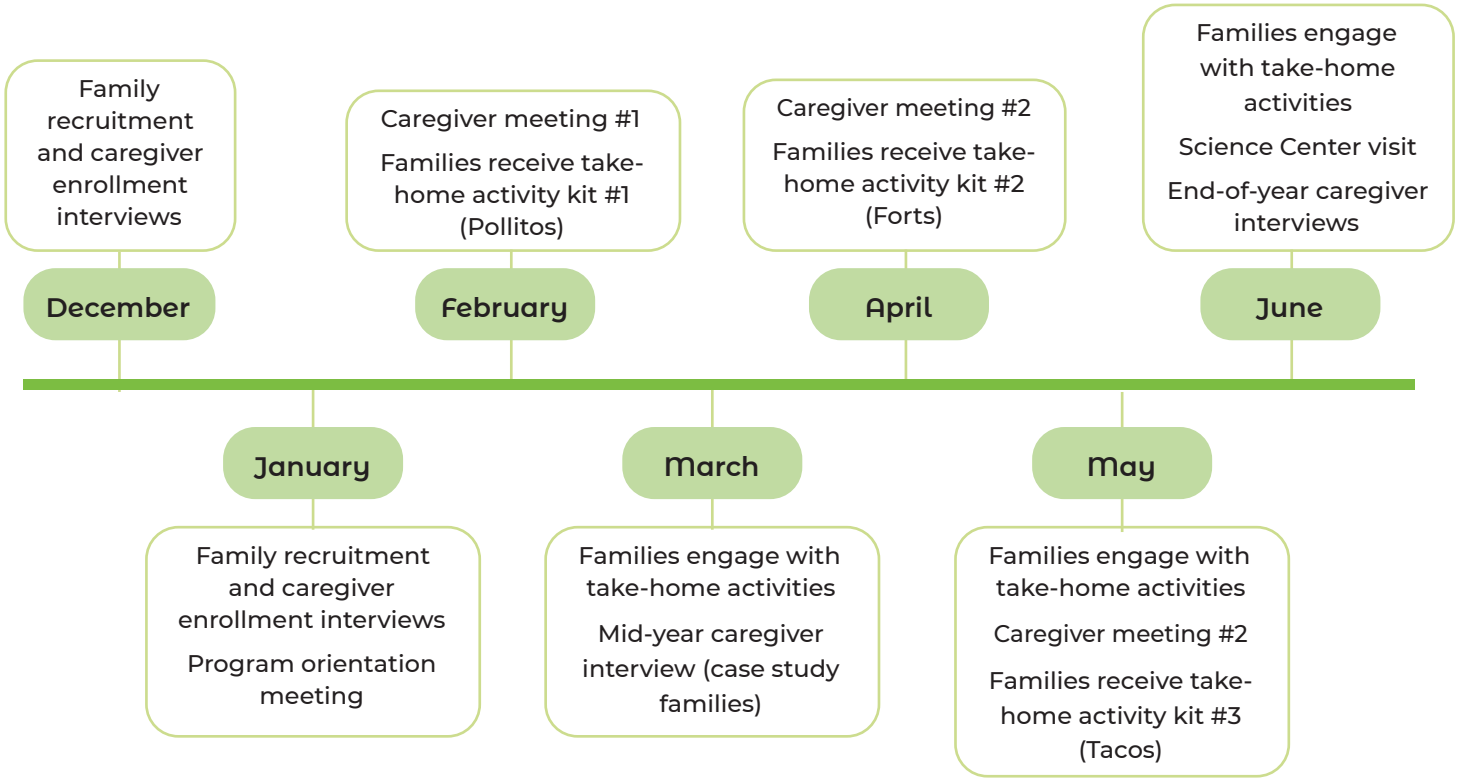
The study was conducted as part of the ongoing National Science Foundation-funded Head Start on Engineering (HSE) initiative (Pattison et al., 2020; Pattison, Ramos Montañez, & Svarovsky, 2022). Launched in 2014, HSE is a research-practice partnership focused on collaborating with low-income families from the Head Start community to better understand and support engineering learning in early childhood. From its inception, HSE has focused on supporting Spanish- and English-speaking families through bilingual and culturally relevant programming and research approaches. Recently, the project has also worked to expand support for Arabic- and Dari-speaking families in the community.

The HSE initiative is situated within the context of the Mt. Hood Community College (MHCC) Head Start program, located in the metro region of Portland, Oregon. Head Start is a national program designed to help low-income families with children birth through 5 years through classroom-based preschool education and family support services. Families are eligible to participate if their household income is below the federal poverty line, they receive State or Federal income-based public assistance, or they are classified as homeless. Head Start is not culturally specific, but staff members often work to provide support that is responsive to language preferences and cultural backgrounds. Staff also provide a variety of family support services beyond the preschool classroom, such as home visits, monthly parent meetings, referrals for other child and family needs, and opportunities to participate in the governance of the Head Start program. During the 2020–21 program year, MHCC Head Start served 392 enrolled children and their families across 22 locations and 67 classrooms. During the following program year (2021–22), enrollment had increased to 695 children and their families. Both years, the program served a broad community of families with diverse language preferences, including English, Spanish, Arabic, and other languages from Africa, Eastern Asia, Middle East, Pacific Islands, and Eastern Europe.

Through HSE, project partners worked together using the DBIR process to design, implement, study, and iteratively refine family-based engineering learning experiences each year for children, families, and staff at one or more sites within the MHCC Head Start program. The approximately 6-month program typically included a series of parent and caregiver workshops, take-home family engineering activity kits, online videos and resources, classroom activities, educator professional development, and a culminating field trip to the local science center. During 2020–21, the program was entirely virtual because of the global health pandemic. After initial enrollment conversations, caregivers participated in four bilingual (Spanish/English) videoconference-based meetings in which the project team welcomed families, introduced engineering and connections to families' everyday problems solving, supported families in their use of the take-home family engineering activities, and provided space for families to share with and learn from each other. In between each workshop, families received one of four bilingual family engineering activities, as described below, and were prompted to share pictures and reflections through a program-specific page on MHCC Head Start's family communication application. The trip to the science center was not possible this year because of the pandemic.

The following year (2021–22), the program continued to evolve through the DBIR process based on feedback from families and lessons learned from the research (see example timeline in Figure 1). All meetings were again virtual, but the project team was able to offer the in-person event for families at the science center. During this year, the project team narrowed the number of activities to three to ensure the scope and timeline of the program was realistic for families. The team also developed a private program website to share participant pictures and reflections because of challenges that families

Figure 1. Example Timeline from 2021–22 Program Year



experienced with the Head Start communication software. In both years, families had access to online resources, such as additional ideas for engineering activities with everyday household materials and videos introducing families to engineering as an everyday problem-solving process. In parallel with the family experience, the project team regularly met with Head Start staff to gather input and provide professional development related engineering education. Head Start staff were invited to participate in all program events and received the same resources as families to use in their classrooms.

Family Engineering Activities

The bilingual (Spanish/English) engineering activities, designed for preschool-age children (3 to 5 years) and their families, were the backbone of the program and served as a primary catalyst for engaging families, introducing them to engineering, making connections to their own everyday problem solving, and catalyzing ongoing STEM-related interest development (Pattison et al., 2025; Pattison, Ramos Montañez, & Svarovsky, 2022; Pattison & Ramos Montañez, 2022). The Pollitos activity (Spanish for "baby chicks") asked families to work together to build a structure using blocks and cardboard to keep a family of baby chick stuffed animals safe and cozy. The Taco activity, which focused on designing a process instead of a physical structure, provided a variety of imaginative play materials for families to plan a taco party and test different ways for guests to assemble their tacos. In the Fort activity, families were challenged to build a fort that would fit the whole family using a variety of clips and materials from around their house. And with the Mouse Run activity[3], families designed a cardboard pathway for a mouse (ping-pong ball) to escape from a hungry cat. All activities included a bilingual children's book related to the activity, a one-page bilingual activity guide, and materials for completing the design challenges. The activity guides included a statement of the design challenge, connections between the challenge and the storybook,

instructions for helping launch and extend the activity, and example questions or conversation prompts.

