Fostering STEM in Early Childhood Programs: Practices of Preschool Parents with STEM Backgrounds

Grace Keengwe
University of North Dakota

ABSTRACT

This study explored the experiences of families with backgrounds in STEM (Science, Technology, Engineering, and Mathematics) and the strategies they use to support their young children's STEM learning. Using a qualitative research design, interviews were conducted with four parents recruited from childcare centers in a small urban town in a Midwestern U.S. state. The findings revealed that family role models, preschool curricula, and a child's intrinsic motivation and passion play key roles in fostering early interest in STEM. Parents emphasized the value of accessible, hands-on activities that can be easily integrated into busy family routines. They also recommended using "plug-and-play" resources, connecting children with STEM professionals, and making learning experiences fun, engaging, and interactive. Importantly, parents advocated for hands-on activities that go beyond simple repetition to promote deeper understanding and sustained interest in STEM.

KEYWORDS
STEM Teaching Practices, Preschool Children, Parent Involvement

Parent involvement is a key predictor of children's academic success, particularly when it involves parents' field-specific social capital. STEM-related social capital, including parents' STEM education, plays a significant role in students' decisions to pursue and persist in STEM fields (Tilbrook & Schifrer, 2021). Children of parents with STEM degrees are more likely to pursue STEM majors than those whose parents lack such degrees.

The Early Childhood STEM Working Group emphasizes that parent and family involvement is critical for fostering STEM learning in early childhood education. They recommend that programs provide resources and opportunities to engage families in STEM education, highlighting the key role parents play in shaping early STEM experiences at home and advocating for high-quality STEM education in schools. However, many parents lack the knowledge or confidence to support early STEM education, so the group calls for robust support systems to build self-efficacy in STEM for both children and adults.

The Dialog: A Journal for Inclusive Early Childhood Professionals
2025, Volume 28, Issue 2
https://doi.org/10.55370/thedialog.v28i2.1878
Contact: Grace Keengwe grace.keengwe@und.edu

Parental expectations are strong predictors of STEM achievements (Wang & Yang, 2019), and higher socioeconomic parents tend to use more effective STEM-supporting strategies. Motivational practices, such as encouragement and positive reinforcement, significantly influence long-term STEM achievement (Ing, 2014; Rashmi, 2016). Programs that help parents understand the value of STEM education for their child's academic success are more likely to foster engagement in STEM activities at home (Pepper, Faulkner, & Barlow, 2017).
Parents who value STEM are more likely to engage in informal STEM learning activities, which are crucial in developing curiosity and problem-solving skills. These activities like nature walks, museum visits, or home experiments encourage children to explore and ask questions, building critical thinking skills. Positive parent involvement in STEM interventions also boosts student engagement, especially for girls (Heddy & Sinatra, 2017).

Despite the benefits, meaningful partnerships with families in supporting STEM learning are often lacking (Steiner et al., 2019). Parent involvement has been identified as a major predictor of students' STEM learning and career decisions (Rivera & Li, 2020). Studies have shown that parental engagement not only motivates students but also fosters intrinsic motivation, improving achievement and self-concept in STEM subjects (Jungert, Levine, & Koestner, 2020; Simpkins, Price, & Garcia, 2015). Parents who actively engage in STEM activities at home play a crucial role in enhancing their children's STEM interest and academic success.

STEM in the Early Years

Introducing STEM concepts early helps foster curiosity, problem-solving skills, and creativity. Research shows that engaging young children in STEM activities, like building structures or conducting experiments, develops critical thinking and a deeper understanding of cause and effect, laying the foundation for future learning (Kuo, 2024).

STEM education also promotes creativity, as it combines systematic inquiry with creative expression. Early exposure enables children to think creatively about solving challenges, leading to an innovative mindset (Bevan, 2017). Activities like building machines or solving problems with available materials enhance both imaginative and analytical thinking. Additionally, STEM often involves group work, promoting communication, teamwork, and social skills. Collaborative learning environments help children express ideas, negotiate, and share resources, which are crucial for both academic and social development (Darling-Hammond, 2020). STEM activities also support language development, as children discuss hypotheses and describe experiments, strengthening both verbal and non-verbal communication skills (English, 2021).

Introducing STEM early can help bridge gender and diversity gaps in these fields. Studies show that exposing all children to STEM activities counteracts biases and encourages both boys and girls to explore these areas (Hill, Witherspoon, & Bartz, 2016). 2010). Early STEM exposure also impacts long-term academic success, with children more likely to pursue STEM subjects and careers (National Science Foundation, 2019). STEM education often involves solving real-world problems, making learning more meaningful. Activities like recycling projects or nature exploration show children the practical applications of STEM concepts, increasing their motivation and investment in learning (Couse & Chen, 2010). Additionally, STEM learning is adaptable to various learning styles, ensuring it benefits all types of learners (Kim, et al.,2015).

Technology plays a vital role in early STEM education. Interactive tools like educational apps and robotics enhance learning and equip children with digital literacy skills (Scott & Marsh, 2018). Early exposure to technology familiarizes children with tools they'll use throughout their education and careers. Ultimately, early STEM education is essential for developing critical skills, fostering creativity, and preparing children for future academic and career success. It also helps address gender and diversity gaps and provides a foundation for a range of essential skills. As the world becomes more technology-driven, integrating STEM into early childhood education is crucial.

STEM Careers

Children of parents in STEM occupations tend to perform better academically and persist longer in STEM fields, particularly for female and minority

students (Plasman, Gottfried, Williams, Ippolito, Owens, 2020). For example, girls with STEM-employed parents scored higher on math tests than those with non-STEM-employed parents ((Bowden, Bartkowski, Xu, Lewis, 2017). Key factors influencing STEM career choices include having a parent in a STEM occupation, high STEM social capital, being male, older age, and prior academic achievement, with these factors being especially important for females and students without family STEM connections (Holmes, Gore, Smith, Lloyd, 2017). Role models, particularly female ones, significantly impact women's STEM career choices. Adams, Barber, & Odean, (2018) found that mothers in STEM were linked to a 48% increase in daughters' careers in finance, compared to a 29% increase for fathers in STEM. Similarly, girls with STEM-employed parents, especially mothers, tended to perform better in math (Bowden, et al., 2017). However, qualified women interested in STEM careers are often overlooked, as there's insufficient focus on students with STEM-background parents (Anaya et al., 2021).
Parents' involvement in science-related activities and encouragement plays a crucial role in fostering STEM interest. Parents in STEM fields often use practices like role modeling, exposure to STEM, and providing extracurricular opportunities (Chakraverty, 2013). Positive role modeling, in particular, is a strong predictor of students pursuing STEM careers (Heidi & Johnson, 2007). When parents actively support science learning, students are more confident and motivated (Aschbacher & Tsai, 2013). Students with STEM-oriented aspirations often have parents in STEM, and these students tend to exhibit higher self-confidence and academic motivation (Sheldrake, 2018). Similarly, positive parental relationships with mathematics enhance children's math achievement and persistence (Ing, 2014).

