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From Familiarity to Futures: How Parents Shape STEM Pathways

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Abstract: Parents play an important role in shaping children's engagement with STEM. However, less is known about how parents perceive their own influence on their children's engagement and future STEM pathways. This study examined relationships among parental STEM familiarity, perceived parental impact, family-based STEM participation, and parents' perceptions of their children's future STEM trajectories. Guided by social cognitive theory and the proposed Parental STEM Agency, Self-Efficacy, and STEM Capital (PASC) framework, the study explored how parental beliefs and family engagement practices relate to future-oriented STEM expectations. Data were collected through surveys administered to adult family members attending family-focused STEM outreach events at two elementary schools in a large urban municipality in Ontario, Canada (Site A: n = 34; Site B: n = 41). Descriptive statistics and Spearman's rank-order correlations were used to examine patterns within each site. Across both sites, parents reported positive perceptions of their influence on their children's STEM learning and strong expectations for their children's future engagement with STEM. Perceived parental impact emerged as the most consistent correlate of envisioning children's STEM futures, while parental STEM familiarity and family-based STEM participation demonstrated more variable relationships across contexts. The findings suggest that parents who perceive themselves as capable contributors to their children's STEM development are more likely to envision STEM as a viable future pathway for their children. Differences across sites also point to the influence of broader sociocultural and structural factors on family STEM engagement. These findings contribute to understanding how parents shape children's STEM pathways and suggest that efforts to broaden participation in STEM should attend not only to children's experiences, but also to the family contexts that support the development of STEM aspirations and engagement.

Keywords: parental involvement, parent self-efficacy, science capital, social cognitive theory, STEM education, STEM outreach

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Introduction

Access to meaningful STEM learning opportunities is not evenly distributed, leaving many children without sustained exposure to experiential STEM engagement (Duodu et al., 2017; Grossman & Porche, 2014; Tran et al., 2024). While schools play an important role in addressing these gaps, children's long-term engagement in STEM is also shaped by opportunities, encouragement, and support available within the home environment. In this context, parental involvement becomes a critical factor in guiding children's STEM futures.

Parental involvement broadly refers to parents' time, effort, and support that influence their children's learning and academic success (Grolnick & Slowiaczek, 1994). In this study, *parent* is defined inclusively as any familial adults including parents, caregivers, guardians, and extended family members who engage in STEM learning with the child. Meta-analyses consistently demonstrate a positive relationship between parent involvement and student achievement (Castro et al., 2015; Fan & Chen, 2001; Hill & Tyson, 2009; Jeynes, 2005; Kim, 2022; Sujarwo & Herwin, 2023; Wilder, 2013). Parental involvement also significantly improves children's STEM learning outcomes (Erol et al., 2025; Dotterer et al., 2022; Gülhan, 2023; Harackiewicz et al., 2012; Marotto & Milner-Bolotin, 2018; Perera, 2014; Thomas et al., 2020). While parents clearly play a key role in their children's learning, less is known about how they perceive their influence on their children's STEM trajectories. This study addresses this underexplored area.

The research was conducted with parents of elementary school children in a large, diverse, urban municipality in Ontario, Canada. Data collection sites were accessed through a 2023–2025 family-focused STEM outreach initiative led by the author in a partnership with their university and two regional school boards. In addition to providing free, in-community events for parents and children with limited access to extracurricular STEM learning, the setting provided a valuable opportunity to learn about how parents regard their involvement in their children's STEM experiences. This research responds to a gap in the literature by examining perceptions of parental influence in shaping their children's engagement in STEM. Two research questions are being investigated:

1. How do parental beliefs about STEM relate to their perceptions of their children's future STEM trajectories?
2. How do parents perceive the role of family-based STEM participation in supporting their children's engagement with STEM?

Theoretical Framework

Social cognitive theory suggests that people are not merely shaped by their environments but actively influence outcomes through their beliefs and actions (Bandura, 2001), providing a useful lens for understanding parental influence on children's STEM pathways. Central to this stance is human agency, one's capacity to intentionally influence outcomes through their actions and judgments (Bandura, 2001). A key mechanism of agency is self-efficacy. According to Bandura (1995) self-efficacy is "the belief in one's capabilities to organize and execute the sources of action required to manage prospective situations" (p. 2). In practical terms, agency underpins self-efficacy as individuals are more likely to act when they believe their efforts will be effective. In this study, *parental STEM agency* is understood as parents' capacity to actively influence their children's STEM experiences.

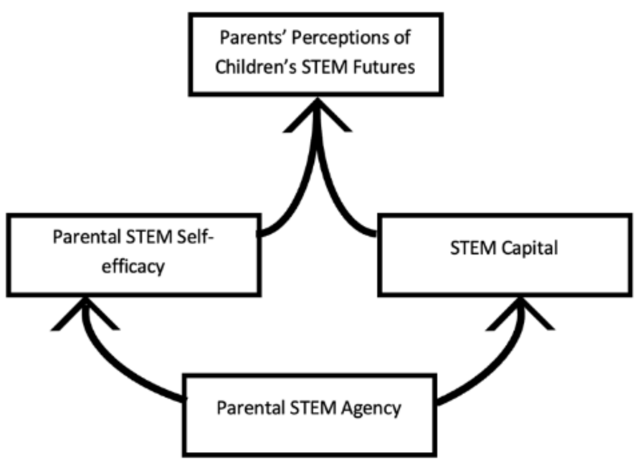
Extending this view of STEM parental agency as the capacity for action, self-efficacy plays a critical role in shaping how parents enact this influence. Self-efficacy has been linked to more positive parenting practices and better child behavioral, social-emotional, and academic outcomes (Jones & Prinz, 2005). Self-efficacy determines whether parents believe they can influence their child and their environment to effectively support their development and success (Ardelt & Eccles, 2001). This sense of influence can also be understood through parents' roles in shaping their children's STEM experiences. By examining parents' interpretations of this influence, this study provides insights about *parental STEM self-efficacy*, the belief in their ability to successfully guide and facilitate their child's STEM learning (Zucker et al., 2021).

While parental STEM self-efficacy influences parents' willingness to support learning, the extent to which this support can be enacted may depend on access to STEM-related forms of capital. Grounded in Pierre Bourdieu's (1986) theory of capital, Archer et al. (2015) conceptualize science capital as the accumulation of science-related knowledge, attitudes, experiences, and social resources developed over a lifetime. In this study, the theoretical notion of capital is used to better understand parents' access to and mobilization of assets that support their children's STEM engagement and aspirations. This is consistent with the view of science capital as "a conceptual tool for understanding the production of classed patterns in the formation and production of children's science aspirations" (Archer et al., 2014, p. 5). Science capital has been associated with stronger science identities, more positive attitudes toward science, and greater aspirations to pursue science-related careers (Archer et al., 2012; Archer & DeWitt, 2016). Extending this concept, *STEM capital* more broadly reflects the knowledge, experiences, dispositions, and social resources related to participation across the STEM fields (Hasenhütl et al., 2025). Higher levels of STEM capital can support learning, aspirations, and navigation of academic and career pathways in STEM (Hug et al., 2025; Luo et al., 2025).

Parental STEM agency, parental STEM self-efficacy, and STEM capital, can help build an understanding of parents' perceptions of their children's future trajectories in STEM. Together, these constructs guide the development of a preliminary conceptual framework for this research (see Figure 1). This framework positions parental STEM self-efficacy and STEM capital as complementary influences that shape parents' perceptions of their children's STEM futures with parental STEM agency acting as the mechanism that connects and activates these resources. This framework will be used as an analytical guide to interpret relationships that emerge from this study.

Figure 1

Parental STEM Agency, Parental STEM Self-Efficacy, and STEM Capital Mediation of Parents' Perceptions of Children's STEM Futures (PASC) Framework



Literature Review

Parental STEM Beliefs

Parental beliefs about STEM have been associated with more favourable student STEM attitudes and outcomes. In an extensive review of the literature, Šimunović et al. (2018) found that children's perceptions of parental encouragement and valuing of STEM were the strongest predictors of children's own STEM values. Jungert et al. (2020) surveyed high school students about their motivations in STEM and found that parental enthusiasm for STEM positively predicted students' intrinsic motivation, which in turn mediated gains in STEM achievement over time. Positive parental beliefs have also been reported to impact how students envision their future career paths in STEM. Drawing on data from a national longitudinal study tracking educational pathways and outcomes across the lifespan in Germany, perceived parental support was shown to impact students' initial entry and persistence in STEM (Stefani, 2024). Students with parent STEM support are more likely to switch from non-STEM to STEM future career expectations and maintain these expectations (Starr et al., 2022a). Researchers in Chile investigated indicators of STEM career expectations among middle school children and found those whose parents held expectations for STEM careers were nearly seven times more likely to see themselves in STEM roles in the future (Morales et al., 2024).

