

## Expectancy-value theory & preschool parental involvement in informal STEM learning



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### ABSTRACT

Using expectancy-value theory, we explored whether parents' perceived expectancies, value, and costs relate to parent involvement in science and math activities. We also explored whether informal learning varied based on child gender and parent's report of having a science, technology, engineering, and math (STEM)-related career. Specifically, we examined the mediating role of parents' STEM expectancies, value, and cost as well as whether parents held a STEM-related career on the outcome of parental involvement. Our sample consists of 208 parents of 3- to 5-year-olds from mostly middle class families of diverse races/ethnicities. Descriptively, 56% of these parents reported reading everyday with their child, but just 35% reported any daily STEM activities. Controlling for sociodemographic factors, results revealed that only a parent's rating of STEM value, not expectancies or cost, was directly related to parental involvement in science and math. But maternal report of a STEM-related career was indirectly related to parental involvement in STEM through parents' higher self-efficacy for facilitating informal STEM learning. No significant relations were found for child gender. We discuss implications for supporting parents' involvement in early STEM given these findings that parents who feel empowered to do science and math engage their preschooler in informal STEM learning more often.

From the earliest ages, children are surrounded by opportunities to learn about science, technology, engineering, and math (STEM) by exploring how things work and why things happen the way they do. Parents play a critical role in their children's observations, exploration, and investigation of the world around them. Parents have daily opportunities to provide materials and create conversations that help children learn about nature, counting, building, tools, and other STEM concepts. Providing such experiences at an early age is critical, because early STEM skills lay the foundation for later learning (e.g., [Duncan et al., 2007](#)). In fact, early investments in children's STEM education can have effects that compound over time ([Heckman, 2006](#); [Hulleman & Barron, 2016](#)). This study surveyed groups of U.S. parents who were seeking informal learning experiences and resources and, thus, may have been uniquely aware of their potential roles in supporting their preschooler's learning.

Although children can build STEM knowledge and skills during formal schooling, informal learning experiences with parents provide additional and more varied chances for children to develop their STEM knowledge and abilities ([Bell et al., 2009](#)). For example, informal

learning within play-based activities such as puzzles and blocks builds spatial skills that are valuable in later STEM learning ([Newcombe & Frick, 2010](#); [Verdine, Golinkoff, Hirsh-Pasek, & Newcombe, 2014](#)). But more information is needed on STEM-related perceptions of parents of young children for facilitating these types of STEM activities. The current study focuses on psychological factors of preschool parents that may support or hinder parental involvement in informal science and math learning. Specifically, using expectancy-value theory of motivation ([Wigfield & Eccles, 2000](#)), we examine potential positive supports as well as possible barriers parents may face in supporting science and math with young children.

### Parental involvement in informal learning

Family involvement in learning is broadly beneficial to young children's early education outcomes (e.g., [Ma, Shen, Krenn, Hu, & Yuan, 2016](#); cf. [Pomerantz, Moorman, & Litwack, 2007](#)). This study focuses on one dimension of family involvement - *parental involvement in learning* - that refers to parents engaging their children in various activities to

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promote intellectual development at home or during outside-of-school time (OST; [Fantuzzo, Tighe, & Childs, 2000](#)). This is synonymous with parents' home engagement in learning activities (i.e., self-reported behavioral frequency; [Barnett, Paschall, Mastergeorge, Cutshaw, & Warren, 2020](#)). Meta-analytic findings suggest that parental involvement in learning significantly influences children's academic achievement from preschool through high school with small to moderate effects ([Castro et al., 2015](#); [Jeynes, 2012](#); [Ma et al., 2016](#)). In a study of Head Start preschoolers, parental involvement in OST learning (e.g., reading at home, providing materials for learning at home) was found to have the strongest association with children's learning outcomes when compared to other parent behaviors such as volunteering at school or conferencing with the teacher ([Fantuzzo, McWayne, Perry, & Childs, 2004](#)). We are particularly interested in understanding parental involvement in STEM activities that range from math concepts (e.g., counting objects, comparing size of objects) to science and engineering knowledge and concepts (e.g., talking about weather/seasons, observing animals and plants, noticing patterns, using logic to play games, designing solutions to problems, tinkering with objects).

By the time children enter preschool there is tremendous variability in their math and science knowledge (e.g., [Bullock, Sodian, & Koerber, 2009](#); [McWayne, Cheung, Wright, & Hahs-Vaughn, 2012](#); [von Hippel, Workman, & Downey, 2018](#)) that influences their future rates of learning ([Dumas, McNeish, Sarama, & Clements, 2019](#)). Both the frequency and quality of parental involvement in math and science activities explains some of this variability (e.g., [Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010](#); [Ramani, Rowe, Eason, & Leech, 2015](#); [Skwarchuk, 2009](#)). The frequency of home learning activities (e.g., cognitive stimulation, shared book reading) within nationally representative samples of young U.S. children consistently predicts children's cognitive development (e.g., [Barnes & Puccioni, 2017](#); [Barnett et al., 2020](#); [Powell, Son, File, & Froiland, 2012](#)). Qualities of parent-child interactions influence learning and socialize the child to understand the family's cultural norms, interests and expectations ([Grusec & Davidov, 2010](#); [Le et al., 2008](#); [Ramani et al., 2015](#)). From early childhood through the elementary grades, parents' support for teaching math concepts and high expectations for academic achievement are key characteristics of effective parent-child math interventions ([Castro et al., 2015](#); [Klein, Starkey, Clements, Sarama, & Iyer, 2008](#); [Levine et al., 2010](#)).

Parents can "do science and math" within their everyday routines or play. For example, during math-related play, parents can talk about numeracy ([Gunderson & Levine, 2011](#); [Levine et al., 2010](#); [Napoli & Purpura, 2018](#)) and number operations ([Leyva, Tamis-LeMonda, Yoshikawa, Jimenez-Robbins, & Malachowski, 2017](#); [Skwarchuk, 2009](#)). When exploring science-related topics, parents may support children's cognition and engagement with descriptive talk, open-ended questions, and by encouraging inquiry (e.g., [Callanan, Castañeda, Luce, & Martin, 2017](#); [Haden, 2010](#); [Leichtman et al., 2017](#); [Tenenbaum, Snow, Roach, & Kurland, 2005](#)). Despite these types of opportunities to engage in math and science at home, parents tend to report more home literacy activities than STEM-related activities.

Some STEM researchers suggest parents in North America have internalized the message it is important to read daily to young children, but they perceive that doing science and math is not as important to focus on every day ([Skwarchuk, 2009](#); [Skwarchuk, Sowinski, & LeFevre, 2014](#)). Data from the Programme for International Student Assessment (PISA) and other international sources show there is tremendous variability around parental involvement in science versus literacy involvement (e.g., [Ho, 2010](#); [Manolitsis, Georgiou, & Tziraki, 2013](#)). Further, data from the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ELCS-K: 2011) suggest that parents of kindergarten children engage in literacy-related activities at higher frequencies than science-related activities. Specifically, 51% of parents of kindergarten children reported reading books to their child every day, while only 12% of parents reported talking about nature or doing science projects with

their child with the same frequency ([Barnett et al., 2020](#)). The current study sought to describe the relative frequency of parent involvement in OST literacy- and STEM-related learning within a sample of parents who have slightly younger preschool children and were actively seeking informal learning resources. That is, our sample was recruited from either parents visiting a local children's museum or parents who were registered for an online activity collection. Thus, we expected this parent sample to be uniquely motivated to support informal learning.