This study explores the STEM practices of parents with STEM careers, aiming to provide strategies for non-STEM parents to support their children's STEM learning. By highlighting the cultural resources and social capital of STEM parents, the study offers valuable insights for all parents. The findings could inform new approaches to support STEM learning and provide examples for early childhood educators and teachers to share with students, fostering greater interest in STEM fields.

Conceptual Framework

The decision to pursue a career in Science, Technology, Engineering, and Mathematics (STEM) is shaped by a variety of factors at multiple levels, which can be effectively understood through Bronfenbrenner's (1977) ecological systems theory. This theory highlights how an individual's development and career decisions are influenced by interconnected systems, ranging from the immediate family and school environment to broader societal factors. In the microsystem, factors such as parental involvement, peer influence, and the quality of school experiences play a significant role in determining STEM career interests. For instance, parental support, especially from those with a background in STEM, can encourage children to pursue similar paths, while peer groups and school environments either foster or discourage interest in these fields, especially in the context of gender and social stereotypes (Wang, 2013; Ennes, Jones, Chestnutt, Childers, 2023). Schools that offer resources like advanced courses and extracurricular activities provide opportunities for students to engage with STEM, further shaping their career aspirations.

At a broader level, the mesosystem emphasizes the interactions between various aspects of the microsystem. The synergy between family support, peer influences, and school resources can create a strong foundation for a student's interest in STEM. For example, when parents and teachers work together to encourage STEM activities, or when students have access to community-based programs and mentorships, the likelihood of pursuing STEM careers increases (Beasley & Fischer, 2012; Hill, Witherspoon, & Bartz, 2016). In contrast, the exosystem refers to external factors, such as the work environments of parents or the availability of community-based resources, that indirectly influence career decisions. Parents' careers in STEM can expose children to these fields early on, while community resources like internships and local STEM organizations play an important role in offering opportunities, especially in under-resourced areas (Stout, 2011).

The macrosystem and chronosystem encompass larger societal and temporal influences. Societal values, cultural norms, and educational policies significantly shape career pathways, particularly by reinforcing gender stereotypes or providing access to STEM opportunities through national policies (Cheryan, Ziegler, Montoya, & Jiang, 2017; National Science Foundation, 2020). Shifting cultural attitudes and public initiatives aimed at increasing diversity in STEM fields have begun to challenge traditional barriers and encourage more inclusive participation. Additionally, the chronosystem reflects the influence of time and life stages on career choices, highlighting how personal development and societal changes can alter interests in STEM fields over time. As new technologies and emerging fields evolve, they offer fresh opportunities that may inspire students to pursue careers in previously unconsidered areas (Wang & Degol, 2017). By examining all these layers of influence, we can better understand the complex factors that guide individuals toward STEM career paths.

Method

This study examined STEM practices of preschool parents with STEM backgrounds. It was guided with the following research questions:

- What STEM practices do parents with STEM backgrounds engage with their children?
- What kinds of experiences and family interactions have supported and encouraged parents with STEM backgrounds to pursue science related fields?

We employed a qualitative approach, which is particularly useful for examining processes and phenomena where the perspectives of multiple participants are central to understanding the issue or practice (Trainor & Graue, 2014). This approach is also well-suited to research questions that seek to explore a process or phenomenon occurring in a particular context, especially when variables are difficult to control or measure.

Sample & Data Collection

Participants for this study were recruited from a University Children's Learning Center (UCLC) located in a small urban town in the Midwest. After receiving approval from the author's institution's Institutional Review Board (IRB), an email outlining the purpose of the study was sent to the program director, who then forwarded it to the parents in the program. The email invited parents who were interested in participating to contact the researcher directly via the provided email address. Four parents expressed interest and reached out to participate. Prior to the interview, participants completed an informed consent form, where they were asked to indicate their voluntary agreement to participate in the study. Their responses were recorded as either "yes" or "no" on the consent form, and this consent was also documented in the audio recording.

The study intentionally recruited participants from this program, as it serves parents primarily from the university community, including both faculty and students, which likely increased the probability of finding parents with STEM backgrounds. In purposive sampling, the researcher relies on participants' knowledge to select the most suitable candidates for the study (Campbell, Greenwood, Prior (2020). For this research, a STEM background was defined as having a career, training, or education in a STEM field. Both mothers and fathers were encouraged to participate to ensure a diversity of perspectives from different STEM backgrounds. Once willing participants were identified, emails were sent to schedule interviews, asking them for their availability. Parents were also sent the interview questions in advance for review.

The six interview questions used in the study were adapted from Chakraverty's (2013) research on parental occupation and science inspiration. The questions were as follows: (1) What childhood experiences or family interactions do you believe were supportive and encouraging in your science pursuits? (2) What types of activities did you engage in that fostered your interest in science? (3) Who were the key people in your life who helped cultivate your science interests? (4) What activities do you do with your children that support their STEM learning? (5) What challenges have you faced in fostering STEM learning? (6) What suggestions do you have for encouraging early science interest in children?

A demographic section was also included in the interview, where parents were asked to provide information about their STEM background, their current career, the number and ages of their children, and other relevant details. Each parent was interviewed via Zoom for approximately 40 to 60 minutes. The interviews were audio-recorded for later review and analysis.

Parent Demographics

The participating parents had diverse backgrounds in STEM fields. One parent, Tess, held a Bachelor of Arts degree in Biology and had worked in various STEM research roles over the years. At the time of this study, she was employed at a biorefinery lab, a position she had held since 2016. Tess had one daughter who attended the University's Children's Learning Center twice a week and also went to a private home daycare two days a week to help reduce childcare costs. Tess was married and worked full-time from 8 am to 4:30 pm, Monday through Friday.

The second parent, Sandra, held a Bachelor of Science degree in Occupational Safety and Environmental Health. In addition, she was enrolled in graduate school, having completed a year and a half of coursework toward a Master of Science in Homeland Security and Emergency Management. Sandra worked for the Energy and Environmental Research Center at the university. She had a 2-year-old child and two older children in college. Sandra also worked full-time, with a schedule of 8 am to 5 pm on weekdays, and was on-call some weekends.