Although the program primarily focused on the preschool-age children enrolled in Head Start and their caregivers, families were welcome to include other family members in the program. Older and younger siblings frequently participated in the take-home activities and science center visits (See Pattison et al., 2023) and other adult family members besides the primary program contact, such as partners or grandparents, occasionally participated in caregiver workshops or other program events.

Study Participants

Across the two years, we recruited 48 families to participate in HSE (24 families in 2020–21 and 24 families in 2021– 22). Recruitment was conducted in collaboration with Head Start family advocates, who coordinate communication with caregivers for the Head Start program and serve as advocates for families along with teaching staff. At the beginning of each year, team members presented information about HSE during welcoming family events. Families then reached out to their family advocate contacts to indicate their interest in the program. The team also collaborated with family advocates to reach out directly to families, such as when more English- or Spanish-speaking families were needed to balance program enrollment.

Of the 48 families that were recruited across the two years, 22 agreed to be involved in the more in-depth case study research (10 in the first year, 12 in the second). Six case study families from each year were selected for additional analysis informed by prior literature on agency, as described below. These families were chosen to represent the diversity of program families that completed the majority of data collection activities, balanced by program year, language preference, and focal child gender (see Table 1). Four of the primary caregivers in these families reported preferring Spanish, and two of these indicated the family also spoke English at home. Of the eight adults that reported preferring English, three said the family also spoke Spanish at home.

Table 1. Characteristics of Families Selected for Agentic Interest Analysis

ID	Parent Pseudonym	Child Pseudonym	Program Year	Language Preference	No. Adults in Home	Child Ages (yrs.)	Primary Adult Identity
1	Lau	Mateo	2020-21	Spanish	2	4	Mexican
5	Evelyn	Aurora	2020-21	English	2	5	Caucasian
13	Ceñeda	Mia	2020-21	Spanish	3	4	Mexican
17	Rosario	Miriam	2020-21	English	3	4, 6, 7, 9	Hispanic
21	Melissa	Clementine	2020-21	English	1	5, 11	Caucasian
27	Holly	Aria	2020-21	English	2	5, 6, 8	White
31	Anahi	Alberto	2021-22	English	2	1, 3, 5, 10	Hispanic/ Mexican
37	Magda	Aracely	2021-22	Spanish	2	5, 8	Hispanic/Latino
40	Virginia	Emilia	2021-22	English	2	4	Hispanic/Latino
46	Natalia	Niquee	2021-22	English	2	4, 7	Black
51	Florisia	Isabela	2021-22	Spanish	1	4, 10, 14	Hispanic
58	Issac and Fausta	Matthew	2021-22	English	2	2, 4, 5	Black

The primary caregivers from the 12 case study family was also asked to share the ways they preferred to identify their race and ethnicity. Seven adults identified as Hispanic, Latino/a, or Mexican; two identified as Black; and the remaining three identified as White or Caucasian. In almost every family, the primary caregiver described the identities of their children similar to themselves. One mother identified her children as African American and Caucasian. Family size and structure varied, including two families with adopted children, families with either the father or mother as the stay-at-home caregiver, and several families with extended relatives living in the home (e.g., a grandparent). Based on their eligibility for Head Start, all families were considered to have low income.

Data Collection

At the beginning of the program, each family was assigned a research liaison who built relationships with families and maintained ongoing contact throughout the study. The program liaison both collected data from their assigned families and supported program participation more broadly. For both years, data collection was embedded within the program and included (a) participation tracking; (b) an enrollment interview for the primary caregiver before the program and a post-program interview at the end of the school year; (c) participant observations and documentation of all program events; and (d) collection of photos, videos, and other artifacts shared by families.

Interview protocols and other data collection methods were developed in collaboration with Head Start staff members based on the research team's experience conducting qualitative, equity-centered research with families with young children (Pattison et al., 2020; Pattison & Dierking, 2018). The overall suite of data collection methods was selected based on the team's prior experience studying interest with Head Start families (Pattison et al., 2020, 2022; Pattison & Dierking, 2018) to elicit caregivers' evolving perspectives on their interests and those of their children and families and to capture both expressed interests, through interviews and conversations during program events, as well as interest-related behaviors, including evidence of engagement through videos and photos and caregiver reports of interest-related family activities. The interview questions were co-developed in Spanish and English, with bilingual team members iterating on each language version in parallel to ensure that the central ideas were clear in both languages and that the protocols and questions were culturally appropriate and relevant. Throughout the project, the team worked to ensure that the methods were accessible, feasible, and rewarding for participants and continuously refined methods and instruments based on feedback from caregivers.

During the interviews, researchers gathered perspectives on the reasons caregivers reported joining the program, their ongoing experiences, evolving ideas about engineering, engagement with the activities and ideas from the program, and other life events and contextual factors that were potentially influencing their experiences with HSE. Caregivers that were recruited for the case study investigation also participated in an additional interview in the middle of the program and a follow-up interview the subsequent year, when many of the children had transitioned into kindergarten (9 to 17 months from their enrollment interview). All interviews with caregivers were qualitative, semi-structured in format (Patton, 2015), and conducted virtually (either by phone or videoconference) in the preferred language of the participant (Spanish or English). Researchers collected near-verbatim notes in the language of each participant and also recorded the interviews. After each interview, the notes were cleaned, and additional details were added from the recordings if needed.

The interviews with caregivers were conversational, broad ranging, and meant to encourage caregiver stories, perspectives, and interests through a variety of questions. During the pre-program interview, caregiver interests and motivations were elicited by asking participants

to share their reasons for joining the program; what they hoped they and their family would get out of the experience; stories about what they, their children, and their family were "really into right now" and how they "liked to spend their free time." During this initial interview, caregivers also talked about their ideas about engineering and examples of everyday problem solving in their families. Subsequent interviews prompted caregivers to talk about their experiences with the take-home activities and other aspects of the program, provide feedback on ways the activities and program could be improved, reflect on their evolving ideas about engineering, discuss ways the program was or was not supporting their interests and those of their families, and share thoughts about other interests and interest-related behaviors that had possibly been supported by the program. For example, during the mid- and end-of-year interviews, caregivers were asked to rate how often they engaged in a series of interest-related indicators based on the team's prior research (Pattison et al., 2020, 2022; Pattison & Dierking, 2018) and then share thoughts and stories about those responses. Indicators included: (a) continuing to use any of the activities or materials from the program, (b) changing or adapting the activities and materials, (c) looking for new activities or resources related to the program, (d) continuing to use or talk about the idea of engineering and problem-solving from the program with their family or with others, and (e) anything else the caregiver, children, or family had done related to or inspired by the program. Artifacts from the program experience were used across the interviews to support the conversations. For example, before the interviews researchers reviewed videos and photos shared by families and integrated details from these artifacts into the question prompts.

During the 2020–21 program, case study families were also asked to record video with their phones the first time they used each engineering activity at home and share these with the team (see Pattison et al., 2023). During 2021–22, all program families were instead asked to share pictures and reflections via text from their engagement with the activities, which were then shared with permission for all participants to see on the private program website.

Data Analysis

Aligned with a qualitative case study approach, analysis was an ongoing process. At the end of each year, data from case study families were documented and synthesized through a case study narrative (Stake, 2006; Yin, 2018). To begin, each research liaison synthesized data across sources using a case study narrative template developed by the research team. The template was structured to create a comprehensive, temporal account of each family's experience, as well as to highlight families' evolving perspectives and interests (see below). The narratives also allowed the research team to synthesize data across sources (Yin, 2018), including the caregiver interviews, details from videos and photos shared by families, and notes from observations of program events. For example, researchers integrated reflections from families about their experiences with each activity with details from the review of photos and videos of those interactions. These narratives were then updated after review and discussion by other members of the research team, as well as select review by project advisors. Although the case study narratives were developed in English, quotes from participants were preserved in their original language, with translations provided as needed for other team members or advisor review.