### Expectancy-value theory applied to parents' science & math perceptions

We investigated how parents' motivation relates to parental involvement in informal STEM learning ([Eccles, 2015](#)). Expectancy-value theory (EVT; [Wigfield & Eccles, 2000](#); [Wigfield & Gladstone, 2019](#)) offers a multidimensional approach to describe parent motivation to support OST learning. The first EVT dimension is *expectancy*, or the perceived likelihood of achieving a desired outcome. We examined two aspects of expectancy: (a) parents' expectancies for how well their child will do in math and science; and (b) parents' expectations of how well they can guide and facilitate their child's learning within STEM tasks. This second aspect is also referred to as *parental self-efficacy*, meaning the parent's perceived ability to positively support their child's learning and development ([Bandura, 1997](#); [Le et al., 2008](#)). The second EVT dimension is *value*, or the importance of the task to the individual. For example, some parents see value in reading with their preschooler but perceive less utility or enjoyment in doing science and math activities with their child ([Skwarchuk, 2009](#)). The final dimension of EVT is *cost* or the perceived efforts, loss of time for alternative activities, or negative emotional impacts that may hinder motivation ([Flake, Barron, Hulleman, McCoach, & Welsh, 2015](#)). For example, some parents may have had troublesome math experiences as students that produce continued math anxieties or other negative emotions ([Bekdemir, 2010](#)). The combination of parents' STEM expectancies for their child, parental self-efficacy, values, and costs is expected to influence the choice of whether to be involved in OST learning activities ([Šimunović & Babarović, 2020](#)).

The EVT framework has been extensively applied to elementary-through college-age students to explain their STEM interest and achievement (e.g., [Bergey, Parrila, & Deacon, 2018](#); [Eccles, 2007](#); [Gaspard et al., 2015](#); [Hulleman & Harackiewicz, 2009](#)). Young children's STEM interest is influenced by parent beliefs, as parents' perceptions are a means of socialization around how families do science and math ([Lee & Shute, 2010](#); [Wang & Degol, 2013](#)). For example, in nationally representative U.S. samples, parental expectations of young children predict kindergarten math achievement as well as children's later expectations of self in Grade 8 ([Froiland, Peterson, & Davison, 2013](#)). In fact, one study found that parents' STEM expectancies were a more powerful predictor of elementary science achievement than teachers' or children's own expectancies ([Thomas & Strunk, 2017](#)). Likewise, international data show that higher parental value of science (i.e., broad value of science to society, personal value of science, importance of science for jobs) predicts students' science achievement ([Perera, Bomhoff, & Lee, 2014](#); see also [Harackiewicz, Rozek, Hulleman & Hyde, 2012](#)). Finally, perceived costs can lead to avoidance or procrastination ([Jiang, Rosenzweig, & Gaspard, 2018](#)). It is plausible that parents' perceived costs (effort costs, opportunity cost) could prevent them from doing math and science with their child or doing STEM with negative affect. Yet all of these parental beliefs are malleable factors that can be enhanced with early interventions and that may mediate intervention effects (e.g., [Loughlin-Presnal & Bierman, 2017](#)). Thus, it is important to understand parental beliefs towards STEM, as interventions to enhance low STEM expectancies will be quite different than those that aim to increase the perceived value of science and math. By targeting parental beliefs with the strongest links to parental involvement, we can increase the effectiveness of future interventions.

## Potential discrepancies in parental beliefs depending on child gender and SES

Parents' involvement in STEM activities with their children may be influenced by many socio-cultural factors, including cultural stereotypes about gender and STEM (Jacobs & Eccles, 1992; Tiedemann, 2000). *Stereotypes* are beliefs linking groups with particular traits or characteristics, such as the belief that STEM is "for boys," or that boys are better than girls at STEM (Master & Meltzoff, 2020). If parents believe that STEM activities are more gender-appropriate for boys, it may distort their perceptions of their child's potential to succeed in STEM (Eccles, 1993). They may place greater weight on the value of STEM for boys, and spend more time and involvement on STEM activities with sons than daughters (Gunderson, Ramirez, Levine, & Beilock, 2012; Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005; Lee, Shin, & Bong, 2020). Even parents of young children endorse these stereotypical beliefs (Lummis & Stevenson, 1990). Previous findings on parental involvement in STEM activities based on child gender have been mixed. Some studies have found that parents underestimate elementary- and middle-school-aged girls' interest in science (Ford, Brickhouse, Lottero-Perdue, & Kittleson, 2006; Tenenbaum & Leaper, 2003), and spend less time talking about science to girls than boys between ages 1 and 8 (Crowley, Callanan, Tenenbaum, & Allen, 2001). However, other studies have found no differences in the math materials that mothers give to elementary-school children (Simpkins, Fredricks, & Eccles, 2012). We explored potential gender differences in parents' STEM involvement and perceptions for their preschoolers.

Parents' involvement in STEM activities may also differ depending on the family's income status. Empirical research consistently demonstrates that children from low-income families and minorities are at increased risk for poor math and science achievement (Bacharach, Baumeister, & Furr, 2003; Jordan, Kaplan, Nabors Oláh, & Locuniak, 2006; Lee & Buxton, 2010). This achievement gap begins early. Children from low-income backgrounds typically enter preschool with lower math and science skills, improve less in these areas during the preschool period, and transition to kindergarten with lower math and science skills relative to their peers (Brenneman, Stevenson-Boyd, & Frede, 2009; Greenfield et al., 2009; Jordan, Kaplan, Locuniak, & Ramineni, 2007). However, some evidence suggests that children in low-income families may benefit more from their parent's involvement in STEM than their middle-class peers. In a sample that represented the U.S. population, there were stronger relations between parent involvement in OST learning for children in low-income households compared to higher socioeconomic status (SES; e.g., Barnett et al., 2020).

## Parent's own STEM background and relations to motivation for informal learning

Parents' experiences with STEM and identity as someone who uses STEM in their career may influence their beliefs and involvement in their child's math and science learning. The decision to pursue a STEM-related career is influenced by multiple components such as psychological beliefs (values, goals, and interests), socialization influences (social and cultural experiences) as well as individual abilities (Wang & Degol, 2013). Parents' own childhood home environments likely relate to whether they enrolled in college and/or pursued STEM careers (Degol, Wang, Ye, & Zhang, 2017; Rozek, Svoboda, Harackiewicz, Hulleman, & Hyde, 2017). For example, a longitudinal study showed that participation in an intensive after-school, science museum program during high school influenced college matriculation and pursuit of STEM, medical and health-related careers (Fadigan & Hammrich, 2004). Parents with STEM-related careers may have taken proactive steps to support their own science and math interest and learning (e.g., Patall et al., 2019) that, in turn, could make science and math topics more personally relevant and promote their child's identity as someone who could hold a future STEM-related career (cf. Hulleman & Harackiewicz,

2009). When a parent does math and science activities with their young child, they bring conscious and unconscious motivations about math and science that are likely influenced by their own career pathway (Dorsen, Carlson, & Goodyear, 2006). Parents who have advanced STEM training may also be less likely to treat girls and boys differently, as higher levels of education and income are linked to more egalitarian gender attitudes (Dorius & Alwin, 2011; Scott, 2008). As parents who attained a STEM-related career bring considerable STEM-related training, coursework, and experiences to all parent-child interactions, this study investigated direct and indirect influences of parents' STEM-related career on their involvement with informal STEM learning.