Parents with higher perceived capability to support STEM enact this confidence through different practices. These include co-participation in science activities, asking explanatory questions, encouraging prediction and reasoning, providing STEM resources, supporting course decisions, communicating the importance of STEM, and having high academic expectations (Crowley et al., 2001; Halim et al., 2018; Hsieh & Simpkins, 2022; Simpkins et al., 2015; Starr et al., 2022b).

Positive parental beliefs may also help mitigate disadvantage in terms of STEM engagement and achievement. Through an analysis of data from the OECD's 2006 Program for International Student Assessment (PISA) survey, Perera (2014) reports that children from disadvantaged backgrounds improved their science test scores more than their affluent peers if their parents had favourable beliefs about science. Using national longitudinal data tracking students from ninth grade into the workforce, researchers in the United States found that parental STEM support was most strongly associated with adolescents' motivation in families where the parents lacked a STEM background (Hsieh and Simpkins, 2022). According to research involving adolescents from the UK, those who perceived science-specific encouragement from their parents reported more positive attitudes toward science and greater involvement in science activities, independent of gender and social class (Breakwell and Beardsell,1992). Collectively, these findings center parental involvement as a key mechanism through which beliefs and involvement shape students' STEM motivation, achievement, and career pathways.

Parents' self-efficacy beliefs play a key role in shaping children's attitudes, motivation, and developmental outcomes (see Fang et al., 2021; Glatz et al., 2024; Jones & Prinz, 2005) and can mediate the relationship between socioeconomic status and children's academic achievement (Svoboda et al., 2016; Tazouti & Jarlégan, 2016; Yosef & Karisma, 2021; Yin et al., 2025). In the school context, parents' beliefs about their children's abilities play a central role in influencing a child's academic self-concept and task values, sometimes exerting a stronger influence than the child's actual performance or classroom experiences (Eccles & Harold, 1993). In a study of parent involvement and efficacy in a preschool intervention program, Canadian researchers found that self-efficacy is strongly associated with higher levels of parent involvement, as perceived by teachers, although parents with limited English proficiency tend to report lower efficacy and involvement due to language barriers and unfamiliarity with the school system (Pelletier & Brent, 2002).

In terms of discipline-specific parental self-efficacy, the concept has been more extensively explored in mathematics. For example, it has been found to be a positive predictor of children's mathematics achievement (Froiland et al., 2013; Harris et al., 2022; Liu & Leighton, 2021; Outhwaite et al, 2025). However, less is known about parental self-efficacy in terms of STEM education. Similar processes to parental STEM self-efficacy have been examined through expectancy-value perspectives. Expectancy-value theory posits that individuals' beliefs about their capabilities and the value they assign to tasks guide their behaviour (Eccles & Harold,1993; Eccles & Wigfield, 2002). Consistent with Bandura's (2001) theory of self-efficacy, parents who feel more capable in STEM are more likely to value and engage in STEM-related activities with their children. In a study by Zucker et al. (2021), preschool parents' perceptions of the value of STEM, rather than their beliefs about success or perceived costs (e.g. effort, time, emotional impacts), were directly associated with their involvement in science and mathematics activities. Thomas and Strunk (2017) examined the expectancy value of parents and teachers in rural schools in the United States. The analysis revealed that parents' expectations for their children's success significantly predicted fifth-grade science achievement and were a stronger influence than both teachers' expectations and children's own self-efficacy.

Family-based STEM Participation

The research on parental STEM beliefs confirms they are influential on children's STEM outcomes. Active engagement with STEM is one way this influence can be manifested. Family-based STEM participation is the ways families involve children in STEM learning through activities, interactions, and support in everyday home and community contexts. It is a key mechanism in building STEM capital as it involves perceptions and resources that forecast sustained participation in STEM. This aligns closely with research on parental involvement in STEM education. Evidence indicates that family-based STEM activities and emotional support enhance children's STEM motivation and success (Dotterer et al., 2022; Gülhan, 2023; Marotto, & Milner-Bolotin, 2018; Salvatierra & Cabello, 2022; Šimunović & Babarović, 2020; Thomas et al., 2020). Furthermore, informal STEM learning that happens through participation in community programs such as those offered by museums, libraries, and other community organizations can positively affect student achievement (Alexandre et al., 2022; Ennes et al., 2023; Morris et al., 2019; VanMeter-Adams et al., 2014; Zucker et al., 2022). Parent-child interactions in this type of informal STEM learning can promote curiosity, deepen conceptual understanding, strengthen self-efficacy, and lead to more sustained interest in STEM pathways (Tillinghast et al., 2017; Zucker et al., 2022).

While parental involvement is a driver of student engagement and success in STEM, access to early and sustained STEM learning remains uneven. Gaps in science achievement have been associated with both household income and parental education (Barzanji, 2013; Curran, 2017; Betancour et al., 2018). Barriers such as limited time, economic constraints, and competing responsibilities can restrict STEM participation (Ju et al., 2020) can limit access to STEM capital. Conversely, families with higher socioeconomic status often use their greater resources such as education and income to provide the encouragement and hands-on STEM opportunities necessary to build their children's long-term interest and confidence in science (Gu et al., 2025; Suortti et al., 2024; Tran et al., 2024).

From an equity perspective, access to STEM capital is unevenly distributed across socioeconomic and cultural contexts, contributing to persistent disparities in participation in advanced STEM education and careers (Archer et al., 2012; Luo et al., 2025; Rendón et al., 2025). Families who have had limited exposure to STEM education or careers may be less likely to view STEM futures as attainable, even when children demonstrate strong interest or ability. Importantly, STEM outreach programs can strengthen family-based STEM capital by providing access to STEM resources and experiences while also improving parents' STEM-related beliefs and attitudes (Gu et al., 2025). Outreach that intentionally engages caregivers alongside children plays a critical role in redistributing STEM capital by increasing parental familiarity, expanding awareness of STEM pathways, and challenging narrow narratives about who belongs in STEM fields (Hasenhütl et al., 2025; Simpkins et al., 2015). By strengthening family-level STEM capital, these initiatives have the potential to enhance parental STEM self-efficacy and, in turn, elevate children's aspirations and persistence in STEM learning and careers.

Collectively, this research highlights the important role of parental beliefs and family participation in shaping children's STEM experiences. However, fewer studies were located that directly examine parents' STEM-related beliefs and experiences, with many relying instead on external or indirect measures. While prior work has established the importance of parental involvement in STEM education, less is known about how parents understand their influencing role and how this translates into expectations for their children's participation in STEM. This study addresses this needed perspective. In addition, the proposed PASC framework recognizes that parents possess STEM agency and, when they believe in their capacity to support their child, can draw on STEM capital and translate these resources into expectations and forms of support that shape children's STEM pathways.

Methods

The project took place in one of the largest municipalities in Ontario, Canada characterized by cultural, linguistic, and socioeconomic diversity in urban and suburban communities. Access to the study sites was furnished through the author's leadership of an in-community STEM outreach project from 2023-2025. To address inequities in access to extracurricular STEM learning opportunities, the author's Faculty of Education partnered with fifteen schools from local school boards to organize and co-host free STEM outreach events for families. Faculty and undergraduate students from the University planned and facilitated 20 STEM activity stations offering high-interest, hands-on science and technology experiences (e.g. experiments, design challenges, games, technology activities, 'make and take', etc.). Activities were designed to support multilingual, multi-age participation and shared engagement between children and adult family members.

While ethical commitments to anonymity preclude detailed reporting of school or neighbourhood demographics, the participating schools served communities with documented structural barriers to STEM enrichment. The school boards invited schools serving communities with higher proportions of households with lower incomes and lower parental educational attainment (Government of Ontario, 2025). Provincial standardized assessments also indicated that a greater proportion of students in these schools do not meet provincial standards in Grades 3 and 6 reading, writing, and mathematics compared to provincial averages (Government of Ontario, 2025). Fifteen urban elementary schools accepted invitations to co-host after school outreach events for their surrounding communities.

In collaboration with the school boards' research offices, two of the 15 participating schools were purposefully selected to take part in a research component based on indicators consistent with the purpose of the study. This was done to reflect variation in community contexts rather than to achieve statistical representativeness. Guided by a quantitative pragmatic orientation (Creswell & Creswell, 2023), the study employed survey methods to describe how parental perceptions function within distinct contexts, and not to directly compare sites.