Throughout this process, we used prior conceptualizations of interest as sensitizing concepts to guide case study development and analysis (Charmaz, 2014). Aligned with prior research, we looked for evidence of both the ways that caregivers expressed interest in specific topics or activities as well as the behaviors and actions they described that indicated repeated, self-motivated engagement with topics or activities across contexts and over time (Harris

& Ballard, 2021; Renninger & Hidi, 2011). In both cases, we were also attentive to the affect that caregivers associated with these interests and behaviors, such as expressing enjoyment or pleasure from participating in a certain activity or displaying evidence of these emotions when talking about memories and experiences related to specific activities or topics (Hidi & Renninger, 2006; Renninger & Bachrach, 2015)

For example, caregivers might share that they were interested in improving their own skills as a parent, or they might describe how they repeatedly sought out resources and programs associated with parenting skills and the enjoyment, pleasure, or satisfaction they gained from these experiences over time. Sometimes in the interviews or program experiences, caregivers explicitly talked about their interests or the interests of their children. But they also expressed these ideas in other ways, including sharing what they liked to do, indicating the activities and topics that were enjoyable or rewarding to them, or describing their goals, reasons, or motivations underlying their choices and aspirations.

Although this study primarily focused on the perspectives of caregivers, we were also attentive to the how they described the interests of their children and other family members, how these appeared to interact with caregiver interests, and how this shaped family-level interest patterns (Pattison et al., 2016, 2020, 2025) As noted, prior research has highlighted the close connections between caregiver and child interests, especially during early childhood. For example, caregivers might talk about how they were interested in supporting the interests or hobbies of their children, how they repeatedly sought out experiences and resources to support these interests, and the enjoyment and pleasure they gained from providing this interest support. Similarly, although the research was conducted in the context of an early childhood engineering program, we purposely did not limit ourselves to thinking about the engineering- or STEM-related interests shared by caregivers. Motivated by the agency literature described above, we focused on any interests that caregivers brought with them to the program and how they appeared to leverage the engineering program content, resources, experiences, and activities to support these.

Initial review of the case studies from both years highlighted the importance of existing caregiver interests, the ways these shaped the program experiences, and the agency families demonstrated in leveraging the program to support their interests (Pattison, Ramos Montañez, Santiago, et al., 2022). Based on these emergent findings, the research team selected 12 case study families across both years for further analysis. The team used a qualitative "purposeful" sampling approach (Patton, 2015), with a focus on ensuring that selected cases had sufficient data collected across sources and time points and that they represented the diversity of program participant families in terms of program year, primary language preference (Spanish or English), and focal child gender[4].

Borrowing from the narrative research technique of "restorying" (Creswell, 2013) and guided by our growing understanding of the agency literature, we then restructured the case studies to more explicitly describe and explore connections between the initial interests families shared at the beginning of the program, choices families made about leveraging program elements related to their interests, and ways families extended their interests beyond the program. More specifically, this restructuring involved: (a) carefully reviewing each case study narrative and identifying evidence of initial caregiver interests expressed at the beginning of the program; (b) reorganizing the case study narrative text around those initial interests to explore how the initial interests persisted or evolved throughout the program and how they appeared to be related to the family's program experience; and (c) additional review of primary data as needed, such as the caregiver interview notes and program observations, to add clarification and details

related to new organization of the case study narrative. As before, each restructured case study was developed by one researcher and then reviewed and discussed with a second research team member until all disagreements were resolved. The research team then iteratively discussed the restructured case studies, using the constant comparative method to identify themes within and across families and search for confirming and disconfirming evidence (Charmaz, 2014; Glaser & Strauss, 1967; Patton, 2015).

To support rigor and cultural responsiveness, we used reflective memos, reviewed and discussed analytic artifacts with multiple team members, and ensured that data collection and analysis were led by researchers who shared linguistic and cultural backgrounds with study participants. The research team also regularly reviewed data from other program participants and the broader DBIR study to compare and triangulate findings. In addition, we conducted member checks with participants at several stages of the study. For example, during the final case study interview, a summary of the interest development narrative was shared and discussed with the primary caregiver as a member check and a prompt for ongoing reflections. At the end of the 2021–22 year, the research team also facilitated a focus group with select caregivers from both years to share initial themes from the analysis, gather caregiver input, and discuss family priorities for project documentation and sharing. Data were collected and analyzed in the original languages of families by bilingual and bicultural researchers, following best practices in collecting and analyzing data in multiple languages (Choi et al., 2012; Khilji & Jogezai, 2024; Temple et al., 2006). In reporting the findings below, we include the original language of participants to preserve the intent and meaning of their voices, remain grounded in their perspectives, and elevate the importance of multilingual research in the field.

Research Findings

Existing Family Interests

Motivated by the literature on agency, we were attentive to the existing interests that caregivers and families brought with them to the program experience. Based on the enrollment interview, most caregivers articulated clear reasons why they joined the program. A majority talked about their interest in supporting their children's learning and development. Some also talked about specific learning challenges with their children and how the program might help address these. For example, Rosario (Family 17) mentioned she hoped the kids could work on their speech, since they were having some issues with pronunciation. But for many caregivers, their interests focused on supporting children's early skills in general, such as counting, learning the alphabet, practicing English and Spanish, critical thinking, and managing emotions. Lau (Family 1) talked about the variety of skills she hoped could be supported through HSE:

> *"La meta que tenemos ahora es que él aprenda los números del 1 al 30. Ya él se sabe la mayoría, pero no se los sabe en orden.... También estamos trabajando a que se calme, que entienda la situación que está pasando, que pueda manejar emociones."* [The goal that we have now is for him to learn the numbers from 1 to 30. He already knows most of them, but he doesn't know them in order... We are also working on staying calm, helping him understand what's happening and that he can manage his emotions.]

Another important caregiver interest was using the program to spend time together as a family. For example, Ceñeda (Family 13) mentioned she wanted more opportunities to *"estar con ella y tuviera algo en que entretenerla para que aprenda hacer cosas diferentes"* [to be with her daughter and have something that entertains her and can teach her to do different things]. Other families talked about these activities as something new to do together, outside their regular routine. Anahi (Family 31) specifically mentioned the program as a way for the family to work together as a team: *"We have never been a part of a program... I am not sure what the program will exactly be but the hands-on and working as a team would be good."*

Some caregivers seemed generally interested in more fun activities. For example, Rosario (Family 17) described how *"estamos en cuarentena y los niños están aburridos y se me hace difícil encontrar algo con lo que los niños se diviertan"* [we are in quarantine and the kids are bored. It's difficult for me to find things for the kids to do to have fun]. But even in these cases, caregivers stressed the importance of supporting children's learning. Magda (Family 37) talked about the value of the program in the winter: *"Pues es que viene el invierno y los niños no pueden salir afuera. En vez de que vean tele o se queden ahí, nomás haciendo nada, pues aprenden algo."* [The winter is coming, and the kids can't go outside. So instead of watching TV or doing nothing, they are learning something.]

In a few cases, caregivers talked about their hopes that the program would support their children's STEM learning or connect with existing STEM-related interests. Holly (Family 27) saw the program as an opportunity to help her daughters *"see that science is fun! There are a lot of cool things that she can do with science and feeling connected to the community would be nice."* Evelyn (Family 5) shared that their daughter[5] had been bored learning colors, numbers, and the alphabet and that they were *"excited for her to do something that is slightly science oriented this early on."* Fausta (Family 58) talked about supporting

their son's aptitudes related to building and engineering, as well as giving their children the chance to get *"good jobs,"* such as those in STEM-related fields.

Beyond their own interests, caregivers also shared a range of family and child interests that were potentially relevant to the program. They talked about activities that their families liked to do together, such as playing outside, doing craft activities, cooking and sharing meals together, watching movies, playing boardgames, taking trips, listening to music, and more. Caregivers were also attentive to their children's evolving interests, such as drawing and art, movies, building activities, video games, reading, pretend play, and dinosaurs. Not surprisingly, many families mentioned that their routines had been greatly disrupted by the global health pandemic.

Evidence of Family Agency

These accounts of initial caregiver and family interests provided an important context for understanding the experiences of families and their evolving interests. Through the analysis, it became clear that families not only entered the program with existing interests but that they demonstrated agency in leveraging their program experiences to support these. Specifically, caregivers demonstrated agency the following ways:

- Leveraging the program to support their interests and those of their families
- Connecting the program with other existing interests as they learned more the opportunities afforded by the program
- Navigating challenges external to the program to remain involved and support initial and emerging interest connections

Although the evidence for each theme varied across families, many demonstrated multiple aspects of agency. To explicate these findings, we present an in-depth look at the experiences of one family for each of the first two agency-related themes, using each caregiver's initial interests as an organizing framework. After each in-depth family description, we also explore how their experiences related to those of other case study families. For the third theme, we share insights from a variety of families to provide a broader perspective on family challenges and the resourcefulness they demonstrated in navigating these.