Parents 3 and 4 were a married couple. Miranda, the wife, held a Master's in Business Administration and a Bachelor's degree in Business Administration. At the time of the study, she was a stay-at-home mom, having left her job after the birth of their second child. The family had moved frequently, so Miranda had not sought new employment opportunities. Before becoming a full-time mom, Miranda worked as an accountant for 5 years and as a financial analyst for 2 years. She and her husband, Dan, had two sons: 2-year-old Joe and 4-year-old Henry. Henry attended preschool, while Joe was at home, waiting to turn three before starting preschool. Dan, the husband, was a military engineer with a Bachelor of Science in Civil Engineering, a Master's in Business Administration, a Master's in Engineering Management, and a graduate certificate in autonomous assistance.

Data Analysis

A thematic approach was used to analyze the data, which is the process of identifying patterns or themes within qualitative data. The goal of thematic analysis is to identify patterns in the data that are important or interesting and use these themes to address the research questions (Braun & Clarke, 2006). Braun and Clarke's six-phase framework was used to analyze the interview data. In the initial step, reading and re-reading the parent interview transcripts was done to become thoroughly familiar with the entire dataset. Notes were jotted down and early impressions. For instance, one recurring theme was that parents emphasized the importance of encouragement from early childhood. Next, the data was organized in a meaningful and systematic way by applying codes to the script in Step 2. Open coding was used and developed and themes modified as working through the data was done. The purpose was to reduce the data into manageable segments that addressed the specific research questions. For example, we noticed that having someone passionate about STEM in their earlier schooling (e.g., elementary or middle school) or having someone working in a STEM field emerged as a recurring idea in many interviews. After further review of each transcript, preliminary codes were developed. Each interview was coded separately, with every relevant segment marked. The codes were then reviewed and refined as necessary.

In Step 3, patterns or themes within the coded data that captured something significant or interesting about the research questions were looked for. Braun & Clarke (2006) suggest that a theme is a pattern that holds significance. Sometimes, especially with smaller datasets, coding and theme searching can overlap. In this study, several codes were related to the influence of role models—adults who inspired the participants. These codes were grouped together into an initial theme called "inspirations." By the end of this step, the codes were organized into broader themes that seemed to address specific aspects of the research questions.

Once the initial themes were identified (role models, encouragement, expectations, hands on learning, problem solving approach, STEM pre-

-school curriculum, passion, curiosity), more review and refinement was done in Step 4 making sure that the data connected to each theme truly supported it. Also, consideration was made if there was overlap between themes and whether certain themes needed to be split or combined for clarity. This continued in Step 5, of further refining the themes to identify their relatedness to the research questions and combined them into five themes; role models, encouragement/expectations, hands on learning/problem solving approach, STEM preschool curriculum, passion/curiosity. This similar process was done for the research question on STEM practices with their young children, challenges in STEM fields, and advice to ECE programs. Finally in Step 6, a compilation was made that guided the writing of the findings.

Findings

Family Influencers to STEM

We examined parents upbringing experiences that influenced their interest to STEM. In the interview question we asked parents to describe inspiring childhood experiences and family interactions they perceived were supportive and encouraging in their science pursuits, the kinds of activities they engaged in that fostered their science interest, and the people that were instrumental in their science interest journey. Several major themes were identified. First at the ontogenic level, passion and curiosity were identified as major themes. Second at the microsystem level three major themes were identified, a) role models - passionate teachers, b) parent encouragement and high expectations, c) teaching method- hands on/problem solving approach. Finally, at the macrosystem level, the themes of preschool curriculum and STEM resources in the community were identified.

Microsystem Levels

The **microsystem** is the immediate context in which individuals experience their day-to-day lives. In terms of STEM career choices, several direct influences can shape a person's decision.

Curiosity/Passion. Parents agreed that curiosity played a significant role in fostering interest in STEM career fields. This curiosity was often sparked by role models in their lives—parents and mentors—who, through engaging in STEM activities, nurtured their interest and motivated them to explore more. Preschool programs that integrate STEM activities and provide role models who are passionate about STEM can be instrumental in drawing children into these fields. Tess shared her experience, saying,

> My parents fostered my interest, and I was very self-driven in my own way. I wanted to do things, and I wanted to do them better. It was easy for me to dive into topics like biology and life sciences because I enjoyed them and wanted to learn more.

Dan also reflected on his natural curiosity:

> I'm a curious person, and that drove me in a biological direction. I'm naturally inclined to ask why behind a lot of things. I've always had a tendency towards research. It wasn't just about my parents' guidance; this part of life just fascinated me." Sandra's experience echoed this sentiment: "I remember doing activities in school, like density-related experiments—sink or float—and I continued taking science courses throughout high school. I prioritized science, and my experiences at the library really impacted my interest in science.

Parents reported being curious and self-driven from a young age. Tristan shared, "I'm naturally curious. That led me to biology. If I didn't know something, I would find it—either by looking through books or asking others." Sandra also emphasized the importance of curiosity and curriculum in nurturing

"Parents agreed that curiosity played a significant role in fostering interest in STEM career fields. This curiosity was often sparked by role models in their lives—parents and mentors—who, through engaging in STEM activities, nurtured their interest and motivated them to explore more."

STEM interest in young children. Programs that focus on STEM from an early age help students explore topics they may not have encountered otherwise, providing them with opportunities to engage with STEM communities and develop a love for learning. Teachers and parents can help identify children's interests and guide them to activities and people that will nurture those interests.

These parents also recognized the role of adults in children's lives at this stage of development. Tess shared how her extracurricular activities shaped her path,

> Some of my extracurricular activities, like working with animals, put me in touch with biology. I did 4-H and FFA projects, showed cattle, and had a horse. I learned a lot about animals and agriculture. I got involved in both practical and academic ways, and when it was time to go to college, I knew I wanted to study biology, maybe even veterinary science. But the idea of 8 years of school was overwhelming, so I chose to pursue a four-year biology degree instead.

Parents also mentioned the advantages of living in science-rich communities, where exposure to various STEM resources helped them experience science early on. For example, Miranda shared,

> My husband was in the army, and I was fortunate to fall into the research field. I lived in Bethesda, Maryland, near the National Institutes of Health, and that opened doors for me. It really spoke to my natural inclinations toward science.