## Current investigation goals and hypotheses

As stated, the current study uses EVT to understand the science and math beliefs of U.S. parents of preschool-aged children and how these parental perceptions relate to parents' involvement in their child's STEM learning. Our sample was somewhat diverse in terms of SES but was mostly middle-class parents. As noted, this sample was unique in that these parents were all seeking informal learning resources either through visiting a local children's museum on a free admission night or by registering for access to an online family activity collection. There were typically long lines and high attendance at this museum on free admission Thursday nights that allowed us to recruit and survey parents while their families waited to enter the museum from 5 to 8 pm. The families recruited through the CLI Engage Family Activity Collection likely registered for updates because they were seeking tips and ideas to support learning at home. This survey research using EVT of motivation can inform interventions aimed at increasing parental involvement in science and math learning outside of school. This study focuses on the quantity of parental involvement in learning, recognizing that frequency of interactions relates to quality (e.g., Barnett et al., 2020). As a secondary interest, we compared the frequency of parental involvement in STEM activities to literacy activities. We examined the following descriptive and correlational research questions (RQ):

1. How often do parents of preschoolers engage in STEM activities within this sample? How does this compare to the reported frequency of literacy activities?
2. How do parents' expectancy, value, and cost relate to quantity of self-reported parental involvement in informal STEM learning activities?
3. Does child gender relate to parental value, expectancy, cost, and involvement with STEM?
4. Does parental participation in a STEM career relate to parental value, expectancy, cost and involvement with STEM?

For the descriptive question RQ1, we expected this sample of mostly middle-class parents who were actively seeking informal learning resources to report relatively frequent use of some STEM activities (such as counting or talking about weather/seasons), but that this would still be less frequent than reported literacy activities (cf. Barnett et al., 2020; Skwarchuk, 2009). For RQ2, we hypothesized that as parental expectancy and value increased, parental self-reported involvement in STEM learning would be more frequent; conversely, as perceived costs increased we expected parental involvement would decrease (e.g., Powell et al., 2012). For RQ3, given the broader cultural milieu around gender stereotypes (Master & Meltzoff, 2020), we hypothesized that parents may have different values and expectations of boys relative to girls for STEM. For RQ4, although we recognize parents' interest and ability to obtain a STEM-related career was likely to relate to higher value and expectations for STEM (Wang & Degol, 2013), we did not have a directional hypothesis for costs. That is, we realize some potentially demanding STEM occupations could increase and/or decrease perceived opportunity costs of taking time for informal STEM learning activities. For this final question, we were primarily interested in parents' self-

description of their career as STEM related or not, but also coded groups of STEM occupations to further understand this relation.

## Method

### Procedures

Survey participants were recruited through two primary methods – online and face-to-face within a children's museum. Over a 7-week period (Feb. 7, 2019 to March 28, 2019), research staff solicited survey responses. Researchers used an IRB-approved, passive consent process that invited families of 3- to 5-year-old children to complete a 10-min survey that was introduced by explaining, "We want to learn more about what parents of young children think about doing science and math at home. Understanding parents' thoughts and needs will help us develop better materials to support learning at home." The majority of responders completed an online survey via Qualtrics that was sent to a database of families registered at Children's Learning Institute (CLI) Engage website ([www.cliengage.org](http://www.cliengage.org) for teachers and family reports and [www.cliengagefamily.org](http://www.cliengagefamily.org) for family activities). The CLI Engage platform is a University owned website that had 23,320 public access users (educators, school administrators, parents) at the time of the study. This website is used by families to: (a) learn about developmental milestones and screening, or (b) access learning activities for families with children from birth through kindergarten. We filtered the registered users to only send the survey to parents of 3- to 5-year-olds. Before beginning the survey, a screening question asked if the parent had a child who was currently preschool aged; if this response was "no," the survey did not advance to additional items. Initially, 3258 emails were sent with an invitation to the survey; amongst those 73 emails failed or bounced back, resulting in 3158 online invitations. From these, 168 completed surveys were registered, representing a 5.27% response rate for online surveys.

Research staff also collected written survey responses during five museum visits on Thursday nights when museum entrance is free. The Children's Museum Houston hosted more than a million visitors during this year. Researchers surveyed some parents as they waited in line for free admission after 5 pm or after they visited museum events on these free family nights. Researchers also attended a story time in the museum library and invited parents to complete the survey before and after this read-aloud. An exact response rate could not be determined because not all families attended the entire storytime; however, this method resulted in 35 surveys amongst 100 parents invited, representing approximately a 35–40% response rate for face-to-face survey collection. Although 257 parents answered at least some survey questions (across online and face-to-face modalities), only 208 completed the majority of survey items (i.e., may have skipped 1–5 questions, such as income questions) and could be used in analyses. Note that 100% complete survey data was provided by 185 parents.

### Participants

The final sample included 208 participants mostly (91.34%,  $n = 190$ ) from the Southwestern region of the U.S. About 17% ( $n = 34$ ) of the surveyed families resided outside of Texas; however, the vast majority of families were recruited through in-person surveys or registered for the CLI Engage platform ([www.cliengagefamily.org](http://www.cliengagefamily.org)) that mostly serves families in this state. That is, most registered user signed up when attending outreach events the university team conducted across Texas or when their preschool teachers shared this website as part of statewide professional development programs (e.g., [Crawford, Zucker, Van Horne, & Landry, 2017](https://doi.org/10.1016/j.jed.2017.05.001)). Mothers were the most common survey participants (67%). Participants reported on both mother and father's education and careers. Although there is some diversity in this sample, the maternal education and household income levels were mostly middle class. For mothers, over 70% reported a Bachelor's degree or higher, see Table 1.