1. Agency in Leveraging the Program: Virginia and Family

> *"Estamos interesados en participar para pasar más tiempo juntos como familia y pasar tiempo en actividades que la ayuden a desarrollarse."* [We are interested in participating to spend more time together as a family and to spend time with activities that help with her development.]

Virginia (Family 40), her husband, and their only child, Emilia, participated in the HSE program during the 2021–2022 school year. Emilia turned 4 in October 2021 and had just joined Head Start that fall. At the time, Virginia worked as an office manager and her husband was a kitchen manager. During enrollment, Virginia indicated that she identified herself, her husband, and their daughter as Hispanic/Latino and that all three of them spoke both Spanish and English. Virginia initially chose to communicate in Spanish with her program liaison because she said they were trying to use more Spanish at home. However, she switched back and forth between both languages throughout the program and research activities.

Initial Family Interests

At the outset, Virginia and her husband seemed to connect their participation with two primary interests: (a) spending more time together as a family and (b) supporting Emilia's learning and development. Virginia said that they had a very busy life and that *"estamos interesados en participar para pasar más tiempo juntos*

como familia y pasar tiempo en actividades que la ayuden a desarrollarse." [We are interested in participating to spend more time together as a family and to spend time with activities that help with her development.] Her husband shared similar sentiments during the orientation meeting: *"Como padre me toca trabajar fuera de la casa y muchas veces no tenemos tiempo así que nos gustaría con el programa integrarnos más como familia, convivir más juntos."* [As a father, I work outside of the home and often I don't have time. So with the program we would like to connect as a family and spend more time together.] When Virginia mentioned family interests, she highlighted activities that allowed them to spend time together, like visiting the park, riding bicycles, watching movies, and camping.

Virginia also said she hoped that they could use that time to support Emilia's learning and development. She mentioned they were having some challenges with Emilia and were working on helping her follow rules at home. She connected her interest in Emily's learning to a range of developmental areas: *"En la escuela es buena niña, pero me gustaría que en casa pueda seguir reglas... que aprenda a utilizar y a practicar sus "motor skills," que podamos aprender tomar turnos."* [At school she is good, but I would like her to be able to follow rules at home... I want her to use and practice fine motor skills and to learn to take turns.] In later interviews, Virginia stressed how this was particularly important for their family because Emilia is an only child and because of her upcoming transition to kindergarten.

Leveraging the Program to Spend Time Together as a Family

Virginia's reflections highlighted the ways her family leveraged the program activities to support their interest in spending time together. During the end-of-year interview, Virginia shared that the take-home engineering activities were valuable because they allowed them to spend quality, focused time together despite their busy schedules:

> Taking the time to do the activities together really helped us. Having that to look forward to was exciting ... It felt like a date. We had to plan, since our schedules are different and my husband works so much. Sometimes we only see him at night, so it was good to have this time together. Being able to make that time showed us that there is that time.

For all three activities, it seemed important that all family members worked together and had input on the activity. In the end-of-year interview, Virginia said that the Fort activity was the favorite because it reminded her of when she built forts as a child. During the Fort meeting, Virginia said they wanted to make a fort big enough for all three of them and stable enough so they could do different activities inside. Once built, she described how they played with puzzles and read books inside the fort together as a family.

Leveraging the Program to Support Their Daughter's Learning

Virginia also shared ways that they leveraged the program to support Emilia's learning and development, including curiosity, creativity, taking turns, and collaboration. Virginia seemed to enjoy learning more about her daughter as she watched Emilia practice these skills and her attention to Emilia's behavior and learning were evident throughout her reflections. During the end-of-year interview, Virginia talked about these experiences:

> "It is really hard to figure out how we could slow down and spend time and focus and identify the ways we can help Emilia, her development, her curiosity... I really valued that. It's made me think the different things as a mother I can do, how we can use one thing to make the situation valuable, to explore her mind and spend quality time with Emilia."

Virginia also shared ways they used aspects of the engineering design and problem-solving process presented in the program to support Emilia, and especially to help her deal with frustration. Across the program, it appeared Virginia's ideas about engineering evolved substantially: *"I would have to say when I first heard of engineering, I didn't think it would be found in simple things."* In subsequent conversations, Virginia not only talked about how her perception of engineering had expanded, but how she now saw engineering as a tool for helping their daughter solve problems and manage her emotions. She described everyday situations where they could practice problem solving, and she talked about some of the challenges during those situations, such as helping Emilia get dressed by herself or finding solutions to help get Emilia out of the bath. At the Fort activity meeting, Virginia shared her evolving perspectives about the engineering design process and the connections she saw with her child's development:

> *"Con Emilia, yo creo que utilizamos el proceso con cualquier cosa del día... Ella 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, quiere estar segura de hacerlo bien."* [With Emilia, I think we use the engineering design process with all kinds of daily things... She is impatient, she gets frustrated, and she asks why she isn't doing things well. She wants to do things on her own, whether that's putting on clothes, she wants to be sure she's doing it well.]

When asked in the end-of-year interview if they had continued to use or talk about the ideas of engineering and problem-solving, Virginia described how they were using the engineering as a tool for supporting Emilia's emotion regulation and problem solving:

> "We use it every day with Emilia, in different ways not only when she is playing. Today we went on a hike, and she was trying to get through the rocks, and we had to think about problem solving. How she could make it around some rocks without getting stuck. She gets pretty upset when things are not going the way she wants to, so we say slow down and we talk about solution. There is always a solution, and we can figure it out."

The Experiences of Other Families

Virginia's story highlights some of the many ways that caregivers demonstrated agency in leveraging the program to align with their own interests and those of their families. Like Virginia, many caregivers focused on using the program as an opportunity to spend time together and strengthen family bonds (see also Theme 2 below). Other families shared that they had children who were experiencing learning challenges or disabilities and that they had found ways to adapt the activities and program to the learning needs of their children. For example, Anahi (Family 31) talked about how she and her husband used the activities to support their son's special needs after he was diagnosed as being on the autism spectrum. Similarly, Florisia (Family 51) said she specifically sought out opportunities outside of school to help with what she saw as behavior challenges with her daughter Isabela at home: *"Pues le cuento que ella es una niña rebelde... Hace muchas travesuras. Es una niña muy inteligente, pero se me hace que está muy mimada. Me hace mucho berrinche. Es bien diferente en la escuela y en la casa."* [I will tell you she is a rebellious girl. She misbehaves a lot. She is a very intelligent girl, but I think she is spoiled. She throws to many fits. She is very different in school and at home]. Later in the program, Florisia talked about ways she had adapted both the program activities and research tasks to create a positive experience for her daughter, such as not

recording video of the activities if it made Isabela upset. She also talked about the importance of the books in the activity kits and how they had used them to strengthen her connection with Isabela and support Isabela's growing interest in reading:

> *"Si creo que si ha cambiado. Nunca había participado en programas cómo este con ninguno de mis hijos. Me he dado cuenta de que ella [Isabela] piensa diferente, que se le ha despertado el interés por la escuela y por los libros … Tiene intenciones de aprender a leer y eso ayuda a que aprenda más."* [Yes, I think she's changed. I've never participated in a program like this with any of my kids. I've realized that Isabela thinks differently, that she has new a interest in school and books. She wants to learn to how to read and this helps her to learn more.]

2. Agency in Connecting with Other Family Interests: Isaac and Family

The previous examples highlight ways caregivers found to leverage the program experiences and resources to support their initial interests. But for many, these connections were not static. During and after the program, caregivers brought up new ways the program could support other existing caregiver or family interests as they learned more about the opportunities afforded by the engineering program. In other words, families demonstrated agency in flexibly and creatively making connections between the program and existing family interests beyond those connections they perceived at the outset of the experience.

The story of Isaac and his family (Family 58) provides a powerful demonstration of this type of agency. The family included Isaac and his wife Fausta and the three children they had recently fostered a month before joining the program: Matthew (5 at the start of the program) and his younger sister and brother (4 and 2 years, respectively). During the program, they fostered another baby and then officially adopted all four kids at the end of the school year. As the family grew, Isaac became a stay-at-home father while his wife worked at their church. Before this, Isaac had been an automotive technician. When we reconnected with Isaac in the spring the year after the program, we learned that the family had adopted two other children and that Isaac had started working as an instructional assistant for Matthew's elementary school.