Beyond their own curiosity, parents also noted the influence of passionate teachers. Dan explained,

> School played a key part in it. I had teachers who encouraged me to participate in things like Science Olympiad. I started in elementary school and continued through high school. These competitions allowed me to present and share my findings. My teacher supported me, and my parents backed me financially. They drove me to events, but they never helped with my projects. They were clear: you've got to figure it out on your own.

This combination of curiosity, supportive role models, hands-on learning, and a nurturing environment all contributed to the development of these parents' interest in STEM and shaped their paths toward scientific careers.

Role Models. Parents identified family role models as one of the key influences on their interest in science. They noted that these role models didn't have to be immediate family members but could also be extended family or someone who had a meaningful relationship with the family during their childhood. Moreover, these role models didn't necessarily have to have a STEM career; rather, it was the STEM-related activities they engaged in at home that helped raise awareness of STEM fields. Three out of the four parents interviewed had a family member involved in a STEM field. For example, Tess shared her experience,

> Growing up, I was really into animal care. One of my aunties was a veterinary technician. This matched perfectly with my passion for life sciences. From a young age, I combined my love for animals with her career in veterinary technology.

For Dan, Miranda's husband, his interest in STEM developed through working with his dad on home repairs. His childhood environment emphasized a hands-on approach to learning and problem-solving. Dan explained,

> Neither of my parents had a STEM background. My mom works as a security administrator, and my dad is in sales. But growing up, working with my dad on home renovation projects—fixing things instead of just buying new ones when they broke—helped me learn a lot. For example, when a lawn mower broke, we'd take it apart and fix it. A lot of it was just hands-on work, like fixing my own car instead of taking it to a shop. It's more of a trade skill, but when you think about carpentry or woodworking, you're constantly thinking about how to make things stronger. That's what led me toward engineering. And with technology, I enjoyed taking apart computers and making them better. It was all about using my hands and making things work, especially when we didn't have a lot of money. That's how I got into it.

Sandra highlighted the significant impact of role models, especially in the context of her stepchildren. Despite coming into their lives later in high school, she was able to encourage them to explore STEM careers. She shared:

> One of my stepchildren is in social work, and the other is in aviation. I came into his life when he was in middle school, and I encouraged more science activities, and we had a lot of conversations about science. He eventually switched his major to STEM—he had been pursuing music education but changed to aviation instead.

Expectations & Encouragement. Parents also agreed that having someone who encouraged them to pursue science was incredibly valuable. Having someone who recognized the importance of science and motivated them to start early with hands-on projects, experiments, and thinking beyond what was expected in the classroom made a significant impact. Dan's wife, Miranda, whose parents both had STEM careers, emphasized the importance of developing STEM resilience in children. She believes that pushing students to go beyond the minimum requirements, consistently engaging them in STEM activities, and focusing on specific STEM disciplines fuels their desire to learn. Both Dan and Miranda highlighted that this kind of commitment requires someone who truly believes in fostering an interest in STEM and is dedicated to nurturing it in students. Miranda shared her experience, saying,

> I had a bit of a different approach because both my parents were in STEM careers. My dad is an electrical engineer, and he's always fixing things—his passion is taking cars apart. So, math was always emphasized in our house. It was something that was really pushed. My mom, on the other hand, was always into science, particularly biology, and she would encourage us to conduct experiments. If there was something assigned in school that explained a concept on paper, she'd make us find the materials and recreate it practically from start to finish.

Hands-on and Problem-Solving Approach. Parents unanimously agreed that their approach to teaching STEM was hands-on, with a focus on letting children learn through doing while maintaining high expectations. They shared that their own parents or role models had challenged them to figure things out independently. For example, Dan reflected on learning science through a "nurture vs. nature" lens. He recognized that his upbringing was more aligned with nurture, as he had to figure things out on his own, whereas his wife's upbringing was more rooted in nature, where her parents took a more active role in guiding her through tasks. This highlights how both teachers and parents can apply scientifically supported strategies to foster a love for STEM in children.

The experiences of both Dan and Miranda demonstrate that fostering a passion for STEM is possible regardless of one's background. By challenging children to think creatively, engaging them actively in their learning, and encouraging them to go beyond the basics, we help develop the resilience needed to overcome obstacles and self-doubt in STEM. These parents believe in the importance of fostering problem-solving skills and encouraging children to persist until they solve problems—approaches that can be nurtured both through independent exploration and hands-on involvement. Dan summed up his thoughts on his wife's STEM upbringing, saying,

> My wife's upbringing was more about nature, and mine was more about nurture. With my parents, it was always 'Figure it out on your own.' If you wanted something, you had to figure out how to get it. But it sounds like her parents were more involved, like 'We're going to do this together.

Macrosystem Level

The macrosystem involves the broader societal context, including cultural values, societal norms, and public policies. These larger forces shape the framework in which career decisions are made.

Preschool Curriculum. Parents agreed that the type of preschool they attended played a significant role in sparking their interest in STEM. They highlighted how curriculums that integrated STEM activities, combined with passionate teachers, helped foster a love for science and exploration. Additionally, being in a community rich with STEM resources provided opportunities for deeper immersion in STEM learning. Sandra, for example, shared that the Montessori preschool she attended offered many STEM-focused activities that helped nurture her interest. She continued, "in early education, I went to a Montessori preschool, and my childcare program took us on library tours twice a week. They had interactive science-related activities at the library, which really sparked my interest in science."

Rich STEM Communities. Sandra also said,

> I also grew up in a town with multiple museums, including a state heritage center that now has a science museum for kids. They had some amazing exhibits, like the dinosaur displays, which really pushed me to think more deeply about STEM.

Sandra's experience highlights the importance of hands-on, immersive learning environments from an early age, where exposure to science and curiosity-driven activities can set the foundation for lifelong interest in STEM.

STEM Practices at Home

We describe the STEM practices that parents reported engaging in to support their children's STEM learning. Parents identified three broad STEM activities when we asked what they were doing to support their children's STEM learning after analyzing the interviews; (1) Intentional parent involvement, (2) purposeful selection of STEM resources and, (3) providing STEM related experiences such as spelling and writing related to STEM.

Intentional STEM Parent Involvement

All four parents strongly emphasized their intentional involvement in STEM-related activities at home. They focused on incorporating science concepts into everyday activities and actively helping their children recognize these concepts in real-world contexts. As scientists themselves, they believed in stimulating the scientific process in their children by asking questions and encouraging curiosity.