**Table 1**  
Demographic characteristics for overall sample.

| Variable                                   | n (%)    |
|--|----------|
| Parent characteristics                     |          |
| Maternal education                         |          |
| Eighth grade or less                       | 1 (1)    |
| Less than high school                      | 5 (3)    |
| High school degree                         | 12 (6)   |
| Some college or vocational training        | 21 (11)  |
| Associates degree                          | 14 (8)   |
| Bachelor's degree                          | 43 (23)  |
| Some graduate school but no degree         | 17 (9)   |
| Master's or postgraduate degree (MA or MS) | 44 (24)  |
| Professional degree (e.g., MD, PhD, JD)    | 28 (15)  |
| Paternal education                         |          |
| Eighth grade or less                       | 3 (2)    |
| Less than high school                      | 11 (6)   |
| High school degree                         | 22 (12)  |
| Some college or vocational training        | 19 (10)  |
| Associates degree                          | 10 (5)   |
| Bachelor's degree                          | 49 (26)  |
| Some graduate school but no degree         | 9 (5)    |
| Master's or postgraduate degree (MA or MS) | 32 (17)  |
| Professional degree (e.g., MD, PhD, JD)    | 30 (16)  |
| Parent reported household income           |          |
| 11,000 or less                             | 11 (6)   |
| 11,001–20,000                              | 5 (3)    |
| 20,001–30,000                              | 9 (5)    |
| 30,001–40,000                              | 20 (11)  |
| 40,001–70,000                              | 31 (17)  |
| 70,001–100,000                             | 24 (13)  |
| 100,001–150,000                            | 32 (18)  |
| 150,001 or more                            | 48 (27)  |
| Self-reported STEM career                  |          |
| Mother – Yes                               | 82 (44)  |
| Father – Yes                               | 88 (48)  |
| Child characteristics                      |          |
| Child sex (female)                         | 89 (48)  |
| Child race/ethnicity                       |          |
| Black/African American                     | 21 (11)  |
| Hispanic/Latino                            | 47 (25)  |
| White/Caucasian                            | 87 (48)  |
| Asian                                      | 19 (10)  |
| Other                                      | 11 (6)   |
| Language(s) spoken at home                 |          |
| English only                               | 112 (60) |
| Spanish/English                            | 44 (23)  |
| Chinese/English                            | 10 (5)   |
| Other                                      | 22 (12)  |

The median family income was \$70,001–100,000, which is higher than the 2019 median income in the U.S. of \$68,703 ([Semega, Kollar, Shrider, & Creamer, 2020](https://doi.org/10.1016/j.jed.2020.101320)). There was some income variability with 14% reporting below \$30,000 and 45% of respondents reporting over \$100,000 a year (as compared to 21% and 34% respectively in the general population in 2019; [Semega et al., 2020](https://doi.org/10.1016/j.jed.2020.101320)). Note that income was an option field completed by 70% of participants. Parents answered several questions regarding home language. As detailed in Tables 1, 40% indicated that they spoke a language other than English at home. Children were considered dual language learners (DLLs) if their parents reported speaking a language other than English in the home. For DLLs, the most common language spoken was Spanish (59%). There were sixteen other languages represented in the sample. These preschool children were 48% female and represented diverse race/ethnicities: 48% White/Caucasian, 25% Hispanic or Latino/a, 11% Black/African American, and 6% responded 'Other.'

Parent occupations. We also asked participants to report whether they currently held a STEM career. This was captured with a series of four questions to capture the mother's and father's career type: (a) "What is the occupation of the mother/father?"; and (b) "Is this a STEM (Science, Technology, Engineering, and Mathematics) related career?" For the self-described STEM career in part (b) b, 44% of mothers reported working in a STEM career, and 48% of fathers were self-reported

as in a STEM career. In most families only one parent self-reported a STEM career ( $n = 77$ ), or no parents in STEM careers ( $n = 63$ ), but a number of families reported both parents were in STEM careers ( $n = 48$ ) and some data were missing ( $n = 20$ ). For comparison, approximately 13% of employed adults in the U.S. are employed in STEM-related occupations, although the definition of "STEM-related" can vary (Pew Research Center, 2018).

As we will present in the results, given that mother's STEM occupation (and not father's) was a significant predictor in our primary specification, we conducted a robustness check to our results by recoding the mother's self-reported STEM career. Specifically, to categorize parent open-ended occupation responses, we created a set of occupation codes drawing from the Standard Occupational Classification system (SOC; Emmel & Cosca, 2010; Standard Occupational Policy Committee, 2012). Based upon the SOC codes and associated documents delineating STEM careers (U.S. Bureau of Labor Statistics, 2018), we categorized occupations into six groups, including: (1) life, physical sciences, engineering, mathematics, information technology/computing; (2) social sciences; (3) architecture, (4) health and medical, (5) teaching and education; and (6) not a STEM career. Some parents left this response blank ( $n = 47$ ) or did not provide enough information to make a determination ( $n = 5$ ). For the rest, 4.52% ( $n = 8$ ) mothers were categorized as life, physical sciences, engineering, mathematics, information technology/computing; 6.76% ( $n = 12$ ) as a social science occupation; 12.99% ( $n = 23$ ) as a health occupation; 25.42% ( $n = 45$ ) as teaching/education related, and 47.45% ( $n = 84$ ) as not having a STEM career. No architecture careers were reported. For the purposes of re-estimating this alternative model specification, we combined categories (1) and (2) into "other STEM"; the rest of the categories (i.e., categories 4, 5, and 6) were left as is.

#### STEM survey development and psychometrics

The survey included 40 initial items about STEM learning and additional reading items detailed in the Online Supplemental Appendix A1. Ten items addressed parental involvement in STEM activities over the past week, using an 4-point rating scale (1-Not at all; 2-Once or twice; 3-Three or more times, but not every day; 4- Every day). Sample items include: "How many times in the past week have you compared sizes of objects or toys with your child?" "How many times in the past week have you talked to your child about plants, animals or other living things?" The parental involvement items were adapted from the Head Start Family and Child Experiences Survey (FACES; West, Tarullo, Aikens, Malone, & Carlson, 2011); these same items have been used in other nationally representative samples such as the Early Childhood Longitudinal Study (ECLS) to permit comparisons. We included some literacy items interspersed with the STEM items; for example, the first question asked, "How many times in the past week have you read books to your child?" because parents may be accustomed to reporting on reading frequency (e.g., home reading logs sent by teachers). We added items beyond the FACES and ECLS items to ask about additional math and science activities, but using the same item structure and scale (e.g., weather/seasons, plants/animals).

The remaining 30 items were based on EVT and were designed to assess parents' perceptions about STEM for their child, including items related to: (a) parental expectancy for their child's success with STEM activities; (b) parental self-efficacy for supporting their child's STEM learning; (c) parental value of STEM knowledge; and (d) items related to costs of doing informal STEM learning. These items had 7-point rating scales with two different types of anchors. For example, some items (e.g., "In the job market it helps to have good math knowledge and skills") used this scale: 1-Strongly Disagree, 4-Neither agree nor disagree, 7-Strongly agree. Other items (e.g., "Because of the other things I have to do, I don't have enough time for doing math with my child") used this scale: 1-Not true at all, 4-Neutral, 7-Very true. Some items from the PISA (2006) were used, and items were adapted from other studies that used

EVT with other populations (e.g., Jiang et al., 2018). In addition, we included some literacy-related EVT items that were not part of the primary analyses; these items were designed to reduce parents' social desirability to rate STEM involvement and motivation highly because it was presented in isolation and to provide a comparison to literacy activities. For example, the literacy involvement items asked about how often in the past week parents read to their child or taught their child about writing or letters; see all items in Online Supplementary Table A2.