According to Isaac and Fausta, the family identified as Black and spoke English at home. Isaac had training as an urban farmer and enjoyed using their home garden to teach the kids to be *"a good steward while producing some of our own good healthy foods."* Isaac and Fausta also shared that they were a religious family and said they spent time praying as well as listening to music, dancing, going for walks, and riding scooters.

Initial Family Interests

At the beginning of the program, Isaac and Fausta talked about several interests that motivated them to join, including fostering their son Matthew's interest in STEM and supporting skill development for all their children. Fausta said Matthew was a smart child and that he had a *"mechanical mind"* that made her think of him as an engineer. Isaac had been spending time with Matthew exploring agriculture and farming, and they hoped the program activities would provide an additional focus.

After the enrollment interview, Isaac became a stay-at-home dad and shifted to the family's primary program contact. In our early conversations, he seemed to connect the program to his own experiences as a gardening teacher, automotive technician, urban farmer, and self-proclaimed "nerd." He also emphasized the importance of education for his children:

> "I am a first-generation college student in my family … 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 hope they can stay creative and focus on getting jobs to solve problems … Contribute to the world to make it a better place."

Emerging Connection with Family Relationship Building

During subsequent interviews, Isaac reflected on how their perspectives on the program had changed as they saw new connections with their focus on building relationships within the family. In the mid-year interview, he said the activities came at a perfect time:

> "These activities were a godsend… We were trying to connect with them and trying to help them develop… We are learning things and doing the exercises. We are also learning about their personal relationships, how well they can work together, what they've learned. While we were doing the exercises, we were able to take a relaxed way of working on some other issues and prepare their minds to receive the engineering training. We've been learning about ourselves and our family and how we work together."

The family worked together across all the activities. For example, with the Taco activity, Isaac described how the kids set up everything in the hallway and that they prepared a party for a large group of people. They divided the work, with some in charge of decorations and others in charge of setting up. Isaac said he learned that his son was more interested in the building, set up, construction, and organizing the tables and seats while his daughter was focused on the placement and aesthetics. For all the activities, Isaac said they often enjoyed reading the books first because it was an opportunity to bond and brainstorm about what they were going to do.

Related to relationship building, later in the program Isaac also began to talk about his interest in leveraging the experience to help the children deal with trauma. According to him, the children had been through some challenges. The program, therefore, provided fun experiences that allowed them to focus on healing:

> "I think the most memorable or meaningful thing was our connections… We are concerned about the trauma healing. I see a healing coming from being involved in this. We did not have a lot to relate to their lives. They had been through tough things. With this we are able to bond in a way that's not so serious or thinking about the past. We have a great future we are working on with the program and focused on moving forward."

A year after their experience with HSE, Isaac shared that, with the support of their church, they had continued to use STEM-related experiences to support relationship building and healing for their growing family, including regular visits to the local science center.

Emerging Connection with Community Goals

Another connection between caregiver interests and the program that seemed to emerge for Isaac was helping others in their community to have similar experiences and learn more about engineering. Isaac expressed gratitude not only for the program but to his community for supporting them as they came together as a new family. Given this, he expressed a strong interest in wanting to share the experience with others: *"Now my goal is to help on a more community level spreading what you guys have done for my kids."* He started talking to friends about inviting other families to do the activities, talk about engineering, and find other ways to address what

he saw as a limited focus on engineering, math, and science in the community:

> "This opens me up to engineering of a playground, a landscape, or solving a problem with rainwater that's puddling. There are many examples of engineers. It makes it more attainable … Engineering is for the interested, not just for the gifted."

Isaac also offered to help the project team expand the program, including fundraising and finding meeting spaces, and advocated that the project team should have a "louder voice" in the community. When we spoke a year after the experience, he shared that he had incorporated these ideas into his new job at his son's school, including talking to the school principal about how important it was to engage the kids with engineering early and borrowing ideas from the project to present a variety of challenges for the kids to solve. For example, he built on a school assignment about bridges in Portland to ask students to build bridges using dominoes, construction paper, and plastic cups. As the kids built, they talked about the infrastructure challenges in the city and how the kids could contribute to solving community problems.

The Experiences of Other Families

Other caregivers also demonstrated agency in creatively and flexibly making connections between the program and other family interests throughout their experience. Like Isaac, several caregivers shared how they increasingly saw the engineering program as a way to support their interests related to spending time together and building family relationships. For example, Natalia (Family 46) highlighted in later interviews her growing appreciation of how the activities supported collaboration for her daughters: *"I liked the part of the activity that was including everybody. It taught my kids to work together, which they were not doing for a while because it was all about competition."* Inspired by the program, they continued to find more activities to do together as a family, such as craft activities or decorating for holidays. Similarly, because her husband worked late and was usually absent during HSE activities, Magda and her kids (Family 37) decided to plan regular Friday crafts nights that also included the extended family.

Other families demonstrated agency in connecting the program to interests related to supporting other aspects of their children's learning and development—connections that they had not discussed at the beginning of the program but rather emerged over time. For Melissa (Family 21), the connection between engineering and everyday problem solving that emerged through the program meetings seemed to deeply resonate with her. As the program went on, she shared how this connection motivated a more explicit focus on using the program to develop her children's problem solving as a critical life skill:

> "It's so important to watch and allow them their minds to work on how to solve a problem … That's the main skill in life, problem-solving … That's what the engineering process is about … I'm going to keep my eye out for little activities with everyday materials to help their imagination grow—to help them be able to say, this isn't working, what can I do to fix it."

(3) Agency in Navigating External Challenges

Finally, the analysis highlighted the powerful ways families demonstrated agency in navigating challenges external to the program to remain involved, make the most of their experiences, and support their interests and those of their families. Across the interviews, families shared a variety of these challenges, including the pandemic, school closures, health issues, child's learning disabilities, busy schedules, housing instability, language and cultural barriers, and more. As equity scholars have highlighted, many of these issues are connected with broader

systemic factors that often go overlooked by researchers and educators (Ishimaru, 2020; Marchand et al., 2019). Nevertheless, research has documented the ways families demonstrate resilience and resourcefulness in navigating challenges to support their children (e.g., Cabrera et al., 2022; Melzi et al., 2021; Stern et al., 2024; Tolbert Smith, 2022).

Ceñeda and Family

Ceñeda (Family 13) shared a variety of stories about the challenges she had been dealing with and the ways she had managed to stay engaged with and benefit from the program. A particular challenge was using her phone to connect with the videoconference meetings and record videos through the project's Zoom-based recording system. To help, Ceñeda sought out support from her research liaison and her older adult son (18 years). More importantly, Ceñeda leveraged this connection with her older son to support her interest in spending more time as a family. In the enrollment interview, Ceñeda shared that she was hoping the program would allow her to spend more time with Mia, her younger daughter in Head Start. Initially, her older son was not involved. But after asking for his help recording videos, the family started doing the activities together. By the end of the year, Ceñeda said the experience *"nos han acercado más a que convivamos como familia"* [It helped us bond more as a family]. She had not been able to spend as much time with her older son when he was young, so she had been looking for other experiences to support more family time. She seemed to fondly remember how her son's involvement had strengthened the connection between her children:

> *"Él también le enseñaba. Fue muy interesante también para él. O sea, estaba conviviendo pues con su hermana estaba risa y risa. Incluso había momentos que no grabábamos y estábamos jugando los tres."* [He would also teach her. It was really interesting for him as well. He bonded with his sister, and they would laugh and laugh. There were also moments that we wouldn't record and the three of us would play together.]