Survey data was collected at site A at an event in May 2023 and site B at an event in May 2024. Adult family members (e.g. parents, caregivers, guardians, and extended family members) accompanying children at the events were invited to participate in the research. Before participating, potential respondents were asked to confirm they were at least 18 years of age and review and sign an informed consent form outlining the study's purpose, voluntary participation, confidentiality, and right to withdraw. Convenience sampling at the events was conducted using a paper questionnaire that participants could complete quickly and anonymously with minimal interruption to the family's participation in the event. In addition, a "one adult per family" sampling strategy was employed which also ensured data independence and avoided intra-family bias. Since the final attendance was unknown prior to the events, the required sample size was determined post hoc.

The quantitative survey was designed to examine variables that were aligned with the research questions, the mission of the outreach initiative, the literature relating to parental involvement in STEM education, and the interests of the school board partners. The design aligned with the informal, time-limited nature of the STEM outreach events so respondents could participate quickly and efficiently, reducing participant burden, and increasing response rates. The survey used 5-point Likert agreement scale questions, posed to gather data on parents' beliefs about STEM learning. These questions addressed the constructs of parental STEM familiarity, envisioning their children's STEM futures, and perceived parental impact. To collect information on patterns of family participation in STEM activities, a count-based multiple response approach was used to determine the total types of activities and a Likert frequency scale to determine their frequency. For Site A, Likert agreement scale questions were asked about STEM outreach, focusing on how parents perceived its impact on STEM engagement for children and for parents. These final items were not included on the Site B survey, as the constructs were not a focus of the partnering school board in the second phase of data collection. These minor revisions to the survey instrument further support the study's non-comparative descriptive research design.

Analyses were conducted separately for each site as the purpose was not to compare sites directly or generalize across them, but to examine how parental perceptions and engagement functioned within distinct contexts. Sites A and B were not expected to yield equivalent analytic depth. Instead, each site contributed distinct evidence toward understanding how parental STEM perceptions operate within a specific community context.

Data Analysis

At Site A (2023), 34 surveys were collected from an estimated population of 50 family units (i.e., one survey per family) yielding a 68% response rate. At Site B (2024), 41 surveys were collected from an estimated population of 70 family units. With margins of error of approximately ±10% at a 95% confidence level (adjusted for small population sizes) the response rates were sufficiently high to support statistical representation of event attendees.

Survey results were converted to numeric values, tabulated, and uploaded to JASP statistical software version 0.18.3 for statistical analysis. Descriptive analysis was conducted to provide an overview of participant responses. In keeping with analysis suitable for ordinal data, the median and interquartile range (IQR) were calculated. The median gives an indication of the central tendency of the data and represents the middle of an ordered dataset (i.e., typical responses). The IQR represents the variability of the middle 50% of the dataset from the 25th to the 75th percentile. (i.e., degree of consensus among respondents) with smaller ranges indicating greater agreement among participants.

Inferential correlational analysis was used to examine whether observed associations among variables were statistically meaningful and consistent with theoretical expectations, without implying causal relationships. Spearman's rank-order correlation was selected because it is well suited to ordinal survey data, robust to non-normal distributions, unaffected by differences in scale range, and provides stable estimates of association in modest sample sizes (Norman, 2010). Correlation matrices were visualized using a Spearman's rho (ρ) heatmap to support the identification of patterns and clusters across variables. The findings should be interpreted as indicative of relational patterns among variables rather than evidence of direct effects as relationships between the variables does not indicate cause and effect.

Results and Discussion

The results and discussion presented in an integrated format to facilitate a more coherent interpretation of the findings. For each site, the results of the descriptive and inferential statistical analyses are outlined, followed by discussion centred on themes related to the two research questions: parental envisioning of children's STEM futures and family-based STEM participation.

Site A Results

Table 1 provides a summary of the descriptive statistical analyses conducted for the Site A data (n = 34). Parents consistently reported positive and relatively uniform perceptions of envisioning STEM for their children's future (Mdn = 4.5, IQR = 4–5), their own parental impact (Mdn = 4.0, IQR = 3–4) and familiarity with STEM (Mdn = 4.0, IQR = 3–4). Parent responses indicated that families were engaging in several different types of STEM-related activities outside of school (Mdn = 5.0, IQR = 4–8) with varying frequency (Mdn = 3.0, IQR = 2–4). These two variables had a wider range of responses compared to the others. There was relatively consistent reporting of very positive perceptions of the impact of STEM outreach on children's engagement (Mdn = 5.0, IQR = 4–5) with slightly lower results in terms of its impact on parental engagement (Mdn = 4.5, IQR = 4–5).

Table 1

Descriptive Statistics for Parental STEM Variables (Site A)

Variable	n	Mdn	IQR
1. Parental STEM familiarity	34	3.0	2–4
2. Envisioning child's STEM future	34	4.5	4–5
3. Perceived parental impact	34	4.0	3–4
4. Total types of family STEM activities	34	5.0	4–8
5. Frequency of family STEM activities	32	3.0	2–4
6. Outreach impact on child engagement	34	5.0	4–5
7. Outreach impact on parent engagement	34	4.5	4–5

Note: Collected data for variables 1, 2, 3, 6, and 7 represents responses to statements measured using 5-point Likert-type agreement scales, variable 4 is a count-based measure of selected options (range =1–11), and variable 5 used a 5-point frequency Likert scale.

Figure 2 presents Spearman's rank-order correlations (ρ) parental STEM variables for data collected at Site A. Positive correlations suggest constructs co-occur while negative correlations reveal inverse relationships. Correlation strength was interpreted using conventional thresholds (Evans, 1996), with values of $\rho \leq 0.19$ considered very weak, $\rho = .20–.39$ weak, $\rho =.40–.59$ moderate, $\rho = .60–.79$ strong and $\rho \geq .80$ very strong. In Figure 2, darker shaded cells indicate stronger relationships between variables and lighter/unshaded cells indicate weaker relationships.

Figure 2

Spearman's Rank-Order Correlations Among Variables (Site A)

Variable	1	2	3	4	5	7	7
1. Parental STEM familiarity	—						
2. Envisioning child's STEM future	.56***	—					
3. Perceived parental impact	.31	.48**	—				
4. Total types of family STEM activities	.15	.28	.37*	—			
5. Frequency of family STEM activities	.30	.45**	.49**	.33	—		
6. Outreach impact on child engagement	.26	.37*	.05	.03	.26	—	
7. Outreach impact on parent engagement	.38*	.48**	.26	.21	.56***	.36*	—

Note: Values represent Spearman's rho (ρ). $p < .05$*, $p < .01$**, $p < .001$***. Exact *p* values are reported in the text. Values of ρ ≤ .19 are unshaded, .20–.39 the lightest grey, and .40–.59 medium grey.

Site A: Parental Envisioning of Children's STEM Futures

At Site A, parents' perceptions of STEM careers as viable future options for their children had a moderate positive correlation association with multiple family-level factors. Among these, parental STEM familiarity demonstrated the strongest association with envisioning children's STEM futures (ρ = .56, $p < .001$), followed by perceived parental impact (ρ = .48, $p = .004$), outreach impact on parent engagement (ρ = .48, $p = .004$), and frequency of family STEM activities (ρ = .45, $p = .009$). Notably, there was no statistically significant correlation between the parents' envisioning of their child's STEM future and the total types of family STEM activities (ρ = .28, $p = .412$).

Parental expectations have been established as key drivers of students' motivation, achievement, and STEM career aspirations (Taskinen et al., 2016). The present findings indicate a range of internal and external variables may influence parents envisioning of their child's future in STEM. Parental STEM familiarity functions as an enabling factor through which parents support their children's potential engagement in STEM pathways. Although the survey did not probe the sources of familiarity (e.g., education, employment, or personal interest), prior research suggests that parents' encouragement, attitudes, and everyday STEM engagement rather than possessing formal STEM credentials alone play a central role in shaping children's STEM interest, self-efficacy, and identity development (Gu et al., 2025; Thomas et al., 2020). In this way, familiarity operates not simply as background knowledge, but as a mechanism through which future-oriented STEM expectations are socially constructed. Evidence further indicates that increasing parents' awareness of STEM's relevance for future opportunities is associated with improved student preparation and later pursuit of STEM careers (Rozek et al., 2017). This compels deeper examination as to what entails parental STEM familiarity and, in turn, how this translates into STEM-specific support.