"All four parents strongly emphasized their intentional involvement in STEM-related activities at home"

Tess shared how she integrates STEM into her daily life,

> I'm a huge advocate for getting my daughter into the STEM field. I try to incorporate it naturally. For example, when we go on walks, I point out things in the natural world—like leaves or animal tracks—and we connect what we read in books with what we see in the real world. My husband, who's a plumber but has a technical degree in industrial maintenance, is great at explaining things too. Our daughter is at the stage where she asks a lot of 'why' questions. We give her lots of information without overwhelming her, and we focus on showing her the real science behind it, even if she doesn't fully understand yet. When we're working on something, we encourage her to help and see the science in action.

Tess also talked about how she integrates STEM while cooking,

> When I'm baking or cooking, she likes to help. I involve her in measuring ingredients, and we talk about what the ingredients do. I ask her to describe things—like the color or texture—so we're fostering her natural curiosity. She's a very inquisitive child, and I try not to shut that down. I give her a lot of information before she gets tired of it, but I can see she's naturally inclined to science. We encourage her to keep asking questions and wondering why.

Parents also reported using everyday home activities, like cooking and nature walks, to teach scientific concepts. In the kitchen, children can learn about measurements, food changes, colors, and math. Nature walks were mentioned as great opportunities to explore questions about the world around them, such as what it takes for a plant to grow. Some parents also used activities like hunting to discuss anatomy and biology. These parents tried to have intentional conversations with their children, guiding them through the science behind their experiences.

Parents also noted the value of purchasing resources to support their children's STEM development. They discussed actively exposing their children to science-related content, even if it was beyond their current age level. For example, Miranda shared,

> For my toddler, we do a lot of science through baking and cooking. I also found an online activity box with monthly STEM projects. We get a subscription box that includes activities like building a volcano. . It's great because I don't have to plan anything—it just arrives in the mail, and we can dive right into the activity. The one we get is from Green Kids Craft, designed for 5-6-year-olds. We also do a lot of outdoor activities. I turn everything back to logic. My husband is a hunter, and we talk about the process, then tie it to anatomy. I'm very intentional about connecting science to real-life experiences. We also have plants in the house, so we talk about why they need water and nutrients to stay alive. He's only three, but he understands that plants need water and sunlight, just like we do.

Parents also used construction and building activities to teach the science of how things are built and how structures get stronger. Many mentioned using Legos and other building toys to encourage problem-solving and observation skills. Dan and Miranda shared how they incorporate these activities into their routine,

> We do a lot of building with tracks and Legos. Most of our boys' toys involve building something to get to a specific result. Our younger one, who's about 2, has a mini tool bench where he can drill and hammer. My older son, who's 4, is getting into Legos now. He's learning how to hold pieces, how to count, and how to make things sturdier, like figuring out how to keep things from bending in the middle. Science is a bit harder for them right now because Matt, the younger one, tends to destroy things, but we do basic science experiments. We use food coloring to show how things change, simple experiments like that. For math, we have a lot of number puzzles and games. We also have balancing scales so they can figure out how to balance wooden blocks. We've got a ton of STEM-related books, too.

This intentional approach to STEM at home reflects a shared belief among these parents in fostering curiosity, critical thinking, and problem-solving skills through everyday activities, helping their children develop a strong foundation in science and other STEM fields.

Purposeful Selection of STEM Resources.

All parents agreed that they were intentional about purchasing materials to support their children's STEM learning at home. These materials included a variety of books, such as encyclopedias, number books, books focused on concepts like more/less, as well as science curriculums, STEM subscription boxes, STEM-focused TV programming, iPad activities, and educational games. They also made it a point to request that gifts for their children be STEM-related. Tess explained,

> I buy books with a STEM focus. I also ask people to buy gifts aligned with this goal—things like magnetic tiles, experimental tables, and supplies for running different experiments. As we do these experiments, I try to explain the science behind what's happening. I'm also intentional about the programming I let her watch. I like to pick shows with high-quality content. Right now, her favorite is Helene Wonders Why. Each episode covers a subject and explains it from different perspectives—why things happen the way they do. Teaching science is a strong interest of mine, and I really enjoy it. I still love this stuff, so it's easy for me to choose things that align with that.

Parents also acknowledged that their children were young but emphasized the importance of exposing them to STEM activities early on. They believed that doing so would help them understand their children's personalities and interests, especially if those interests aligned with STEM. By tapping into these interests early, parents felt they could nurture and develop their children's potential. Some parents, like Tess, used high expectations to encourage growth and help determine their child's capabilities. Miranda shared,

> He doesn't sit still for books, but I still buy lots of encyclopedia-style science books. For iPad time, we choose science-based activities for him to engage with. We have a YouTube playlist with science videos that he can choose from. We're very intentional about this approach.

Both Dan and Miranda expressed strong support for investing in science-related activities and resources. Miranda added,

> For math, we have a number of puzzles and games. We also have balancing scales so they can experiment with things like comparing the weight of wooden and plastic blocks to see which is heavier and how to balance them. We have a ton of books on these topics too.

In addition to their focus on STEM, parents emphasized the importance of giving equal attention to all areas of child development, including language and social-emotional growth. They felt that while preschool often placed strong emphasis on language and social skills, STEM education should receive similar focus. Miranda explained,

> I'm an accountant and financial analyst, so I work in math. From my perspective, learning finance is just as important as learning to read. With our kids, we have books focused on numbers as much as we have books on letters. We also put a lot of emphasis on concepts like counting, more/less, and colors, alongside letters.

This approach reflects a holistic view of learning, where all subjects, including STEM, are seen as equally important and worthy of attention and investment.

Challenges of Being in STEM Fields

Parents agreed that obstacles such as gender inequalities, religious beliefs, and lack of preparation can hinder students' interest in STEM and should be addressed early on. By equipping students with the right tools to navigate these challenges, both teachers and parent training programs can help ensure students succeed in STEM fields. Sandra shared her experience of overcoming gender-related challenges in the STEM field. She emphasized the importance of self-belief and hard work for women, noting that this mindset had helped her succeed. She explained,

> In my career, I had to pass many professional exams and certifications to gain the same respect as my male counterparts. In some situations, a man's word would be accepted without question, but I had to back up my reasoning to have it taken seriously. These are the kinds of challenges I've had to navigate.

Sandra encourages girls to focus on what they can control and to push against stereotypes that undermine women in STEM.

> To combat negative stereotypes, I always remind people to appreciate women in STEM for their hard work, not for how special they are. It's important to recognize that it's their dedication and persistence that got them where they are. Talk about the journey—how many years of schooling it took them to become professionals, like doctors. Acknowledge the effort and determination it takes to succeed.