Evelyn and Family

Evelyn (Family 5) also faced a variety of challenges external to the program. But like Ceñeda, they were able to navigate these challenges and use them as opportunities to extend their interests and those of their family related to engineering (see note above about participant's preferred pronouns). Evelyn was a single mother who prior to the year they joined did not have permanent housing and had been living in a car with their daughter, Aurora. Since then, Evelyn had gotten married, moved to an apartment with Aurora, and gone back to school. Evelyn was also pregnant when they started the program. Unfortunately, they had a challenging pregnancy and were on bed rest. Because of the pandemic and their health, the family could not see other people at this time. Evelyn said they had been struggling with all this:

> "The hardest part is despite the fact that my classes were still trying to happen online I couldn't keep attending because I didn't have childcare and I didn't know what to do about it … In person Head Start shut down and I had 5-year-old who was now in class once or twice a week for 20 minutes and I was in class every day for 2 or 3 hours. I am also a music teacher, and I had to do this while paying attention to the instruments… I was supposed to start teaching in the classroom this year, and I wasn't going to try and do that online."

Despite the challenges, Evelyn remained committed and found creative ways to pursue their interest in supporting their daughter's learning. Even when bedridden, Evelyn tried all the engineering activities and participated in

the videoconference meetings. They focused on things they could do together with their daughter, like cooking: *"We've been doing a lot of cooking. So, she has been doing a lot of ratios and learning how to measure things out for cookies and things like that."* After the pandemic, Evelyn and their daughter continued to use the program resources and were seeking opportunities to include others in the experiences. Evelyn also connected the program to their broader interests in teaching and music. In later interviews, they shared that when they were able to return to the teaching program they had begun exploring ways of creating music learning kits like the engineering activity kits as part of the final project.

Anahi and Family

Other families talked about the ways they had remained involved with the program while navigating their children's behavioral challenges or learning disabilities. For example, in the middle of the program, Anahi (Family 31) shared that her son Alberto had been diagnosed as being on the autism spectrum. Supporting his learning was an important interest that she indicated had motivated her to join the program, but it also created challenges: *"Alberto has autism so his way of seeing things is different from other kids. His way of seeing things is touching, feeling, smelling... He is usually a little lost, not sure what to do when he is asked to do something or when he is playing."*

Nonetheless, Anahi navigated these challenges by adapting the program to align with her interest in supporting Alberto and make sure he felt included. With the Pollitos activity, Anahi used the materials to practice colors, numbers, and counting as Alberto sorted the blocks. Anahi also found ways to encourage her kids to work together. At beginning of the activity, she had each kid pick a color of blocks and then they could work with those blocks to build one side of the structure. For a while, Alberto just wanted to knock down the blocks, but then the family put him in charge of the baby chicken stuffed animals, which he seemed to really like. Anahi said that having each child oversee something helped them understand their role and motivated them to protect the chicks. The Taco activity also seemed to be helpful for Alberto, who enjoyed the colors and textures of the materials. According to Anahi, the family continued to use this activity frequently and had bought additional materials for Alberto.

As with other families, Anahi also found creative ways of connecting the program to her interests and using it to navigate the challenges she was facing. When asked for engineering in their everyday lives during one of the videoconference meeting, Anahi even shared how she was thinking about it in relation to supporting Alberto:

> "I get up earlier to get them ready. The days that Alberto doesn't go to school, he asks why ... I have to plan for those days. He doesn't want to be at home. He's not used to that ... He's running and yelling when he stays here because he knows that's not his routine ... Sometimes it doesn't come out as planned. I have to think about what to do. Things change, emergencies come up. Try to keep things constant. I have a Plan A and a Plan B just in case."

Florisia and Family

As a final example, Florisia (Family 51) talked about obstacles related to a busy schedule and housing complexities and what she did to overcome these in order to support her interests related to the program. With five children, she had to manage their different school calendars, special appointments for one of her daughters, and her own career development classes. Nonetheless, Florisia almost always found ways to participate in program meetings and try out the activities with her children, even if that meant multitasking. At one videoconference meeting, she used her cellphone for the engineering

caregiver meeting discussion and her son's tablet to attend a different learning program for her children. She still shared about her experience with other caregivers, even though her camera and microphone were off most of the time.

Florisia and her family were also forced to move to a new apartment during the program because of challenges with their neighbors. She described this as an extremely difficult time for her when she felt alone because she had no support other than her 14-year-old son. They were not able to use several of the engineering activities at this time. But once they found their new apartment, she unpacked the activities and found ways to incorporate them into their family time.

Through all this, it appeared that Florisia came to see the engineering program as a powerful opportunity to reflect on these challenges and others that she had experienced over her lifetime. She called herself *"la dama de hierro"* [woman of iron] and expressed her pride in her own resourcefulness and problem solving. The way engineering was framed in the program seemed to align with her view of life, which in turn seemed to make engineering more relevant as something she was interested in reinforcing with her children:

> *"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... Me han pasado muchas cosas, cuando uno no tiene lo que se necesita se lo inventa uno... Yo trato de enseñarle a mis hijos, pero están verdes. Entiendo que yo soy la culpable por que los he cuidado tanto y no los he dejado sufrir."* [Now I think engineering is in everything, but you think that just because you do it all the time it doesn't relate. A lot of things have happened to me. When you don't have what you need, you have to invent it. I try to teach my kids, but they are green. I know it's my fault. I've sheltered them, and they haven't had these experiences.]

Discussion

In this study, we used a qualitative, longitudinal case study approach to explore the experiences, perspectives, and interests of caregivers with preschool-age children before, during, and after their participation in an early childhood informal engineering education program. In order to go beyond deficit-based perspectives on STEM-related interest, we drew from the literature on agency (e.g., Basu et al., 2009; Schenkel et al., 2019; Schenkel & Calabrese Barton, 2020) and focused our attention on the existing interests that caregivers and families brought with them to the program and how these shaped their evolving experiences and perspectives. This lens highlighted how caregivers demonstrated agency in several ways:

- Leveraging the program to support their interests and those of their families
- Flexibly and creatively connecting the program with other existing interests as they learned more about the opportunities afforded by the program
- Navigating challenges external to the program to remain involved and support initial and emerging interest connections

Although we chose specific families to highlight each of these themes, most families across the 12 case studies demonstrated evidence of all three aspects of agency, and the three aspects often appeared to connect with and reinforce each other.

Understanding Agentic Interest

These findings suggest a new perspective for understanding STEM interest, in early childhood and beyond—what we have tentatively called "agentic interest development." Like critical science agency (Basu et al., 2009; Schenkel et al., 2019; Schenkel & Calabrese Barton, 2020), an agentic interest development perspective focuses not only on STEM-related interests but instead on the range of existing interests beyond STEM that caregivers and other individuals bring to any new learning experience and the ways these individuals use the resources, materials, and opportunities afforded by that experience to support their own interests and address goals and issues that are important to them (Carlone et al., 2015; Harris & Ballard, 2021; Kotler et al., 2024; Varelas, Tucker-Raymond, et al., 2015). Interest, therefore, becomes a useful (but not the only) lens for understanding the "critical issues in one's life and society" (Schenkel et al., 2019, p. 310) that motivate program participants. The concept of agency, in turn, draws attention to the ways that these participants use, leverage, and adapt a STEM program like HSE, including all the experiences, resources, and content within that program, as tools to support and extend their interests (Basu et al., 2009; Calabrese Barton & Tan, 2010; Schenkel et al., 2019).

The findings from this study and connections with prior literature suggest several important elements to this emerging agentic interest perspective. First, participants bring many existing interests to an experience like HSE, and attending to these is essential to understanding how participants engage with a program and what they get out of it (Ballard et al., 2018, 2023; Pattison, Ramos Montañez, & Svarovsky, 2022). In this study, these existing interests were evident from our first conversations with caregivers, and we witnessed how they leveraged program experiences and resources like the take-home activity kits and the engineering design process to support and extend those interests. Second, from an interest perspective, the outcomes of a program like HSE are expansive and go well beyond the original goals of the project team (Ballard et al., 2018; Caspe et al., 2019; Schenkel et al., 2019). Informed by their initial interests, caregivers talked about the ways the program supported and

extended their interests related to their children's learning and development, building strong family relationships, supporting equity and justice within their community, and more.