Perceived parental STEM impact is closely associated with parental STEM self-efficacy such that beliefs about one's efficacy shape goal setting, persistence, and supportive behaviors (Bandura, 1995). In this study, perceived parental impact was moderately associated with envisioning children's STEM futures, indicating that parents who view themselves as influential contributors to learning are more likely to imagine STEM as an attainable future pathway. Parents' confidence in their ability to support STEM learning has been shown to influence both indirect mechanisms such as expectations and encouragement as well as more direct active engagement (Dotterer et al., 2022; Šimunović & Babarović, 2020; Nye et al., 2006; Salvatierra & Cabello, 2022; Thomas et al., 2020). Consistent with conceptions of self-efficacy, these types of parental beliefs can be significant predictors of children's future academic pathways (Eccles and Harold, 1993) in STEM.

Family participation in specific activity types (e.g., STEM games, experiments, books) demonstrated weak and non-significant associations with all other variables, reinforcing research showing that no single activity predicts impact across contexts (DeWitt & Archer, 2015). However, the frequency of family STEM activities was positively associated with parents' envisioning of STEM futures though less strongly than familiarity and perceived impact. This pattern aligns with research linking frequent family-based STEM engagement to children's motivation and interest in STEM-related careers (Archer et al., 2015; National Academies of Sciences, Engineering, and Medicine, 2018; Dou & Cian, 2022; Ennes et al., 2023; Gu et al., 2025; Wang & Degol, 2013). However, prior scholarship also indicates that parents' beliefs, expectations, and familiarity often exert stronger influences on aspirations than activity frequency alone (Dorrance Hall et al., 2025; Rozek et al., 2017; Gu et al., 2025). Importantly, the present findings reinforce the notion that the overall patterns of engagement, rather than participation in specific types of STEM activities, were more strongly associated with parents' perceptions of STEM futures.

Together, these findings suggest that while multiple family-level factors contribute to parents' envisioning of their children's STEM futures, beliefs and familiarity play a more influential role than participation alone. Parents' STEM familiarity and perceived impact operate as forms of STEM capital that shape expectations for children's futures. Supporting the development of this type of capital will be key to strengthening STEM pathways.

Site A: Family-based STEM Participation

At Site A, the frequency of out-of-school STEM activities was moderately associated with perceived parental impact ($\rho = .49$, $p = .004$), suggesting that parents who view themselves as influential contributors to learning are more likely to facilitate regular STEM engagement in family contexts. In contrast, the total types of family STEM activities (e.g., STEM crafts, experiments, games) demonstrated weak or non-significant associations with other outcome measures, indicating that overall engagement patterns were more consequential than the nature of any single activity.

Parental participation in family-focused STEM outreach was also meaningfully associated with envisioning children's STEM futures, highlighting the potential role of STEM outreach initiatives in strengthening parental STEM agency. This is consistent with the proposed PASC framework (Figure 1) whereby outreach programs that position parents as capable partners in learning can support increases in familiarity and reinforce parents' perceptions that their actions matter. In a study of parent and child interactions during a STEM activity, co-participation of parents and their children impacts how children engage with and make sense of STEM in everyday contexts (Sobel, 2023). Parent-child interactions during STEM play can also influence children's later engagement and performance, with overly directive support reducing engagement (Gin et al., 2025). From an equity perspective, STEM outreach initiatives may help mitigate structural barriers to informal enrichment, particularly in communities historically excluded from STEM opportunities (Archer et al., 2012).

Although parental STEM familiarity was only weakly associated with perceived outreach effectiveness for increasing parent engagement ($\rho = .38$, $p = .028$), this modest relationship suggests that outreach programs should remain accessible to families across varying levels of prior familiarity. At the same time, stronger associations between frequency of out-of-school STEM activities and perceived outreach effectiveness for children ($\rho = .56$, $p < .001$) indicate that families with existing engagement may be particularly well positioned to build on outreach experiences. Consistent with research on informal family-based STEM learning, sustained engagement across settings supports deeper interest development (Dou et al., 2019). Sobel, 2023; Morris et al., 2019;

From a parental STEM self-efficacy perspective, these patterns highlight the importance of designing outreach experiences that support mastery, modeling, encouragement, and reduced anxiety for parents. Research shows that when parents experience small successes and observe peers engaging effectively in STEM, their confidence and frequency of involvement increase (Simpkins et al., 2015; Archer et al., 2012). However, without intentional scaffolding, outreach programs risk disproportionately benefiting families who already possess higher levels of STEM capital, potentially reproducing existing participation gaps (Archer et al., 2012). Collectively, the Site A findings emphasize that strengthening parental STEM agency is a critical pathway through which family-based STEM engagement and outreach can support more equitable participation in informal STEM learning.

Applied to the Site A data, the study's PASC framework (Figure 1) helps make sense of how beliefs, resources, and actions operate together rather than independently. As shown in the correlations, parental STEM self-efficacy (i.e., perceived parental impact) and STEM capital (i.e., parental familiarity and activity engagement) are both associated with parents' envisioning of their children's STEM futures. Parents who feel capable and have access to STEM-related knowledge and experiences are more likely to act in ways that support engagement, which in turn shapes their expectations for their children's futures. The moderate association between perceived parental impact and frequency of activities further supports this mechanism, suggesting that parental STEM agency translates beliefs into action. Overall, the proposed PASC framework (Figure 1) provides a coherent way to interpret the findings as a dynamic system in which parental STEM agency and STEM capital jointly enable STEM parental self-efficacy, which then influences both engagement practices and future-oriented perceptions.

Site B Results

Rather than testing site differences, the dual-site design of this study allowed for examination of how parental perceptions and forms of STEM capital function within varied community settings. As shown in Table 2, descriptive analyses at Site B (n = 41) indicated generally positive parental perceptions of STEM, with median responses clustering at the upper end of the scale for envisioning children's STEM futures (Mdn = 5.0, IQR = 4-5) and perceived parental impact on STEM learning (Mdn = 4.0, IQR = 4-5). Parental STEM familiarity demonstrated more moderate central tendency with a narrower interquartile range (Mdn = 3.0, IQR = 3-4), suggesting less variability in familiarity levels compared to other perceptual measures. Respondents reported engagement in multiple types of STEM activities (Mdn = 4.0, IQR = 3-6), indicating variation in the breadth of informal STEM experiences. Frequency of out-of-school STEM activities also showed relatively high and consistent participation (Mdn = 4.0, IQR = 3-4).

Table 2

Descriptive Statistics for Parental STEM Variables (Site B)

Variable	n	Mdn	IQR
1. Parental STEM familiarity	41	3.0	3-4
2. Envisioning child's STEM future	40	5.0	4-5
3. Perceived parental impact	41	4.0	4-5
4. Total types of family STEM activities	41	4.0	3-6
5. Frequency of family STEM activities	41	4.0	3-4

Note. Collected data for variables 1, 2, and 3 represents responses to statements measured using 5-point Likert-type scales (strongly disagree, disagree, neither agree nor disagree, agree, or strongly agree). Variable 4 is a count-based measure of selected options (range =1–11). Variable 5 used a frequency Likert scale (rarely or never, yearly, monthly, weekly, or daily).

Figure 3 presents Spearman's rank-order correlations (ρ) parental STEM variables for data collected at Site B. As was the case for Site A, Site B patterns support the use of nonparametric correlational analyses and provide important context for interpreting relational findings. In Figure 2, darker shaded cells indicate stronger relationships between variables and lighter/unshaded cells indicate weaker relationships.

Figure 3

Spearman's Rank-Order Correlations Among Parental STEM Variables (Site B)

Variable	1	2	3	4	5
1. Parental STEM familiarity	—				
2. Envisioning child's STEM future	.38*	—			
3. Perceived parental impact	.25	.65***	—		
4. Total types of family STEM activities	.56***	.13	.16	—	
5. Frequency of family STEM activities	.26	.32*	.31*	.36*	—

Note. Values represent Spearman's rho (ρ). p < .05, p < .01**, p < .001***. Exact p values are reported in the text.* Values of ρ ≤ .19 are unshaded, ρ = .20–.39 shaded the lightest grey, .40–.59 medium grey, ≥ .60 the darkest grey.

Site B: Parental Envisioning of Children's STEM Futures

Site B analyses further illuminate how parental perceptions and informal STEM engagement influence their children's STEM experiences. Correlational analyses indicate that perceived parental impact had a strong positive association with parents' envisioning of their children's STEM futures ($\rho = .65$, $p < .001$). The frequency of family STEM activities ($\rho = .32$, $p < .05$). and parental STEM familiarity ($\rho = .38$, $p < .05$). were also positively correlated but the association was considerably weaker. There was no statistically significant correlation between the total types of family STEM activities and the parents' envisioning of their child's STEM future ($\rho = .13$, $p = .398$).