Sandra also spoke about the challenges of being a woman in a male-dominated field.

> At conferences, there might be 200-300 people, but only about 30 women. Not many people in my profession are at my level, and I've had to adjust to the gender identity challenges that come with it.

Dan highlighted the importance of early preparation for STEM fields, especially to avoid struggles later on. He shared that his parents, who did not come from a STEM background, did not emphasize the level of hard work needed for success in these fields. As a result, he was unprepared for the rigorous math courses he encountered in college.

> My parents didn't have a STEM background. They took basic math courses, but nothing that would prepare me for the level of math I needed in college. I failed my first-year calculus course and had to great instructor in calculus 3, I eventually got a B and began to improve.

Dan encourages parents and teachers to emphasize the importance of hard work in STEM.

> I wasn't prepared as a first-generation student for how much time I needed to devote to studying. I thought school came easily to me, but I quickly realized that my usual study habits weren't enough. You need to stay on top of your work, or you'll fall behind. STEM requires consistent effort and endurance.

He stresses that students should feel comfortable seeking help from experts when needed.

One parent spoke about the conflict between science and family religious beliefs, particularly regarding evolution,

> My family is very religious, so science projects were difficult for me. I remember learning about evolution, and it was a big concern for me because what I was reading seemed to contradict my family's beliefs. I had a lot of questions and had to find a way to work through that conflict.

This situation raises the question of how religious beliefs impact students' STEM development, particularly across different racial, educational, and socioeconomic groups. Understanding the extent to which religious beliefs influence STEM learning and how to navigate such challenges could be crucial in fostering an inclusive and supportive STEM environment for all students.

In conclusion, addressing obstacles like gender biases, lack of preparation, and potential conflicts between science and religious beliefs early on can empower students to succeed in STEM. Providing students with the tools to navigate these challenges, along with support from both teachers and parents, is essential in helping them thrive in STEM fields.

Parent Suggestions for Enhancing STEM in preschool

Parents were asked to share their suggestions for fostering early science interest in children. Many emphasized the importance of providing accessible, hands-on activities that can easily be incorporated into busy family schedules. One key recommendation was for preschool programs to offer pre-made activity packs that parents can take home. These packs would remove the need for parents to plan or gather materials, making it easier for them to engage with their children in STEM activities. Parents expressed appreciation for similar resources available at public libraries, where families can borrow activity kits, take them home, and complete the activities without additional effort.

Parents pointed out that many families may not have the time, money, or resources to seek out STEM activities on their own, so these "plug-and-play" resources would be especially valuable. They suggested that preschool programs consider implementing similar activity kits or creating lending libraries to complement what public libraries are already offering. Additionally, parents recommended that these resources be designed for different age groups to ensure they're developmentally appropriate.

Another suggestion was for preschool programs to connect children with professionals in STEM fields. Parents emphasized the value of exposing children to role models early on and allowing them to shadow individuals in science-related careers. By doing so, children can make connections between what they are learning and real-world applications, which may help spark their interest in pursuing STEM fields later on.

In terms of teaching strategies, parents encouraged preschool programs to make science fun, engaging, and hands-on. They stressed the importance of creating "aha moments" for children that fuel their curiosity and wonder. Dan shared a few examples of how he fosters his children's interest in science through everyday experiences,

> Showing them something that mesmerizes them and asking, 'Do you think this is cool?' then following up with, 'If you thought that was cool, wait until you see this!' Breaking down why things are the way they are is key. For example, my boys love watching construction vehicles at work. When we had our highway repaved, I used that as a teachable moment. I explained how certain materials like asphalt wouldn't stick unless certain processes were followed. There's a lot of math and science involved in road design, and I broke it down in ways they could understand, like how long a road will last based on its construction.

Dan also emphasized the importance of creating hands-on activities that go beyond simple repetition.

> We don't just reread books; we recreate projects that allow them to explore concepts on their own, with purpose. For example, when I took Henry for a walk, I asked him to find five acorns. We counted using his fingers, and when he found two, I asked him to drop two fingers and figure out how many were left. It's a simple, rudimentary way of teaching math while integrating nature into the learning process.

These examples highlight the significance of teaching STEM concepts through practical, everyday activities that both engage and educate children, making learning feel more relevant and excit-

-ing. In summary, parents suggested that preschool programs provide accessible, hands-on learning resources, connect children with STEM role models, and encourage curiosity-driven teaching methods. By incorporating these approaches, preschool programs can create a strong foundation for fostering early interest in science and STEM fields.

Discussions & Implications

Parents with STEM resources and expertise play a significant role in shaping their children's learning, both at home and in schools. Macro-level STEM initiatives such as those at the federal, state, and foundation levels are vital in building STEM capacity for both teachers and students. These initiatives are crucial for all students, especially those who lack access to adequate resources and quality instruction. Without proper support, students are at risk of falling behind. Initiatives should aim to train parents on how to engage their children in STEM activities, while also preparing teachers to develop their STEM skills. Additionally, classrooms and curricula must be redesigned to better support STEM learning. Parents involved in the study highlighted the importance of the resources they had access to whether from their own upbringing or through what they now provide for their children. Each child's macrosystem should be enriched with meaningful STEM resources. However, many homes lack the resources needed to provide high-quality STEM learning opportunities. Quality education often requires significant financial investment, and studies show that when schools have sufficient funding for resources and effective teachers, student learning improves (Darling-Hammond, 2004).

Parents in the study emphasized the importance of allowing students time to engage with the scientific process—time to wonder, explore, problem-solve independently, and even have downtime to generate ideas. This suggests that curricula may need to be revised to allow for more open-ended inquiry and exploration in STEM subjects. Parents also need the time and flexibility to work with their children on STEM activities at home. To support this, schools need to implement more student-centered practices, both in the classroom and at home. Macrosystems must develop new models to measure school success that take STEM learning into account.

Parents also shared how various people, programs, and resources influenced their experiences with STEM. It wasn't just about money; it was about the broader environment, including the teachers they had, the extracurricular activities they engaged in, and the competitions they participated in. This highlights the role of the exosystem, children may not directly interact with higher education programs that train teachers, but they do engage with teachers trained by these programs. When these various groups come together, they create a more diverse and supportive environment for STEM education. Colleges and universities can develop programs that connect teachers and parents with the resources and expertise they need. Efforts should be made to ensure that parents who most need these programs are able to participate. Resources go beyond just financial support, parents should be encouraged to seek out STEM resources available within their communities, such as local libraries, STEM workshops, and educational events.