A third aspect of this emerging perspective is that caregivers and families are not passive recipients of STEM learning experiences but are resourceful and creative in the ways they use tools and resources from the program to support their interests (Ballard et al., 2018; Harris & Ballard, 2021; Melzi et al., 2021). Similar to Ballard and colleagues, we observed many moments of "improvisation, resistance, and self-determination" (Ballard et al., 2018) as caregivers appropriated elements of the program to support their children and families, identified new ways the program could support other caregiver and family interests, and navigated barriers within and beyond the program, such as technology challenges, difficult life transitions, and unique child learning needs. And fourth, although not as deeply explored in this study, like critical science agency, an agentic interest perspective draws attention to the ways that the program and the systems within which it is embedded afford and constrain how participants are able to leverage program tools and resources to support their interests. In this study, for example, we saw hints of this in the ways that the broad conceptualization of engineering and the engineering design process that resonated with many families (Harris & Ballard, 2021), the multiple program structures and engagement formats that allowed families flexibility and autonomy (Calabrese Barton & Tan, 2010; Harris & Ballard, 2021), and the space facilitators provided for families to tell their own stories and make their own connections to the activity and content (Rajala et al., 2016).

Another important nuance to this emerging agentic interest perspective framework is the dynamic interplay between caregiver existing interests and their growing understanding of the opportunities and affordances of the STEM learning experience. Although some caregivers seemed relatively consistent in the connections they talked about between their existing interests and the program, others identified new connections as they learned more about the program and content, which in turn seemed to expand the opportunities they saw for leveraging program activities and resources to support a broader range of caregiver and family interests (e.g., using the program activities as healing opportunities to address children's trauma or address equity and justice goals in the community). This dynamic parallels the complex way that scholars have described agency and its evolution over time. In their original conceptualization of critical agency, Basu and colleagues (Basu et al., 2009) framed the development of agency as an "iterative and generative process" (pp. 345). Similarly, Gutiérrez and Calabrese Barton (2015) reflected on how agency "can accrue over time" as new experiences become moments "where ideas, tools, and bodies can refigure learning, giving rise to new relationships and opportunities for meaning making" (p. 578). Other researchers have also described agency as "recursive" and "relational" (Edwards & Mackenzie, 2005; Stetsenko, 2019), emphasizing the ongoing interplay between the agency of individuals and the structures and systems around them (Varelas, Settlage, et al., 2015). Thus, it is important not to conceptualize connections between participants' interests and programs as static but as something that will evolve over time and across contexts (Gutiérrez & Calabrese Barton, 2015).

Advancing Interest Theory

This emerging framework advances existing STEM interest theory and research in several ways. Returning to the discussion of current conceptualizations of STEM interest at the outset, we believe that an agentic interest perspective counters three dominant paradigms in the literature that limit our understanding of STEM-related interests, how they develop, and how they can be supported: (a) the learner as a product, (b) the learner as broken, and (c) interest as linear and unidirectional.

The "learner as product" paradigm relates to what Holland and colleagues (1998) described as a central paradox in research: "humans are products of social discipline yet producers of remarkable improvisation." We argue that existing STEM interest research has primarily positioned learners as "products" by focusing on the ways programs and experiences impact participant interests (e.g., Neher-Asylbekov & Wagner, 2023; Schonning & Perez, 2024; Xia et al., 2024), thus either intentionally or unintentionally valuing researcher and educator goals and conceptualizations of STEM interests above those of learners, depicting learners as passive participants in the interest development process, and ignoring the active ways that individuals, families, and communities identify, pursue, and cultivate their own interests over time and across learning settings (Azevedo, 2013, 2015; Barron, 2010; Bricker & Bell, 2014). In this study, by asking about the initial interests of caregivers, we saw how these participants (a) were aware of their interests and how these relate to their decisions to join the program, (b) actively made connections with and sought opportunities to use the program to support these interests, and (b) were directly involved as "producers" of the unique opportunities and outcomes that they described emerging from the program experience.

The related "learner as broken" paradigm is omnipresent across education research and is closely linked to deficit views of learners and communities—and especially those from systemically marginalized communities (Ladson-Billings, 2007; Mejia et al., 2018; S. Wang et al., 2021). As noted at the outset of the article, within the interest literature this paradigm is perpetuated by emphasizing the lack of STEM-related interests for learners and communities (Kirchgasler, 2024; Ladson-Billings, 2007; Pinkard et al., 2017; Solis & Callanan, 2016); ignoring existing learner interests or positioning them as secondary, especially when they do not relate directly to narrow definitions of STEM (Bang & Medin, 2010; Mejia et al., 2018; Wilson-Lopez et al., 2016); and focusing attention on "fixing" learners through opportunities for supporting STEM-related interests (e.g., Renninger & Hidi, 2020). Again, the evidence in this study indicates that caregivers brought their own interests as assets to the program, sometimes related to STEM but often related to other caregiver and family goals and values. The study also highlighted how these existing interests were of central importance in shaping how caregivers talked about the experience and impacts of the program and that caregivers were creative and resourceful in navigating barriers within and external to the program.

Finally, the "interest as linear and unidirectional" paradigm is embedded in many of the dominant theories and frameworks that have guided interest research (Azevedo, 2013, 2015; Pattison & Ramos Montañez, 2022; Robertson et al., 2025). These theories have been important and powerful tools for understanding and supporting STEM-related interests. We argue, however, that they have led the field to primarily focus on the linear movement of individuals from more superficial to deeper levels of STEM-related interest, as defined by researchers and educators. What these conceptualizations do not fully address are the diverse ways that different individuals develop distinct interests and relationships with STEM over time, even through the same STEM learning experience, how these interests interact in complex ways across settings and contexts, the relationships across different interests and between STEM- and non-

STEM-related interests, and the active role that individuals play in guiding and supporting the evolution of their own interests (Azevedo, 2013, 2015, 2018; P. Bell et al., 2012; Crowley et al., 2015; Pinkard et al., 2017). Of particular importance in this study was the way that many caregivers connected the program to different existing interests as time progressed, which seemed to then contribute to the unique patterns of interest they described as emerging from the experience—whether that was integrating engineering design talk into everyday family conversations or using STEM activities to continue to support healing and relationship building for their families.

Study Limitations

We believe that an agentic interest perspective, particularly when integrated with insights from the critical science agency literature, can help the field move beyond these limiting paradigms and develop more expansive, dynamic, and learner-centered understanding of STEM interests. Nonetheless, we recognize that the current study has a variety of limitations and that there is a need for ongoing research and theorizing. In our inclusive and emergent approach to exploring agency and interest, we honored the many ways that caregivers talked about their interests or their interest-related motivations, including their goals, aspirations, and values. We believe that grounding our work in the words and perspectives of participants is an important part of advancing equity in STEM education research (Greenberg et al., 2025; Harris & Ballard, 2021; Philip et al., 2018). However, this line of research can also be complemented by other perspectives on and theories of motivation and how different motivational constructs interact in complex ways (e.g., J. Bell et al., 2019; Renninger & Su, 2012; Struck Jannini et al., 2024; M. Wang et al., 2021). Future research can also more deeply explore the processes and mechanisms of interest development that are elucidated through an agentic interest perspective, including a more nuanced understanding of how the interests of participants in programs like this emerge, are made relevant, and evolve, and what mechanisms and structures within the family, program, and beyond influence this process (e.g., Azevedo, 2013; Dou et al., 2019; Pattison, Ramos Montañez, & Svarovsky, 2022)

We also recognize that there is more opportunity to attend to power dynamics, both in thinking about how caregivers are positioned in the research (Belgrave et al., 2022; Schenkel et al., 2019; Zuniga-Ruiz & Gutiérrez, 2023) as well as their roles relative to the program itself (Ishimaru & Takahashi, 2017; Schenkel & Calabrese Barton, 2020). Similarly, we believe future research can explore not just the ways that caregivers demonstrate agency in navigating and leveraging the program to support their own interests but the ways that caregiver voices, agency, and perspectives directly impact the design and implementation of programs such as HSE, aligned with calls to disrupt and transform educational systems (Basile & Azevedo, 2022; Gutiérrez & Calabrese Barton, 2015; NASEM, 2023). Finally, aligned with a family systems perspective (Broderick, 1993; Cox & Paley, 1997; Pattison et al., 2020), we aspire in future work to gather perspectives more directly from children and other family members about their interests and evidence of their own agency throughout the program experience.