This pattern indicates that parents at Site B maintain strong and consistent expectations for their children's STEM futures, even in the context of lower reported familiarity and variable engagement practices. This suggests that perceptions of parental impact (i.e., parental STEM self-efficacy) can partially compensate for the absence of formal STEM backgrounds and access to out-of-school STEM learning experiences. This is consistent with findings from Hsieh and Simpkins (2022) who found that parental STEM support was most strongly associated with adolescents' motivation in families where the parents do not have STEM credentials. The tight clustering of future envisioning and perceived parental impact underscores a shared belief in both the value of STEM and the parental role in shaping it. Importantly, the divergence between parental impact and more variable engagement suggests that future-oriented STEM expectations are driven less by the consistency or breadth of activities and more by parents' beliefs about their capacity to influence their children's trajectories.

Site B: Family-based STEM Participation

As noted, the correlational analyses revealed that the perceived parental impact emerged as the strongest correlate of envisioning children's STEM futures. This finding underscores the central role of parental STEM agency in shaping how expectations translate into children's imagined futures, consistent with parental involvement and socialization research emphasizing the influence of parents' beliefs on children's educational trajectories (Eccles & Harold, 1993; Marotto, & Milner-Bolotin, 2018).

Parental STEM familiarity was moderately associated with participation in a broader range of informal STEM activities ($\rho = .56$, $p < .001$), suggesting that familiarity may function as an enabling resource that expands access to diverse experiences. However, familiarity was less directly associated with future-oriented perceptions, indicating that access alone may be insufficient to shape envisioned STEM pathways without accompanying beliefs about parental influence. This pattern aligns with self-efficacy models that link motivational processes to future aspirations (Bandura, 1995; Eccles & Wigfield, 2002; Lent et al., 1994).

From a STEM capital perspective, these findings suggest that while parental familiarity represents one dimension of the resources families transmit to their children through everyday practices, parental STEM agency and sustained engagement play a more central role in shaping how STEM futures are imagined (Archer et al., 2012; Dorrance-Hall et al., 2025; Hasenhütl et al., 2025; Stefani, 2024). Consistent with research emphasizing the cumulative effects of informal STEM engagement, repeated participation may reinforce both parental confidence and children's exposure, supporting the development of future-oriented STEM expectations (Maltese & Tai, 2011; Tillinghast et al., 2017). These Site B findings underscore the importance of family-based STEM initiatives that strengthen parental confidence and support meaningful, sustained engagement rather than short term exposure. This illuminates the need for more accessible and ongoing forms of family-focused STEM engagement. For example, the data collection for this research was conducted at an in-community, family-focused STEM outreach events in a diverse urban school community, a model that merits further examination.

These findings provide more precise insight into how the study's PASC framework (Figure 1) operates in practice. Consistent with the notions of parental STEM agency and efficacy, perceived parental impact emerged as the strongest predictor of envisioning children's STEM futures. This suggests that parents' beliefs about their influence play a central role in shaping future-oriented expectations. In contrast, parental STEM familiarity was most strongly associated with the breadth of engagement ($\rho = .56$), indicating that familiarity functions as an enabling resource that expands access to diverse STEM experiences rather than directly shaping aspirations. Frequency and breadth of engagement showed weaker associations with future envisioning, suggesting that participation alone is insufficient to influence how STEM futures are imagined without accompanying beliefs about parental influence. While familiarity contributes to experiential access, parental STEM agency appears to be the mechanism through which these experiences are interpreted and translated into future expectations.

Synthesis of Cross-site Themes

The study deliberately accounts for variations in context, viewing findings as shaped by these distinct settings. Consequently, analyses were conducted separately for each site. The objective was not to directly compare sites or generalize across them, but to explore how parental perceptions and engagement operated within specific contexts. While the findings have been presented by site, several patterns emerged consistently across both Site A and Site B. These patterns offer a more integrated understanding of how parents envision their children's STEM futures and engage in STEM-related activities within the family. An inductive, interpretive approach was used to identify these cross-site themes.

Across both sites, relationships between variables were positive, suggesting they tend to rise together, although the strength of each relationship ranged from very weak to strong and not all were statistically significant. For example, at Sites A and B, perceived parental impact showed moderate to strong associations with envisioning their child's STEM future ($\rho = .48$, $p = .004$ and $\rho = .65$, $p < .001$, respectively). However, at Site A, perceived parental impact was also moderately associated with the reported frequency of family STEM activities ($\rho = .49$, $p = .004$) whereas this was not a substantial nor statistically significant association at Site B ($\rho = .31$, $p = .048$). At Site B, parental STEM familiarity demonstrated a moderately strong association with the total types of family-based STEM activities ($\rho = .56$, $p < .001$) although this was not the case at Site A ($\rho = .15$, $p = .412$).

These findings suggest that parents who perceive themselves as having a stronger influence on their child's STEM development tend to be more confident or optimistic about their child's STEM future. Although this sense of parental STEM self-efficacy is positively associated with more frequent family participation in STEM activities, the relationship is not consistent across contexts. Similarly, parents with greater STEM familiarity report engaging in a wider range of STEM activities with their children, but this pattern also varies by context. Together, these findings point to uneven access to resources that may limit families' capacity to participate in STEM activities. These cross-site differences may reflect broader sociocultural, economic, and structural factors influencing family STEM engagement.

Despite documented benefits of family-based STEM learning, barriers such as cost, transportation, childcare needs, and work schedules disproportionately affect families from marginalized or low-income communities (Ju et al., 2020). Informational barriers such as uncertainty about what constitutes STEM or how to support learning at home can also constrain participation (Ju et al., 2020; Zucker et al., 2022). Parents from immigrant or non-dominant language communities frequently report linguistic and cultural disconnects with program materials or facilitators, further limiting access (Cuevas et al., 2020). These constraints may account for differing family STEM participation patterns across contexts, even when aspirations for children's STEM futures remain high. Even more broadly, this inaccessibility may inhibit parental STEM agency and limit their capacity to actively influence their children's STEM experiences.

Intentional STEM outreach can help reduce these potential barriers. Gu et al. (2025) asserts that STEM outreach programs foster family-based STEM capital by improving access to resources and experiences and by reinforcing parents' STEM-related beliefs and attitudes. Strategies to overcoming systemic to accessing STEM outreach programs include the provision of low/no-cost events, hosting at in-community locations, and offering flexible schedules (Ju et al., 2020). Frameworks must emphasize participatory design and sustained engagement, where families inform programming rather than serving as passive recipients of short-term initiatives (Appel et al., 2020; Zucker et al., 2022). Programs that also provide recurring touchpoints such as newsletters, take-home kits, or digital communities are more effective in embedding STEM learning within family routines (Tillinghast et al., 2017).

This aligns with parental science and STEM capital frameworks emphasizing how family-level resources and dispositions are central in shaping children's long-term trajectories (Archer et al., 2012; Dorrance-Hall, et al., 2025; Galaviz, 2020; Gu et al., 2025, Rozek et al., 2017). While knowledge, experiences, and social resources are understood to collectively contribute to parental STEM capital (Archer et al., 2015; Archer & DeWitt, 2016; Hasenhütl et al., 2025), its development occurs through complex, interconnected, and context-dependent factors. This aligns with Kontkanen et al. (2025), who argue that in real-life contexts, the core drivers of STEM capital operate simultaneously, making it difficult to clearly identify causes and effects.

Limitations

This study should be interpreted within certain limitations. Considerations of school board approval procedures, reflecting appropriate safeguards for research involving vulnerable populations and institutional contexts, restricted the inclusion of additional school communities in the study and the scope of the data collected. This had implications for the range of perspectives captured. Furthermore, event-based convenience sampling may over-represent families already engaging with STEM learning as only parents who elected to come to the STEM outreach events were able to participate in the study. Although response rates were relatively high at both study sites (68% at Site A; 60% at Site B), modest sample sizes limit statistical power. Finally, data collection relied on self-reported survey data, which may be subject to social desirability bias where certain responses are inflated and others are under-reported.

The survey was intentionally designed to be brief to minimize interruption to families participating in the events. For this reason, it did not include built-in redundancy across items, resulting in relatively coarse measures of the variables under study. This limited the precision of the findings. Future research should focus on strengthening the survey instrument through a systematic development process. This includes grounding items in existing validated scales that assess parental beliefs about STEM (see Ayoub et al., 2025; Ennes et al., 2023; Mihelich et al., 2017; Snyder et al. 2024), incorporating expert feedback, and conducting pilot testing to refine question clarity and structure.