Parents also shared their knowledge of different STEM tools they use with their children. Parents need access to research and resources that can help them better support their children's STEM learning (Basham, Israel, & Maynard, 2010). Partnerships with local universities and STEM programs can enhance parents' understanding of how to engage their children with STEM activities. These partnerships should help parents identify where to find helpful resources, such as borrowing tools from libraries or learning about new materials online. Building networks for parents to share STEM experiences and lessons learned can be invaluable. These networks could also expand to include business leaders, STEM professionals, and industry personnel who could serve as role models or provide additional resources for students' learning. Additionally, providing teachers, administrators, and school partners with platforms to share instructional ideas and best practices through social networks could help support diverse student needs.

The mesosystem, the interaction between various systems that influence the student is critical in this process. For children to thrive in STEM, all these systems must align and work together. Parents' STEM teaching at home influences how students engage with STEM at school, while teachers' passion and training shape students' attitudes toward STEM. Efforts should focus on developing or adopting accessible STEM curricula that support all students, both at school and at home. Programs could create STEM materials for parents to use with their children. Curricula should be designed in ways that allow students to engage with the material and demonstrate understanding, and tools should be provided to help parents facilitate this process (Glass, D., Meyer, A., & Rose, D. H., 2013). Both parents and teachers need access to modern instructional tools and professional development opportunities to stay current with the latest educational developments (Edyburn, 2010). Time, commitments, self-efficacy, and resources are the key factors influencing parental engagement in their child's STEM learning (Lee & Nie, 2015). Among these, self-efficacy is particularly important, as it reflects a parent's belief in their ability to positively influence their child's education (Hoover-Dempsey, Walker, Sandler, et al., 2005). Parents without a STEM background may struggle to identify or create at-home activities, often assuming they require costly equipment. Fostering STEM involvement hinges on building confidence to explore projects, even when things don't go as planned. While online resources are available, parents often face difficulty in knowing where to look or how to effectively use the information they find.

Finally, the microsystem which is the direct interactions between the student and their environment, peers, teachers, and family plays a vital role in shaping a student's understanding of STEM. The kind of beliefs, messages that parents share with their children are crucial socializing factors (Mara & Toni, 2020) within these environments. Even though behavioral mechanisms which parents convey their STEM related beliefs are unclear, there is need for studying the quality of parent child interaction in STEM, especially in looking at different backgrounds of families. Teachers and parents must collaborate to provide a meaningful and engaging learning environment. Parent expectations are the most significant factor influencing children's STEM achievements in mathematics (Wang & Yang, 2019). Teacher collaboration on lesson plans and shared goals can further enhance student learning and foster an educational community that supports STEM growth.

Limitations

The small number of participants should be considered when interpreting the results of this study. Additionally, the researcher both conducted the interviews and performed the study evaluation, which introduces the potential for bias, particularly in the theme analysis. To address this, the researcher cross-checked the interview scripts with the audio recordings, which helped enhance the credibility and validity of the findings (Brantlinger et al., 2005). Triangulation of data, achieved through a literature review and secondary sources, was also employed to verify the consistency of emerging themes. Furthermore, integrating both qualitative and quantitative methods (Leko et al., 2023) could have improved the study design and overall quality. Involving participants in the design phase of the study would also have strengthened the research questions. Further, conducting member checking with participants would have enhanced credibility (Brantilinger et al., 2005).

References

Adams, R., B., Barber, B., M., & Odean, T. (2018). STEM parents and women in finance. *Financial analysts Journal*, 2018, 84-97.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., Wong, B. (2012). Science aspirations, capital, and family habitus: How families shape children's engagement and identification with science. *American Educational Research Journal,* 49, 881–908. https://doi.org/10.3102/0002831211433

An, G., Wang, J., & Yang, Y. (2019). Chinese parent's effect on children's math and science achievements in schools with different SES. *Journal of Comparative Family Studies,* 50, 140 – 161. https://doi.org/10.3138/jcfs.50.2.003

Aschbacher, P. R., Ing, M., & Tsai, S. M. (2013). Boosting student interest in science. *Phi Delta Kappan*, 95, 47-51.

Aysun, A., & Ozlen, D. H., (2020). Supporting preschool children's STEM learning with parent-involved early engineering education. *Early Childhood Education Journal,* 49, 607-621.

Basham, J. D., Israel, M., & Maynard, K. (2010). An ecological model of STEM education: Operationalizing STEM for all.

Journal of Special Education Technology, 3, 9-19.

Beasley, M. A., & Fischer, M. J. (2012). Why they leave: Understanding the underrepresentation of women in STEM fields. *Sociology of Education*, 85, 35–48.

Bevan, B. (2017). The promise and the promises of Making in science education. *Studies in Science Education,* 53, 75–103. https://doi.org/10.1080/03057267.2016.1275380

Boonk, L., Gijselaers, H. J. M., Ritzen, H., Brand-Gruwel, S. (2018). A review of the relationship between parental involvement indicators and academic achievement, *Educational Research Review*, 24, 10-30. https://doi.org/10.1016/j.edurev.2018.02.001

Bowden, M., Bartkowski, J., Xu, X., Lewis Jr, R. (2017). Parental occupation and the gender math gap: examining the social reproduction of academic advantage among elementary and middle schools students. *Social Sciences*, 7, 6-12.

Brantlinger, E., Jimenez, R., Klingner, J., Pugach, M., & Richardson, V. (2005). Qualitative studies in special education. *Exceptional Children,* 71, 195-207.

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American Psychologist*, 32(7), 513-531. https://doi.org/10.1037/0003-066X.32.7.513

Campbell S, Greenwood M, Prior S. (2020) Purposive sampling: complex or simple? Research case examples. *Journal of Research in Nursing*. 25, 652-661. 10.1177/1744987120927206

Ennes, M., Jones, M. G., Chestnutt, K., Childers, G. M. (2023). Family science experiences influence on Youths' achievement value, perceived family value, and future value of science. *Research in Science Education*, 53, 1-16. https://doi.org/10.1007/s11165-023-10116-7

Chakraverty, D., Tai, R. H. (2013). Parental occupation inspiring science interest: perspectives from physical scientists. *Bulletin of Science*, 33, 44-52.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin, 143*, 1- 35. https://doi.org/10.1037/bul0000052

Couse, L. J., & Chen, D. W. (2010). A Tablet computer for young children? Exploring its viability for early childhood education. Journal of Research on *Technology in Education, 43*(1), 75–96. https://doi.org/10.1080/15391523.2010.10782562

Dabney, K. P., & Chakraverty, D., & Tai, R. (2013). The association of family influence and initial interest in science. *Science Education, 3*, 395 – 409.