#### STEM survey instrument properties

Rather than scoring by theoretical distinction (e.g., grouping all cost items into a sum score), we used Exploratory Factor Analyses (EFAs) to evaluate whether the items described several latent constructs as expected. EFAs are often used to test whether survey questions represent a latent construct as expected, and can provide initial construct validity evidence (Tabachnick, Fidell, & Ullman, 2007). We conducted an EFA in Mplus 7.2 (Muthén & Muthén 1998–2012) using a maximum likelihood estimator to account for missing data and a Geomin rotation (allowing for correlated factors). Akaike (AIC) and Bayesian Information Criteria (BIC), as well as eigenvalues and model interpretability, were used to assess what factor solution best fit the data, with smaller numbers indicating better fit. Results suggested a five factor model, see Table 2 for a comparison of different factor solutions via the AIC and BIC. AIC and BIC fit statistics were lower for the five factor model than the prior lower factor solutions. The first four factors had eigenvalues greater than two. The fifth factor's eigenvalue was 1.98, but this solution was more interpretable than the four factor solution and so it is described below. We also considered a six factor solution; however, the added factor only included cross loadings and was not interpretable. The final five factors are parental involvement, parental expectations of child, parental expectation of self (self-efficacy), parental value, and parental cost, please see Table 3 for all survey items and factor loadings. These factors related closely to the expected constructs and aligned with Eccles and colleagues' EVT motivation theory. However, as noted under Table A1, although most items included in the EFA loaded clearly to one factor, three items cross loaded on both the parental expectation of self factor and the parental expectations of child factor (with lower but also significant loadings on other factors too). As these items did not fall cleanly on a factor and included multiple high cross loadings, they were excluded from the structural equation model presented below.

#### Statistical analyses

We use the five factors as part of a structural equation modeling approach to evaluate potential predictive associations between parent reported expectancies, value, and cost (independent variables, IVs), and parent reported STEM involvement (dependent variable, DV DV). We allowed residual correlations between items that had the same root (e.g., "I think my child will receive good math/science grades in K;" "When I help my child learn math/science I feel comfortable") if they were indicated in model indices as improving fit within the SEM model. We predicted value and expectancy (including parental expectations of child and parental self-efficacy) would positively predict parental STEM

**Table 2**  
EFA results comparing the fit of different factor solutions.

| Model    | AIC        | BIC       |
|----------|------------|-----------|
| 1 factor | 23,336.76s | 23,737.27 |
| 2 factor | 22,702.25  | 23,232.92 |
| 3 factor | 22,229.25  | 22,886.75 |
| 4 factor | 21,935.66  | 22,716.65 |
| 5 factor | 21,739.72  | 22,640.85 |

*Note.* Eigenvalues were greater than 2.00 for the first four factors and was 1.98 for the fifth factor.

**Table 3**  
Survey items grouped by final factors.

|  | Parent involve | Parent expect child | Parent self efficacy | Parent value | Parent costs |
|--|----------------|---------------------|----------------------|--------------|--------------|
| <b>Parent STEM Involvement</b>   |                |                     |                      |              |              |
| How many times in the past week have you talked to your child about shapes (e.g., triangle, square)?   | <b>0.71*</b>   | -0.18*              | -0.02                | 0.16*        | -0.05        |
| How many times in the past week have you compared sizes of objects or toys with your child (e.g., big, little, shorter)?   | <b>0.76*</b>   | -0.14               | 0.01                 | -0.13*       | -0.03        |
| How many times in the past week have you counted different things with your child (e.g., spoons, grapes, cans)?  | <b>0.68*</b>   | -0.08               | 0.05                 | 0.02         | 0.01         |
| How many times in the past week have you played counting games with your child (e.g., singing songs with numbers)?   | <b>0.65*</b>   | -0.13               | 0.07                 | 0.04         | 0.02         |
| How many times in the past week have you talked with your child about how to make objects or toys move faster/slower or in different directions (e.g., cars roll faster on smooth surfaces)? | <b>0.72*</b>   | -0.07               | -0.01                | 0.05         | 0.04         |
| How many times in the past week have you talked with your child about technology or tools that help us do things?  | <b>0.65*</b>   | 0.08                | 0.09                 | -0.05        | 0.04         |
| How many times in the past week have you talked with your child about weather, seasons, or the environment?  | <b>0.62*</b>   | 0.09                | -0.09                | -0.02        | -0.04        |
| How many times in the past week have you talked with your child about plants, animals, or other living things?   | <b>0.59*</b>   | 0.07                | 0.01                 | -0.08        | -0.13        |
| How many times in the past week have you talked with your child about what people need to be healthy?  | <b>0.56*</b>   | 0.04                | -0.01                | 0.03         | 0.00         |
| How many times in the past week have you played board games or card games with your child?   | <b>0.45*</b>   | 0.04                | -0.10                | 0.02         | 0.11         |
| <b>Parent Expectations of Child</b>  |                |                     |                      |              |              |
| I expect my child to do very well in science.  | -0.08          | <b>0.60*</b>        | 0.02                 | 0.23*        | 0.08         |
|  | -0.22*         | <b>0.54*</b>        | 0.03                 | 0.17         | 0.08         |

**Table 3 (continued)**

|  | Parent involve | Parent expect child | Parent self efficacy | Parent value | Parent costs |
|--|----------------|---------------------|----------------------|--------------|--------------|
| <b>I expect my child to do very well in math.</b>  |                |                     |                      |              |              |
| I think my child will receive good math grades when in kindergarten.                               | -0.05          | <b>0.80*</b>        | -0.06                | 0.07         | -0.01        |
| I think my child will receive good science grades when in kindergarten                             | 0.04           | <b>0.82*</b>        | -0.05                | -0.08        | -0.11        |
| I think my child will go into a math-related career.   | 0.09           | <b>0.35*</b>        | 0.06                 | 0.07         | 0.03         |
| I think my child will go into a science-related career.  | 0.16*          | <b>0.40*</b>        | 0.11                 | 0.10         | 0.04         |
| <b>Parent Self-Efficacy</b>  |                |                     |                      |              |              |
| When I help my child learn science, I feel comfortable.  | 0.23*          | 0.16                | <b>0.73*</b>         | -0.06        | 0.05         |
| I have the materials I need to support my child's science learning at home.                        | 0.34*          | 0.22                | <b>0.44*</b>         | -0.15*       | 0.01         |
| When I help my child learn math, I feel comfortable.   | -0.00          | 0.09                | <b>0.69*</b>         | -0.02        | -0.10        |
| I have the materials I need to support my child's math learning at home.                           | 0.18*          | 0.25*               | <b>0.33*</b>         | -0.14        | -0.06        |
| I am interested in science.  | 0.11           | -0.00               | <b>0.48*</b>         | 0.37*        | 0.06         |
| I am interested in math.   | 0.15           | -0.05               | <b>0.45*</b>         | 0.43*        | 0.10         |
| I know how to support my child's science learning.   | 0.18*          | 0.35*               | <b>0.36*</b>         | 0.03         | -0.13        |
| I am confident that I can support my child's math learning.  | -0.05          | 0.41*               | 0.30*                | 0.05         | -0.29*       |
| I am confident that I can support my child's science learning.                                     | 0.15*          | 0.41*               | 0.28*                | 0.12         | -0.24*       |
| I know how to support my child's math learning.  | 0.00           | 0.42*               | 0.38*                | -0.02        | -0.18*       |
| <b>Parent Values</b>   |                |                     |                      |              |              |
| It is important to have good math knowledge and skills to get any good job in today's world.       | -0.01          | 0.06                | -0.10                | <b>0.77*</b> | -0.07        |
| In the job market it helps to have good math knowledge and skills.                                 | -0.00          | 0.09                | -0.05                | <b>0.71*</b> | -0.18*       |
| It is important to have good scientific knowledge and skills to get any good job in today's world. | 0.24*          | 0.03                | 0.02                 | <b>0.69*</b> | 0.04         |
| In the job market it helps to have good scientific knowledge and skills.                           | 0.08           | -0.01               | 0.11                 | <b>0.71*</b> | -0.04        |
| It is important for my child to learn math.  | -0.01          | 0.15                | 0.02                 | <b>0.51*</b> | -0.12        |
| It is important for my child to learn about science.   | 0.16*          | 0.16                | 0.11                 | <b>0.45*</b> | 0.01         |
| <b>Parent Costs</b>  |                |                     |                      |              |              |