Conclusion

This study was designed to learn about how parents perceive their influence on their children's STEM experiences. Data was collected from two study sites on variables relating to parental STEM beliefs and family STEM engagement patterns. Descriptive and analytical statistical analyses were conducted to determine relationships between variables. The findings demonstrate alignment between parent beliefs about STEM and their perceptions of their children's future STEM trajectories. In addition, family-based STEM participation is revealed to be closely tied to how parents perceive the support they provide for their children's STEM engagement.

This study contributes to understandings of family involvement in STEM by examining how parents perceive their influence on their children's future STEM trajectories. Parents who viewed themselves as having a stronger influence on their children's STEM learning were also more likely to envision STEM as part of their children's future pathways. In addition, the study sheds light on how parental STEM beliefs are related to patterns of family-based STEM participation and how these can vary across contexts. More frequent engagement was associated with stronger perceived parental impact in one setting, whereas broader engagement in a wider range of STEM activities was associated with higher parental STEM familiarity in the other.

The findings offer support for the proposed PASC framework (Figure 1) as a useful lens for interpreting relationships between STEM parental beliefs, family participation, and future outcomes for their children. Grounded in Bandura's (2001) social cognitive theory, this interpretation regards parental STEM agency, defined as parents' capacity to actively shape their children's STEM experiences, as a pivotal factor. The results suggest that parental STEM agency enacts future-oriented perceptions and family participation practices. At the same time, the study's dual-site design highlights that these processes are not uniform. Differences across contexts suggest that the activation of STEM capital through parental agency is likely contingent on local conditions, including access to resources and structural constraints. These variations point to the value of treating the PASC framework not as a fixed explanatory model, but as a flexible conceptual guide that can accommodate context-sensitive pathways.

While barriers such as socioeconomic constraints, linguistic disconnects, and logistical challenges continue to create uneven access to family-based STEM participation, intentional community-based outreach provides a powerful mechanism for increased equity. From a practical perspective, the findings reinforce the importance of family-centered STEM outreach that strengthens parents' confidence and STEM agency. Programs that are accessible, sustained, and designed to actively engage parents and their children may support the accessibility of STEM capital and the development of parental self-efficacy, thereby shaping how families support children's STEM engagement over time. At the same time, persistent inequities in access to informal STEM opportunities underscore the need for outreach efforts that intentionally address these constraints and broaden participation.

It is important to interpret these contributions with appropriate caution considering the limitations of the study in terms of the sampling and measurement. As such, the findings should be viewed as indicative rather than definitive.

In this context, the PASC framework must be regarded as a preliminary model that requires further empirical testing and refinement across diverse populations and settings.

Future research offers important opportunities to extend this work. Longitudinal and mixed-methods designs could examine how parental STEM agency, self-efficacy, and capital evolve over time and interact with children's developing STEM identities. Research with larger sample sizes that focuses on families with lower initial access to STEM resources would be particularly valuable for testing the PASC framework's applicability in equity-focused contexts. Additionally, studies should explore how targeted outreach initiatives can strengthen parental STEM agency. Finally, refining measurement tools that directly measure parental STEM self-efficacy and further validating key constructs will be essential for enhancing the explanatory power of the framework.

Overall, this study underscores the central role of families in shaping children's STEM pathways. By positioning parents not only as participants but as agents whose beliefs, experiences, and resources shape engagement and aspiration, the findings point toward more holistic and equitable approaches to STEM education. Within this context, the PASC framework offers a promising approach for understanding how these elements interact to influence children's STEM futures.

References

Alexandre, S., Xu, Y., Washington-Nortey, M., & Chen, C. (2022). Informal STEM learning for young children: A systematic literature review. *International Journal of Environmental Research and Public Health, 19*(14), 8299. https://doi.org/10.3390/ijerph19148299

Appel, D., Tillinghast, R., Winsor, R. & Mansouri, M. (2020). *STEM outreach: A stakeholder analysis.* 2020 IEEE Integrated STEM Education Conference (ISEC), Princeton, NJ, USA, 2020, pp. 1–9.

https://doi.org/10.1109/ISEC49744.2020.9280723

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Wong, B., & Willis, B. (2015). Science capital: A conceptual, methodological, and empirical extension. *Journal of Research in Science Teaching, 52*(7), 922–948. https://doi.org/10.1002/tea.21227

Archer, L., & DeWitt, J. (2016). *Understanding young people's science aspirations.* Routledge.

Archer, L., DeWitt, J., & Willis, B. (2014). Adolescent boys' science aspirations: Masculinity, capital, and power. *Journal of Research in Science Teaching, 51*(1), 1–30. https://doi.org/10.1002/TEA.21122

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*(5), 881–908. https://doi.org/10.3102/0002831211433290

Ardelt, M., & Eccles, J. S. (2001). Effects of mothers' parental efficacy beliefs and promotive parenting strategies on inner-city youth. *Journal of Family Issues, 22*(8), 944–972. https://doi.org/10.1177/019251301022008001

Ayoub, A. E. A., Ghablan, M. R., Abo Hamza, E. G. and Abdulla Alabbasi, A. M. (2025). Parental attitudes towards STEM scale: development and psychometric properties. *European Journal of STEM Education, 10*(1), 01. https://doi.org/10.20897/ejsteme/16064

Bandura, A. (1995). Exercise of personal and collective efficacy in changing societies. In A. Bandura (Ed.), *Self-efficacy in changing societies* (pp. 1–45). Cambridge University Press.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52*, 1–26. https://doi.org/10.1146/annurev.psych.52.1.1

Barzanji, T. (2013). *Growing the STEM: Encouraging interest in STEM subjects among low socio-economic Australian secondary students.* Harvard Kennedy School Mossavar-Rahmani Center for Business and Government.

https://www.hks.harvard.edu/sites/default/files/centers/mrcbg/files/Barzanji_final(3).pdf

Betancur, L., Votruba-Drzal, E. & Schunn, C. (2018). Socioeconomic gaps in science achievement. *International Journal of STEM Education, 5* (38), 1–25. https://doi.org/10.1186/s40594-018-0132-5

Bourdieu, P. (1986). The forms of capital. In J. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241–258). Greenwood Press.

Breakwell, G. M., & Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science*, *1*(2), 183–197. https://doi.org/10.1088/0963-6625/1/2/003

Castro, M., Expósito-Casas, E., López-Martín, E., Lizasoain, L., Navarro-Asencio, E., & Gaviria, J. L. (2015). Parental involvement on student academic achievement: A meta-analysis. *Educational Research Review, 14*, 33–46. https://doi.org/10.1016/j.edurev.2015.01.002

Creswell, J. W., & Creswell, J. D. (2023*). Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). SAGE.

Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological science*, *12*(3), 258–261. https://doi.org/10.1111/1467-9280.00347

Cuevas, J. A., Medina, J., & Trujillo, K. (2020). Exploring the impact of a Spanish language STEM outreach program on participants, families, and mentors. *Journal of STEM Outreach*, 3(2), 1–10. https://doi.org/10.15695/jstem/v6i2.06

Curran, F. C. (2017). Income-based disparities in early elementary school science achievement. *Elementary School Journal, 118*(2), 207–231. https://doi.org/10.1086/694218

DeWitt, J., & Archer, L. (2015). Who aspires to a science career? A comparison of survey responses from primary and secondary school students. *International Journal of Science Education, 37*(13), 2170–2192. https://doi.org/10.1080/09500693.2015.1071899

Dorrance-Hall, E., Zhang, Y., Edwards, A. L., Wolfe, B. H., Watson, O., Morales, N., & Valdes, P. (2025). STEM career interest development and persistence: what parents do, say, and should say. *Annals of the International Communication Association*, *49*(4), 323–335. https://doi.org/10.1093/anncom/wlaf018

Dotterer, A. M., McHale, S. M., & Crouter, A. C. (2022). Parent involvement, expectancy values, and STEM outcomes among underrepresented adolescents. *Developmental Psychology, 56*(8), 1528–1540.

https://doi.org/10.1007/s11218-021-09677-0

Dou, R., & Cian, H. (2022). Constructing STEM identity: An expanded structural model for STEM identity research. *Journal of Research in Science Teaching, 59*(3), 458–490. https://doi.org/10.1002/tea.21734

Dou R., Hazari Z., Dabney K., Sonnert G., & Sadler P. (2019). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education, 103*(3), 623–637. https://doi.org/10.1002/sce.21499

Duodu, E., Noble, J., Yusuf, Y., Garay, C., & Bean, C. (2017). Understanding the delivery of a Canadian-based after-school STEM program: a case study. *International Journal of STEM Education, 4*(1), 20. https://doi.org/10.1186/s40594-017-0083-2

Eccles, J. S., Midgley, C., Wigfield, A., Buchanan, C. M., Reuman, D., Flanagan, C., & Mac Iver, D. (1993). Development during adolescence: The impact of stage-environment fit on young adolescents' experiences in schools and in families. *American Psychologist, 48*(2), 90–101. https://doi.org/10.1037/0003-066X.48.2.90

Eccles, J. S., & Harold, R. D. (1993). Parent-school involvement during the early adolescent years. *Teachers College Record, 94*(3), 568–587. https://doi.org/10.1177/016146819309400311

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*(1), 109–132. https://doi.org/10.1146/annurev.psych.53.100901.135153.