Darling-Hammond, L. (2020). The need for collaborative learning in early childhood STEM education. *Teaching and Teacher Education*, *88,* 39-50.

English, L. D. (2017). Advancing elementary and middle school STEM education. *International Journal of Science and Mathematics Education, 15,* 5–24.

Glass, D., Meyer, A., & Rose, D. H., & (2013). Universal design for learning and the arts. *Harvard Educational Review, 1*, 98 – 119.

Harackiewicz, J., M., Rozek, C. S., Hulleman, C. S., Hyde, J. S. (2012). *Psychological science, 23,* 899-906.

Heddy, B. C., & Sinatra, G. M. (2017). Transformative experiences and interest with a parent involvement intervention. *Science Education, 101,* 765-786.

Hill, N. E., Witherspoon, D. P., & Bartz, D. (2016). Parental involvement in education during middle school: Perspectives of ethnically diverse parents, teachers, and students. *The Journal of Educational Research, 111*, 12–27.DOI: https://doi.org/10.1080/00220671.2016.1190910

Holmes, K., Gore, J., Smith, M., Lloyd, A. (2017). An integrated analysis of students' aspirations for STEM careers: which student and school factors are most predictive? International *Journal of Science and Mathematics Education, 16*, 655-675.

Howard, N. R., Howard, K. E., Busse, R. T., Hunt, C. (2019). Let us talk: an examination of parental involvement as a predictor of STEM achievement in math for high school girls. *Urban Education,58*(4), 586-613. https://doi.org/10.1177/0042085919877933

Ing, M. (2014). Can Parents Influence Children's Mathematics Achievement and Persistence in STEM Careers? *Journal of Career Development, 41,* 87. https://doi.org/10.1177/0894845313481672

Jungert, T., Levine, S., Koestner, R. (2020). Examining how parent and teacher enthusiasm influences motivation and achievement in STEM. *The Journal of Educational Research,113,* 275-282.

Kathleen V Hoover-Dempsey, Joan M T Walker, Howard M Sandler, et al. 2005. Why Do Parents Become Involved? Research Findings and Implications. *The Elementary School Journal* 106, 105.

Kuo, H. C. (2024). Transforming Tomorrow: A Practical Synthesis of STEAM and PBL for Empowering Students' Creative Thinking. *International Journal of Science and Math Education.* n.p. https://doi.org/10.1007/s10763-024-10511-0

Lee, A., N., & Nie, Y. (2015). The "Why" and "How" of Engaging Parents in Their Children's Science Learning in Informal Contexts: Theoretical Perspectives and Applications. In *Science Education in East Asia,* Myint Swe Khine (ed.). Springer International Publishing, 93–121. http://doi.org/10.1007/978-3-319-16390-1

Leko, M. M., Hitchcock, J. H., Love, H. R., Houchins, D. E., & Conroy, M. A. (2023). Qualityindicators for mixed-methods research in special education. *Exceptional Children,* 89, 432-448. https://doi.org/10.1177/00144029221141031.

Kim, Y., Chu, H.E., Lim, G. (2015). Science Curriculum Changes and STEM Education in East Asia. In: Khine, M. (eds) *Science Education in East Asia*, 149 – 226. Springer, Cham. https://doi.org/10.1007/978-3-319-16390-1_7

National Science Foundation. (2019). *STEM education: Current status and future directions. Report of the National Science Foundation.* Retrieved from https://www.nsf.gov/nsb/sei/edTool/

Plasman, J., Gottfried, M., Williams, D., Ippolito, M., Owens, A. (2020). Parent's occupations and students' success in STEM fields: a systematic review and narrative synthesis. *Adolescent Research Review,* 6, 33-44.

Rashmi, K. (2016). Working with families to inspire children's persistence in STEM. *Childhood Education,* 5, 358-364

Rivera, H., & Li, J. (2020). Potential factors to enhance students' STEM college learning and career orientation. *Frontiers in Education,* 5.https://doi.org/10.3389/feduc.2020.00025

Roberst, T., Jackson, C., Mohr-Schroeder, M., Bush, S. B., Maiorca, C., Cavalcanti, M., Craig Schroeder, D., Delaney, A., Putnam, L., & Cremeans, C. (2018). Students' perceptions of STEM learning after participating in a summer informal learning experience. *International Journal of STEM Education,* 5, 1-14.

Sheldrake, R. (2018). Changes in children's science - related career aspirations from age 11 to age 14. *Research in Science Education,* 4, 1435-1464.

Scott, F., & Marsh, J. (2018). *Digital literacies in early childhood. Oxford Research Encyclopedia of Education* https://oxfordre.com/education/view/10.1093/acrefore/9780190264093.001.0001/acrefore-9780190264093-e-97

Simpkins, S. D., Price, C. D., & Garcia, K. (2015). Parental support and high school students' motivation in biology, chemistry, and physics: understanding differences among Latino, Caucasian boys and girls. *Journal of Research in Science Teaching, 52,* 1386-1407.

Simunovic, M., Babarovic, T. (2020). The role of parental socialization behaviors in two domains of student STEM career interest. *Research in Science Education, 4,* 1055-1071.

Steiner, A., Lemke, J., Nero, D., & McGlamery, S. (2019). *Science and Children,* 56, 76-79.

Stout, J. G. (2011). STEM motivation and gender differences: Examining developmental perspectives. *Psychological Science*, 22, 1052-1059.

Tilbrook, N., & Schifrer, D. 2021. Field-specific cultural capital and persistence in college majors, *Social Science Research,*103. https://doi.org/10.1016/j.ssresearch.2021.102654

Trainor, A. A., & Graue, E. (2014). Evaluating rigor in qualitative methodology and research dissemination. *Remedial and Special Education,* 35, 267 274. https://doi.org/10.1177/0741932514528100

Wang, M. T. (2013). The influences of parental support on adolescent STEM achievement. *Child Development,* 84, 1710-1724.

Wang, MT., Degol, J.L.(2017). Gender gap in Science, Technology, Engineering, and Mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Education Psychology Review,* 29, 119–140. https://doi.org/10.1007/s10648-015-9355-x

Zucker, T.A., Montroy, J., Master, A. Assel, M., McCallum, C., Yeomans-Maldonado, G. (2021). Expectancy-value theory & preschool parental involvement in informal STEM learning. *Journal of Applied Developmental Psychology, 76,* 1-13. https://api.semanticscholar.org/CorpusID:239695115