(continued on next page)

**Table 3 (continued)**

|   | Parent involve | Parent expect child | Parent self efficacy | Parent value | Parent costs |
|---|----------------|---------------------|----------------------|--------------|--------------|
| Because of the other things I have to do, I don't have enough time for doing math with my child.    | -0.17*         | 0.05                | 0.08                 | -0.07        | <b>0.54*</b> |
| Because of the other things I have to do, I don't have enough time for doing science with my child. | -0.21*         | -0.03               | 0.15*                | -0.07        | <b>0.53*</b> |
| It takes too much effort for me to help my child do well in math.                                   | 0.02           | -0.06               | -0.01                | 0.05         | <b>0.91*</b> |
| It takes too much effort for me to help my child do well in science.                                | -0.11*         | -0.13*              | 0.01                 | 0.06         | <b>0.88*</b> |
| It requires too much effort for me to get materials I need to do math activities with my child.     | 0.09           | 0.09                | -0.13                | 0.02         | <b>0.68*</b> |
| It requires too much effort for me to get materials I need to do science activities with my child.  | 0.00           | 0.04                | -0.18*               | 0.05         | <b>0.63*</b> |
| Helping my child with science activities makes me feel stress.                                      | 0.08           | -0.01               | -0.55*               | -0.10        | <b>0.33*</b> |
| Helping my child with math activities makes me feel stress.   | 0.29*          | 0.05                | -0.57*               | -0.12        | <b>0.37*</b> |

**Note.** Bold denotes items were used on that factor during the SEM analyses. Three items with cross loadings on multiple factors were dropped, including: a) I am confident that I can support my child's math learning. b) I am confident that I can support my child's science learning. c) I know how to support my child's math learning. These items are listed under "parent self-efficacy" but are not bolded as they were not included in SEM analyses. Factors listed above follow the theoretical order (Involvement, Expectancies, Values, Cost) of the EVC theory; order does not denote variance accounted for.

involvement, while cost would negatively predict (RQ2). Thus, we built an SEM model with the parental involvement factor regressed on the cost, value, and expectancy factors. Next, to evaluate the role of child gender on parental reported value, expectancy and involvement (RQ3), we include child gender (0 = girl) as a predictor of the value, expectancy, and involvement factors. Finally, we added parent STEM career to the model to evaluate the predictive role of the parent's career on expectancy, value, cost and involvement (RQ4). We also tested several exploratory mediation relationships using bootstrapped direct and indirect effects, as this approach has been shown to provide the most appropriate confidence intervals amongst currently available techniques (MacKinnon, Lockwood, & Williams, 2004; Preacher & Hayes, 2008). Specifically, we tested whether parent self-reported STEM career affected involvement through increased parental value and expectancy. Family income and whether the parent was monolingual (reported English only) or bilingual (reported any language[s] in addition to English) were included as covariates. Specifically, the household income categories shown in Table 1 were used in analyses. The covariates did have some missingness (10–11%). This missingness related to response order on the survey (Missing at random). Missing at random data can appropriately be handled by the full information maximum likelihood estimation (FIML). We correlated all covariates as this is recommended practice to help estimation.

## Results

**RQ1.** What are parents' reported levels of STEM involvement and motivation?

Descriptive statistics for each EVT factor in Table 4 indicate that parents had high self-efficacy ( $M = 5.82$ ,  $SD = 1.37$ , 1 = Strongly disagree, 7 = Strongly agree), and similarly high expectations for their children ( $M = 5.57$ ,  $SD = 1.20$ , 1 = Not true at all, 7 = Very true). Parents generally did not report high costs of doing STEM ( $M = 2.32$ ,  $SD = 1.62$ , which corresponds to "mostly untrue"). Notably, parents perceived a slightly higher STEM value ( $M = 6.36$ ,  $SD = 0.84$ , 1 = Not true at all, 7 = Very true) compared to STEM expectancies ( $M = 5.57$  for expectancies of child;  $M = 5.82$  for parent self-efficacy). This was true for the overall factors (Table 4) as well as the item-level data reported in Online Table A1. There was also less variability in seeing STEM as valuable and important compared to the two expectancy factors. As shown on the right side of Table 4, there were no significant differences between responses of parents of boys versus girls (see Table 4;  $p > 0.05$ ) across all factors (also see item level means by gender in Online Supplementary Table A1).

For involvement in STEM activities, parents in this mostly middle-class sample reported an average score of 2.59 ( $SD = 0.93$ , 1 = Not at all, 4 = Everyday), corresponding to supporting their child's informal science and math learning about two or three times per week, but not daily. Item level descriptives on parental involvement are available in Online Table A2. These data show the least common STEM activities include talk about force/motion and board games (corresponding to once or twice per week) whereas the most frequent items were counting and talking about weather/seasons (three or more times per week). However, parents varied in the frequencies they reported, ranging from not engaging in these activities at all to daily involvement in STEM. Notably, 56% of parents reported reading everyday with their child, but only 35% reported any daily STEM activities, even for the most frequently occurring items (counting and talking about living things). Like most STEM-related items, didactic literacy activities (teaching letters and writing) were unlikely to occur daily (see Online Supplemental Table A3). As expected, parental involvement in STEM was positively correlated with parent expectations of child ( $r = 0.20$ ,  $p < .05$ ), parent self-efficacy ( $r = 0.46$ ,  $p < .05$ ), and parent values ( $r = 0.33$ ,  $p < .05$ ), and negatively correlated with cost ( $r = -0.25$ ,  $p < .01$ ); see Table 5.