Ennes, M.E., Jones, M.G., Childers, G.M., Cayton, E., & Chestnutt, K. (2023). Children and parents' perceptions of access to science tools at home and their role in science self-efficacy. *Research in Science Education, 53,* 671–687. https://doi.org/10.1007/s11165-022-10077-3

Erol, M., Demir, R., & Erol, A. (2025). The effect of family-involved STEM education on girls' engineering habits of mind. *Journal of Educational Research*, 1–17. https://doi.org/10.1080/00220671.2025.2496314

Fan, X., & Chen, M. (2001). Parental involvement and students' academic achievement: A meta-analysis. *Educational Psychology Review, 13*(1), 122. https://doi.org/10.1023/A:1009048817385

Fang, Y., Boelens, M., Windhorst, D. A., Raat, H., & van Grieken, A. (2021). Factors associated with parenting self-efficacy: A systematic review. *Journal of Advanced Nursing, 77*(6), 2641–2661. https://doi.org/10.1111/jan.14767

Froiland, J. M., Peterson, A., & Davison, M. L. (2013). The long-term effects of early parent involvement and parent expectation in the USA. *School Psychology International*, *34*(1), 33 50. https://doi.org/10.1177/0143034312454361

Galaviz, S. (2020). *Designing STEM experiences for the family in order to develop stem family habitus and capital.* Boise State University Theses and Dissertations. https://scholarworks.boisestate.edu/cgi/viewcontent.cgi?article=2817&context=td

Gin, S., Yin, H., Boykin, C. M., & Sobel, D. M. (2025). Examining baseline relations between parent-child interactions and STEM engagement and learning. *Developmental Science, 28*(2), e13611. https://doi.org/10.1111/desc.13611

Glatz, T., Lippold, M., Chung, G., & Jensen, T. (2024). A systematic review of parental self-efficacy among parents of school-age children and adolescents. *Adolescent Research Review 9,* 75–91. https://doi.org/10.1007/s40894-023-00216-w

Government of Ontario. (2025). *School Information Finder*. https://www.app.edu.gov.on.ca/eng/sift/index.asp

Grolnick, W. S., & Slowiaczek, M. L. (1994). Parents' involvement in children's schooling: A multidimensional conceptualization and motivational model. *Child Development, 65*(1), 237–252. https://doi.org/10.2307/1131378

Grossman, J. M., & Porche, M. V. (2014). Perceived gender and racial/ethnic barriers to STEM success. *Urban Education, 49*(6), 698–727. https://doi.org/10.1177/0042085913481364

Gu, B., Yu, D., & Liu, M. (2025). Family science capital factors affecting early childhood science learning: A systematic review. *Behavioral Sciences, 15*(9), 1152. https://doi.org/10.3390/bs15091152

Gülhan, F. (2023). Parental involvement in STEM education: A systematic literature review. *Education and Science, 46*(208), 33–56. https://doi.org/10.20897/ejsteme/13506

Halim, L., Abd Rahman, N., Zamri, R., & Mohtar, L. (2018). The roles of parents in cultivating children's interest towards science learning and careers. *Kasetsart Journal of Social Sciences*, *39*(2), 190–196. https://doi.org/10.1016/j.kjss.2017.05.001

Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping parents to motivate adolescents in mathematics and science: An experimental test of a utility-value intervention. *Psychological Science, 23*(8), 899–906. https://doi.org/10.1177/0956797611435530

Harris, Y. R., Inan, S., Woodbury, G., Modirrousta, A., & Lawal, A. (2022). Does parental self-efficacy predict math performance of black American school-age children? *Negro Educational Review, 73*, 99–

189. https://www.researchgate.net/publication/378286809_Does_Parental_Self-Efficacy_Predict_Math_Performance_of_Black_American_School-Age_Children

Hasenhütl, S., Luttenberger, S., & Paechter, M. (2025). Expanding STEM capital: rethinking equity and engagement in primary education. *Frontiers in Education, 10*, 1-5. https://doi.org/10.3389/feduc.2025.1659034

Hill, N. E., & Tyson, D. F. (2009). Parental involvement in middle school: A meta-analytic assessment of the strategies that promote achievement. *Developmental Psychology, 45*(3), 740–763. https://doi.org/10.1037/a0015362

Hsieh, T.-Y., & Simpkins, S. D. (2022). Longitudinal associations between parent degree/occupation, parent support, and adolescent motivational beliefs in STEM. *Journal of Adolescence, 94*(5), 728–747.

https://doi.org/10.1002/jad.12059

Hug, S., Arnett, S. M., & Way, S. M. (2025). From invisible to invaluable: The critical role of recognition in Latina STEM capital activation. *Journal of Women and Minorities in Science and Engineering, 31*(6), 47–71. https://doi.org/10.1615/jwomenminorscieneng.2025051451

Jeynes, W. H. (2005). A meta-analysis of the relation of parental involvement to urban elementary school student academic achievement. *Urban Education, 40*(3), 237–269. https://doi.org/10.1177/0042085905274540

Jones, T. L., & Prinz, R. J. (2005). Potential roles of parental self-efficacy in parent and child adjustment: A review. *Clinical Psychology Review, 25*(3), 341–363. https://doi.org/10.1016/j.cpr.2004.12.004

Ju, B., Nacu, D., Ravenscroft, O., Erete, S., Flores, E., & Pinkard, N. (2020). *Understanding parents' perceived barriers to engaging their children in out-of-school STEM programs*. IEEE Integrated STEM Education Conference Proceedings, 173–180. https://doi.org/10.1145/3328778.337266

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*(4), 275–282. https://doi.org/10.1080/00220671.2020.1806015

Kim, S. (2022). Fifty years of parental involvement and achievement research: A second-order meta-analysis. *Educational Research Review, 37*. https://doi.org/10.1016/j.edurev.2022.100463

Kontkanen, S., Koskela, T., Kanerva, O., Kärkkäinen, S., Waltzer, K., Mikkilä-Erdmann, M., & Havu-Nuutinen, S. (2025). Science capital as a lens for studying science aspirations – a systematic review. *Studies in Science Education*, *61*(1), 89–115. https://doi.org/10.1080/03057267.2024.2388931

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45*(1), 79–122. https://doi.org/10.1006/jvbe.1994.1027

Liu, Y., & Leighton, J. P. (2021). Parental Self-Efficacy in Helping Children Succeed in School Favors Math Achievement. *Frontiers in Education, 6*. https://doi.org/10.3389/feduc.2021.657722

Luo, T., Chen, Y., So, W. W. M., & Chiu, S. W. K. (2025). Exploring predictors of STEM aspirations from a STEM capital perspective. *Research in Science & Technological Education, 43*(2), 614–632. https://doi.org/10.1080/02635143.2024.2320113

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education, 95*(5), 877–907. https://doi.org/10.1002/sce.20441

Marotto, C. C. F., & Milner-Bolotin, M. (2018). Parental engagement in children's STEM education. Part II: Parental attitudes and motivation. *LUMAT: International Journal on Math, Science and Technology Education, 6*(1), 60–86. https://doi.org/10.31129/LUMAT.6.1.293

Mihelich, J. A., Sarathchandra, D., Hormel, L., Storrs, D. A., & Wiest, M. M. (2016). Public understanding of Science and K-12 STEM education outcomes: Effects of Idaho parents' orientation toward science on students' attitudes toward science. *Bulletin of Science, Technology & Society, 36*(3), 164–178. https://doi.org/10.1177/0270467616687217

Morris, B.J., Owens, W., Ellenbogen, K., Erduran, S, & Dunlosky, J. (2019). Measuring informal STEM learning supports across contexts and time. *International Journal of STEM Education, 6*(40). https://doi.org/10.1186/s40594-019-0195-y

Morales, M. F., del Río, M. F., & Espinoza, A. M. (2024). The influence of parent's expectations and children's early skills on children's future STEM career prospects. *Revista Latinoamericana de Psicología*, *56,* 189–198. https://doi.org/10.14349/rlp.2024.v56.19

National Academies of Sciences, Engineering, and Medicine. 2018. *English Learners in STEM Subjects: Transforming Classrooms, Schools, and Lives.* The National Academies Press. https://doi.org/10.17226/25182