Implications for Research

To continue to advance these more robust understandings of interest development, both in early childhood and more broadly, researchers will need to use new methods, tools, and frameworks. In this study, our growing understanding of the agency literature motivated us to adopt a more family-centered approach to studying STEM-related interest development. This perspective shaped the types of questions we asked caregivers, including centering their existing goals and interests from the very first interview, which subsequently had a profound impact on the nature of the analysis and the insights that emerged from the study. Our

attention to agency motivated a broad and inclusive approach to analyzing STEM-related interests that captured the diverse ways that caregivers leveraged and extended their STEM learning experiences—sometimes aligned with the project team's goals but often in unexpected and unique ways that reflected the interests that families brought with them to the experience.

These reflections highlight the importance of the choices we as researchers make about our methods and theoretical frameworks and how these can fundamentally shape the findings that emerge from a body of literature (Bang et al., 2016; Philip et al., 2018). Notably, in the current study we believe many of the facets of family agency and the ways these connected to STEM-related interest would not have been possible without a deep commitment to centering equity throughout the research. In the broader HSE project, we worked with an external equity advocate and evaluator to develop, articulate, and hold ourselves accountable to a set of equity principles. As noted in our positionality statement, the project team focused particularly on changing the ways we worked with partners and families to disrupt traditional power hierarchies within the education system, as well as broadening our understanding of STEM to reflect family knowledge, skills, and assets (Pattison, Ramos Montañez, Svarovsky, et al., 2022). These commitments, in turn, shaped the focus and approach to the research, including connections to equity-centered literature, a relational approach to working with families, and the centering and elevating of family perspectives. In reflecting on the study, it is clear that without the intentional integration of these equity goals, frameworks, and methods, the agency-driven aspects of family interest that emerged in the study would have been invisible, thus perpetuating static and deficit-based narratives about interest development.

Implications for Practice

Although the agentic interest perspective is new, study findings also suggest implications for educators working in both informal and formal STEM learning environments. As this study highlights, designing programs with caregiver and family interests at the forefront will not only help motivate families to join but will also help them make the most of these experiences and extend the learning beyond the program. Programs often make superficial connections to family cultures or experiences. However, designing programs in which family interests are centered requires rethinking traditional ways of developing programs and structuring program goals and curricula. It is crucial to consider what support educators need to deeply understand the priorities, goals, and interests of families before they develop and implement STEM learning programs. And it is essential to explore what STEM program curriculum might look like that situate the goals and interests of families at an equal level to those of educators (Caspe et al., 2019; Ishimaru & Bang, 2022; Keilty et al., 2022).

This new approach, we believe, would also require attentiveness, flexibility, and responsiveness throughout the program implementation process. The stories from families that emerged in this study highlight the dynamic ways that families adapted as they learned about the program and, subsequently, shifted the ways they connected with program resources and content over time. Several families explicitly mentioned how they appreciated the project team's responsiveness and flexibility, both to align with their individual needs and goals and to support the Head Start community as a whole.

This responsiveness requires educators to closely attend to what they are hearing from children and families about their shifting goals and potentially adapt the program and the nature of support provided. For example, educators might share resources for families

that find the program is a valuable opportunity to support bilingual learning in the household or help create new connections for families that are focused on learning from other caregivers and creating a network of support for their children. As we learned in our experience with HSE, this adaptation can happen on multiple levels, including the individual facilitation strategies educators use during specific program events, adaptation of program resources and structures during implementation, and the iterative improvement of a program across multiple years. These adaptations are only possible, however, through a commitment to authentic, sustained relationship building with families.

Overall, these new approaches to supporting family STEM learning align with the growing calls from equity scholars to shift our perspectives on families in order to achieve meaningful change in the education system (Ishimaru, 2020; Ishimaru & Bang, 2022; Mapp et al., 2022). As the literature on the history of family engagement in this country makes clear, for too long families from institutionally and systemically marginalized communities have been positioned as the passive receivers of education rather than partners, advocates, and active agents in shaping the learning experiences for their children, their families, and their communities (Ishimaru, 2020; Marchand et al., 2019; McWayne et al., 2022). This perspective is built into every facet of education, from the ways we frame funding opportunities, to our approach to curriculum and program design, to our methods for program assessment and research. Centering the interests of caregivers and families in research studies and educational programs is one way to begin to shift this historic power imbalance and strive towards a more just vision of STEM education research.

Notes

[1] We use the phrase "institutionally and systemically marginalized" to move beyond deficit-based accounts and focus on the institutional and systemic factors that drive inequities within education and beyond. Within the communities we work with, children and families have often faced marginalization and discrimination from institutions and systems based on their racial and ethnic identities, language preferences, immigration history, economic status, and other individual and family characteristics.

[2] We use the term "caregiver" throughout this article to refer to the primary adults who care for and support children outside of school. This term recognizes the diversity of family configurations and the broad range of adults beyond biological parents that are involved in children's lives and support their learning and development (NASEM, 2016).

[3] This activity was not part of the second program year included in the analysis for this article.

[4] It is possible that selected families represented participants that were more actively engaged or interested in the program compared to other participants. Overall, attrition for the program and research study were low across both years. During the first study year, 24 families were recruited and 22 completed the program. In the next year, 24 families were also recruited and 20 finished the program. Some families were not able to complete as many of the program or research activities because of life circumstances, such as attending caregiver meetings or sharing videos or pictures of the take-home activities.

[5] This participant indicated that they preferred "they/them" pronouns.

About the Authors

Scott Pattison, Ph.D, is a Research Scientist at TERC. He has been studying and supporting STEM education and learning since 2003 as an educator, program and exhibit developer, evaluator, and researcher. His current work focuses on engagement, learning, and interest and identity development in free-choice and out-of-school environments, including museums, community-based organizations, and everyday settings. He has led numerous informal STEM education initiatives, including Head Start on Engineering, Storybook STEM, Math in the Making, and REVEAL.

Smirla Ramos Montañez, Ph.D., is a bilingual (Spanish/English) and bicultural (Puerto Rican/American) Family STEM Learning Researcher at TERC. She has led and supported a variety of projects in program and exhibit evaluation and STEM education research aimed at providing accessible, culturally relevant, and engaging experiences for diverse audiences. She was the PI of the NSF-funded Diálogos project, which engaged parents as research partners to explore how informal family engineering activities can support the development of executive function skills in preschool-age children from Latinx families.

Viviana López Burgos, M.S., is a science researcher turned education researcher after becoming a mom. She's passionate about STEAM education and family advocacy. She enjoys spending time outdoors with her family and friends, arts and crafts, boardgames, dance, and sports.

Gina Svarovsky, Ph.D, is an Associate Professor of the Practice at the University of Notre Dame's Center for STEM Education. For nearly two decades, her research has focused on how youth—particularly those from traditionally minoritized and non-dominant communities—develop engineering skills, knowledge, and ways of thinking through diverse learning experiences. She has collaborated on initiatives such as Head Start on Engineering and Storybook STEM, and she led the REACH-ECE project exploring engineering engagement in early childhood and family settings.

Annie Douglass, M.Ed., leads Early Childhood engagement at the Oregon Museum of Science and Industry (OMSI), where for over 17 years she has practiced creating equitable, accessible, and play-based experiences for families with young children. She currently specializes in designing and delivering engaging STEM-focused professional development for the early childhood education workforce around the region.

Julie Allen works with the Mt. Hood Community College Head Start program and has taught early childhood education for over 30 years. She has been part of the Head Start on Engineering project for the last 5 years and is committed to partnering with families and staff to integrate STEM education into early childhood experiences.

Catherine Wagner, M.Ed., is the Education and Workforce Development Program Director for the Center for Broader Impacts at the University of Notre Dame. She oversees the planning and implementation of broader impacts initiatives, such as the Research Experiences for Teachers mentor training and STEM Teacher Residencies orientation, and contributes to grant proposal development, research, and program evaluation.

Alicia Santiago is a Bilingual Student Engagement Liaison in the Gresham-Barlow School District. During the Head Start on Engineering project, she worked with Mt. Hood Community College Head Start as part of the research team, supporting relationship building with families, coordinating data collection, and gathering feedback from participants.

Nelda Reyes, M.A., is a bicultural, bilingual (Spanish/English) consultant and cultural advocate serving as Principal of AB Cultural Drivers. Drawing on over ten years of experience in culturally responsive program and exhibit development, she supports museums and community organizations to advance equity, accessibility, and community participation. She also contributes her expertise through advisory roles with multiple arts and cultural organizations, including The Circus Project and the Instituto de Cultura Oregoniana.

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