**RQ2.** How does parents' EVT motivation relate to parental STEM involvement?

We tested whether parent reported value, cost, and expectancy predicted parent-reported involvement. In this first model, only direct associations between the factors were tested (controlling for covariates). Parent value significantly predicted parental involvement ( $\beta = 0.19$ ,  $p = .027$ ), so that for every one unit increase in parent's reported value (e.g., importance for child to learn math/science; value of STEM knowledge/

**Table 4**  
Parent Involvement Descriptives by Child Gender.

| Variables                                   | n (all) | Mean (SD)   | Boys M (SD) | Girls M (SD) |
|---|---------|-------------|-------------|--------------|
| Parent expectations of child                | 196     | 5.57 (1.20) | 5.55 (1.24) | 5.65 (1.10)  |
| Parent expectations of self (self-efficacy) | 187     | 5.82 (1.37) | 5.91 (1.38) | 5.73 (1.38)  |
| Parent values                               | 187     | 6.36 (0.84) | 6.44 (0.81) | 6.27 (0.85)  |
| Parent costs                                | 196     | 2.32 (1.62) | 2.21 (1.61) | 2.42 (1.66)  |
| STEM involvement                            | 208     | 2.59 (0.94) | 2.66 (0.95) | 2.58 (0.92)  |
| Literacy involvement                        | 208     | 2.92 (0.87) | 2.94 (0.82) | 2.91 (0.89)  |

**Table 5**  
Correlations between factors, predictors and covariates.

| Variables                                      | 1      | 2      | 3      | 4      | 5      | 6     | 7     | 8     |
|--|--------|--------|--------|--------|--------|-------|-------|-------|
| 1. Parent STEM involvement                     | 1.00   |        |        |        |        |       |       |       |
| 2. Parent expectations of child                | 0.20*  | 1.00   |        |        |        |       |       |       |
| 3. Parent expectations of self (self-efficacy) | 0.40*  | 0.60*  | 1.00   |        |        |       |       |       |
| 4. Parent values                               | 0.30*  | 0.44*  | 0.42*  | 1.00   |        |       |       |       |
| 5. Parent costs                                | -0.15† | -0.36* | -0.30* | -0.20* | 1.00   |       |       |       |
| 6. Child gender                                | 0.04   | -0.05  | 0.07   | 0.07   | -0.04  | 1.00  |       |       |
| 7. Child language (mono- or bilingual)         | -0.04  | 0.01   | 0.03   | 0.02   | -0.15* | -0.02 | 1.00  |       |
| 8. Maternal career (STEM or non-STEM)          | 0.04   | 0.01   | 0.13*  | 0.06   | -0.01  | 0.02  | 0.01  | 1.00  |
| 9. Parent reported income                      | -0.57* | 0.00   | 0.21   | 0.01   | -0.19  | 0.20* | 0.13† | 0.15* |

Note. For child gender, female is the reference group (0); for child language, English is the reference group; for STEM or non-STEM career, non-STEM career is the reference group.

\*  $p < .05$ .

†  $p < .10$ .

skills for the job market), there was a 0.19 standard deviation increase in parental STEM involvement. Parents' self-efficacy also predicted parental involvement ( $\beta = 0.39$ ,  $p < .001$ ) such that when parents reported higher levels of comfort when helping children with math or science (or more materials), this was associated with doing more STEM-related activities with children during the week. No other association was significant; that is, parental expectancy of their child and perceived costs of doing science and math did not relate to involvement in informal STEM activities.

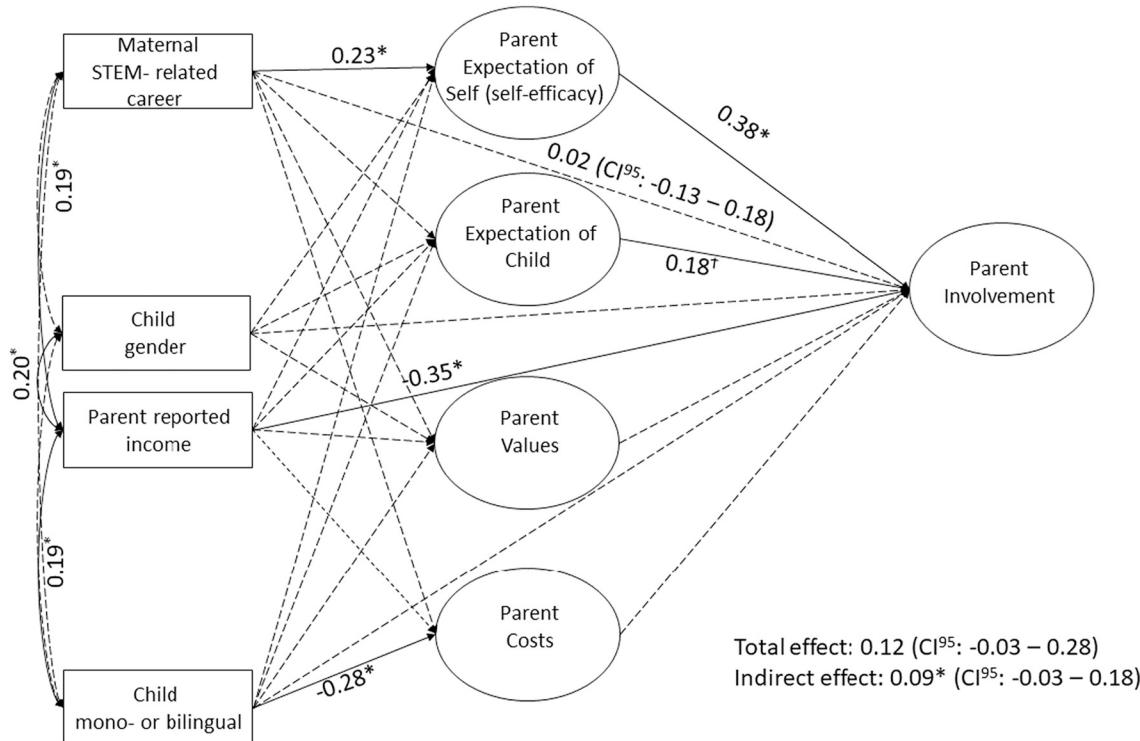
**RQ3.** Does child gender relate to parental value, expectancy, and involvement with STEM?

Next, we tested whether the associations between parent self-efficacy, parent expectations of child, and values differed based on whether the child was a girl or boy. Consistent with the means displayed in Table 4, child gender was not significantly associated with any parent

report factors within the current sample. We note that the lack of gender difference is generally consistent with the larger field results suggesting that associations between child gender and parental beliefs about STEM often manifest later in development (Eccles, Jacobs, & Harold, 1990; Simunović & Babarović, 2020).

**RQ4.** Does a parent STEM career relate to parental motivation and involvement?

Finally, we examined the extent to which a parent's self-report of whether maternal or paternal careers were "STEM related" affected parent reports of EVT motivation and STEM involvement. This included testing whether there was an indirect effect from career to parental involvement through parent reported expectancies, value, and cost factors. Results indicated that paternal STEM-related career was not related to any factor within the model, and thus it was trimmed from the model and we do not discuss it further. However, as can be seen in the



**Fig. 1.** Full Structural Equation Mediation Model of associations between maternal career, STEM Expectancies, Value, Cost, and Parent STEM Involvement. Note. Standardized values are included for significant pathways. Non-significant pathways are denoted by a dashed line. Item loadings on the factors are suppressed to simplify the figure, as were tested mediations between Maternal STEM-related career and all other factors. The association between Parent expectation of child is significant ( $p = .04$ ) when maternal career is not included in the model (RQ1). When maternal career is included, the standardized value is unchanged (0.19), but the  $p$ -value changes to 0.09. Child gender is coded as 0 = girl, 1 = boy.