Norman, G. (2010). Likert scales, levels of measurement and the "laws" of statistics. *Advances in Health Sciences Education, 15*(5), 625-632. https://doi.org/10.1007/s10459-010-9222-y

Nye, C., Turner, H. and Schwartz, J. (2006), Approaches to parent involvement for improving the academic performance of elementary school age children. *Campbell Systematic Reviews, 2,* 1–49. https://doi.org/10.4073/csr.2006.4

Outhwaite, L. A., Fischer, N. M., Jusek, A. S., & Van Herwegen, J. (2025). Understanding the role of parental self-efficacy for supporting children's early learning in the home mathematics environment. *Early Child Development and Care*, *195*, 793–805. https://doi.org/10.1080/03004430.2025.2474668

Pelletier, J. & Brent, J.M. (2002). Parent participation in children' school readiness: The effects of parental self-efficacy, cultural diversity and teacher strategies. *International Journal of Early Childhood, 34,* 45–60. https://doi.org/10.1007/BF03177322

Perera, L. D. H. (2014). Parents' Attitudes towards science and their children's science achievement. *International Journal of Science Education*, *36*(18), 3021–3041. https://doi.org/10.1080/09500693.2014.949900

Rendón, M. G., Hernandez, A., & Schaefer, D. R. (2025). Social reproduction at a minority serving institution: STEM capital disparities among children of immigrants. *Sociology of Education, 98*(4), 273–293. https://doi.org/10.1177/00380407251352785

Rozek, C.S., Svoboda, R.C., Harackiewicz, J.M., Hulleman, C.S. & Hyde, J.S. (2017). Utility-value intervention with parents increases students' STEM preparation and career pursuit. *Proceedings of the National Academy of Sciences, 114* (5), 909–914. https://doi.org/10.1073/pnas.1607386114

Salvatierra, L., & Cabello, V. M. (2022). Starting at home: what does the literature indicate about parental involvement in early childhood STEM education? *Education Sciences, 12*(3), 218. https://doi.org/10.3390/educsci12030218

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 and Caucasian boys and girls. *Journal of Research in Science Teaching, 52*(10), 1386–1407. https://doi.org/10.1002/tea.21246

Šimunović, M., & Babarović, T. (2020). The role of parents' beliefs in students' motivation, achievement, and choices in the STEM domain: A review and directions for future research. *Social Psychology of Education, 23*(3), 701–719. https://doi.org/10.1007/s11218-020-09549-5

Šimunović, M., Reić Ercegovac, I., & Burušić, J. (2018). How important is it to my parents? Transmission of STEM academic values: the role of parents' values and practices and children's perceptions of parental influences. *International Journal of Science Education, 40*(9), 977–995. https://doi.org/10.1080/09500693.2018.1460696

Sobel, D. M. (2023). Science, technology, engineering, and mathematics (STEM) engagement from parent-child interaction in informal learning environments. *Current Directions in Psychological Science, 32*(6), 454–461. https://doi.org/10.1177/09637214231190632

Snyder, A. L., Cingel, D. P., & Patterson Williams, A. (2024). U.S. parents' scientific literacy and efficacy: Associations with children's STEM media engagement. *Journal of Children and Media, 18*(4), 543–554. https://doi.org/10.1080/17482798.2024.2383618

Stefani, A. (2024). Parental and peer influence on STEM career persistence: From higher education to first job. *Advances in Life Course Research, 62,* 100642. https://doi.org/10.1016/j.alcr.2024.100642

Starr, C. R., Ramos Carranza, P., & Simpkins, S. D. (2022a). Stability and changes in high school students' STEM career expectations: Variability based on STEM support and parent education. *Journal of Adolescence, 94*(6), 906–919. https://doi.org/10.1002/jad.12067

Starr, C. R., Tulagan, N., Simpkins, S. D. (2022b). Black and Latinx adolescents' STEM motivational beliefs: A systematic review of the literature on parent STEM support. *Educational Psychology Review*, 34, 1877–1917. https://doi.org/10.1007/s10648-022-09700-6

Sujarwo, S., & Herwin, H. (2023). Parental involvement and student achievement: A meta-analysis of publications in the Scopus database. *International Journal of Instruction, 16*(2), 107–124. https://doi.org/10.29333/iji.2023.1627a

Suortti, E., Havu-Nuutinen, S., & Kärkkäinen, S. (2024). Finnish parents' science capital and its association with sociodemographic issues. *International Journal of Science Education, 14*(3), 257–276. https://doi.org/10.1080/21548455.2023.2263607

Svoboda, R., Rozek C., Hyde, J., Harackiewicz, J., & Destin, M. (2016). STEM course taking through identity-based and expectancy-value theories of motivation. *AREA Open, 2*(3), 1–13. https://doi.org/10.1177/2332858416664875

Taskinen, P. H., Dietrich, J., & Kracke, B. (2016). The role of parental values and child-specific expectations in the science motivation and achievement of adolescent girls and boys. *International Journal of Gender, Science and Technology, 8*(1), 103–123.

https://www.researchgate.net/publication/299579280_The_Role_of_Parental_Values_and_Child-specific_Expectations_in_the_Science_Motivation_and_Achievement_of_Adolescent_Girls_and_Boys?st_source=ai_mode

Tazouti, Y., & Jarlégan, A. (2019). The mediating effects of parental self-efficacy and parental involvement on the link between family socioeconomic status and children's academic achievement. *Journal of Family Studies, 25*(3), 250–266. https://doi.org/10.1080/13229400.2016.1241185

Thomas, J., Utley, J., Hong, S.-Y., Korkmaz, H., & Nugent, G. (2020). Parent involvement and its influence on children's STEM learning: A review of the research. In C. C. Johnson, M. J. Mohr-Schroeder, & T. J. Moore (Eds.), *Handbook of Research on STEM Education* (pp. 323–334). Routledge. https://doi.org/10.4324/9780429021381

Thomas, J. & Strunk, K. (2017). Expectancy-value and children's science achievement: Parents matter. *Journal of Research in Science Teaching, 54*(6), 693–712. https://doi.org/10.1002/tea.21382

Tillinghast, R.C., Petersen, E.A., Fischer, G.L., Sebastian, D., Sadowski, L., & Mansouri, M. (2017). Expanding STEM outreach through multi-generational reach: Establishing library-based STEM programs. *2017 IEEE Integrated STEM Education Conference (ISEC)*, 168–174. https://doi.org/10.1109/ISECon.2017.7910236

Tran, J., Lyon, K., McLeod, K., Jamison, A., Farrokh, S., Wolf, J., Swani, A., Cheung, K., Usprech, J., d'Entremont, A. (2024). Economic, cultural, and science capital: Familial factors shaping access to STEM outreach programs for children and youth. *Proceedings of the Canadian Engineering Education Association (CEEA)*. https://doi.org/10.24908/pceea.2024.18561

VanMeter-Adams, A., Frankenfeld, C. L., Bases, J., Espina, V., & Liotta, L. A. (2014). Students who demonstrate strong talent and interest in STEM are initially attracted to STEM through extracurricular experiences. *CBE Life Sciences Education, 13*(4), 687–697. https://doi.org/10.1187/cbe.13-11-0213

Wang, M.-T., and Degol, J. (2013). Motivational pathways to STEM career choices: using expectancy-value perspective to understand individual and gender differences in STEM fields. *Developmental Review, 33* (4), 304–340. https://doi.org/10.1016/j.dr.2013.08.001

Wilder, S. (2013). Effects of parental involvement on academic achievement: a meta-synthesis. *Educational Review, 66*(3), 377–397. https://doi.org/10.1080/00131911.2013.780009

Yin, X., Jia, S., Shao, Y., & Zhang, L. (2025). The impact of parental educational expectations on subjective well-being among adolescents: The serial mediating role of self-efficacy and learning engagement. *BMC Psychology*, *13*(1), 353. https://doi.org/10.1186/s40359-025-02669-1

Yosef & Karisma, N. (2021). Mothers' self-efficacy and its effect on adolescents' academic achievement. *Advances in Social Science, Education and Humanities Research, 54*, 64–69. https://doi.org/10.2991/assehr.k.210204.009

Zucker, T. A., Maldonado, G. Y., Assel, M., McCallum, C., Elias, C., Swint, J. M., & Lal, L. (2022). Informal science, technology, engineering and math learning conditions to increase parent involvement with young children experiencing poverty. *Frontiers in Psychology, 13,* 1015590.

https://doi.org/10.3389/fpsyg.2022.1015590

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,* 101320. https://doi.org/10.1016/j.appdev.2021.101320

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