final model displayed in Fig. 1, maternal STEM-related career was directly associated with parental self-efficacy ( $\beta = 0.23, p < .01$ ). That is, when a parent reported that the mother's career was STEM-related, this related to higher feelings of efficacy when engaging in informal STEM learning. No other direct associations were significant, suggesting maternal STEM-related career was not directly associated with reported EVT or parental involvement. However, the mediation analyses suggest an indirect relationship between maternal STEM career and parental involvement through higher self-efficacy for supporting their child's informal STEM learning ( $\beta = 0.09, 95\% \text{ CI } [0.03-0.18]$ ). We further tested this relation by repeating the analysis with the researcher-coded STEM careers (i.e., health related; teaching; other STEM) and found consistent patterns such that the researcher-coded STEM careers were positively associated with parent expectations ( $\beta$ 's ranging from 0.192–0.313,  $p < .01$ ); see Fig. A1 in our supplemental material for significant paths. Consistent with our main specification, we found significant indirect between maternal STEM-related careers and parent involvement (indirect paths ranging from 0.07 to 0.121,  $p < .05$ ). This pattern of results suggests that mothers in STEM careers were more comfortable and had more materials related to science and math. This, in turn, led to higher reported involvement. No other indirect pathways were significant. In the final model (with the inclusion of the indirect effects), the magnitude of the direct association between parental value and parental involvement was very similar to the model without indirect paths; i.e.,  $\beta = 0.184; p = .071$  with indirect path; and  $\beta = 0.187; p = .03$  in the model without mediation.

## Discussion

This study used expectancy-value theory (EVT; Wigfield & Eccles, 2000) to understand parents' motivations for engaging in informal science and math learning with their child. This was a unique sample of U.S. parents in that they were actively seeking informal learning resources for their child through a children's museum or family activity website. In this sample, we identified higher parental *value* of science and math as well as parent *self-efficacy* as key predictors of parents' STEM involvement in this mostly middle-class sample. We also identified parents' self-efficacy as a mediator of parental involvement, but only for mothers in STEM-related careers who espoused higher expectations of success for themselves in facilitating their child's math and science learning. A favorable finding was that gender stereotypes did not influence parents' perceptions or involvement in STEM with their preschool children. We discuss below how these and descriptive findings around frequency of parental involvement in STEM inform early interventions.

### Frequency of STEM learning at home

One of the most important findings of this study is that parents do not engage in STEM daily with their preschoolers, even when considering simple activities such as counting or describing the weather. In this mostly middle-class, U.S. sample, 56% of parents reported reading everyday with their child, but only 35% reported engaging in any daily STEM activities. For comparison, in the Early Childhood Longitudinal Study (ECLS) that recruited a nationally representative U.S. sample of preschool children, 45% of parents reported reading daily with their preschool children (Barnett et al., 2020). For kindergarten children, the ECLS-K: 2011 reports that 51% of parents read to their children daily. In our survey, 36% of parents reported talking about nature daily, and about 28% reported talking about weather, seasons, and the environment with the same frequency. In contrast, the ECLS-K: 2011 includes a related item asking parents how often they talk about nature or do science projects with children; about 12% of parents reported the frequency of this item as "every day." Unfortunately the ECLS datasets did not comprehensively assess math and science involvement to permit direct comparisons with our data. That is, we included new items assessing parental involvement in STEM but followed the same ECLS

item structure and scale. Indeed, given that our sample included many middle- and upper-SES parents involved in STEM careers, the present discrepancy between literacy and STEM involvement may not generalize to all U.S. parents (e.g., lower-SES families). Our descriptive findings align with evidence from Canadian samples that parents are more frequently engaged in literacy activities with their young child than math (Skwarchuk, 2009; Skwarchuk et al., 2014). Yet in some European countries, parental involvement in early numeracy and math activities may be more frequent than literacy activities (Manolitsis et al., 2013).

There could be several reasons that parents in North America appear to devote more attention to literacy than math. First, it may be that these parents experience frequent literacy campaign messages that emphasize the importance of shared reading and talking about letters to be ready for school (e.g., Zuckerman, 2009). Second, it could be that these parents perceive science and math learning as a formal, didactic activity, whereas literacy activities like shared reading feel like more informal, naturalistic activities that are more feasible to integrate into the home environment (Early Childhood STEM Working Group, 2017; Skwarchuk et al., 2014). Early family programs at museums, schools, libraries or other community centers could help parents to recognize things they are already doing that are STEM-related. For example, common household items can promote talk about math (e.g., counting or subtracting grapes or crackers on a plate as you eat them; using kitchen equipment to measure quantities) and everyday routines can naturally promote science learning (e.g., observing bugs and birds during a walk; pointing out patterns in seasons and weather).

Given past evidence that preschool parental involvement in home literacy and numeracy activities bidirectionally supports children's broad school readiness across language, literacy, and math outcomes (e.g., Napoli & Purpura, 2018), it is important to increase parental involvement in *both* literacy and STEM activities through family communications and programs. Some longtime national campaigns for U.S. parents, such as Reach Out and Read within pediatric clinics, are exploring ways to add math to their established literacy promotion, but implementation is not yet widespread (e.g., Jones et al., 2015). It is also particularly important to consider tailoring STEM messaging and programs for families experiencing poverty or other vulnerable populations. The frequency of home learning activities is known to be more important for children experiencing poverty or with weak initial skills, as it can serve as a protective factor for their cognitive development (Barnett et al., 2020; Powell et al., 2012).

### EVT and parental motivation for doing science and math

A second key finding is that parents who feel empowered to do science and math engage their preschooler in informal STEM learning more often. In this sample, we found that parents' value of STEM and self-efficacy for facilitating STEM were the EVT factors that directly predicted involvement in STEM during OST. The items assessing value asked parents to rate broad math and science importance as well as STEM utility for future jobs using items that were adapted mostly from the PISA. Syntheses of EVT research suggest that value-related beliefs are the strongest predictors of achievement and career goals related to STEM (Wang & Degol, 2013). Therefore, it is promising that parents' values were relatively high, as they are likely to socialize their children to also see value in STEM learning (Grusec & Davidov, 2010). Frequently doing science and math activities together is a way for parents to send a message to children about how much they value STEM. The items assessing parental self-efficacy tapped into parents' perceived readiness to support their child's math and science learning at home. When parents feel likely to succeed in facilitating STEM learning, they may socialize their child to see science and math as enjoyable or may confidently guide their child's learning. For example, there is evidence that STEM activities with young children are more beneficial when parents use fewer directives and more open-ended inquiry questions (Haden, 2010; Leyva et al., 2017). Indeed, with older children, parents'

negative emotions or overcontrolling behaviors can be unhelpful (e.g., Patall, Cooper, & Robinson, 2008; Silinskas & Kikas, 2019). Thus, preschool family interventions should capitalize on parents' perceptions of STEM as relevant and valuable (cf. Hulleman & Harackiewicz, 2009) and further explicate how adults can effectively guide children's STEM learning (McClure et al., 2017).

Although the finding of greater self-efficacy for mothers who report being in a STEM-related career is somewhat intuitive, we did not hypothesize that this would mediate the frequency of parental involvement in science and math. It is well established that parental self-efficacy, or parents' perceived ability to positively support their child's learning in a given task, influences behavioral choices (Bandura, 1997; Le et al., 2008). Also, it is well-established that pursuing a STEM-related career is associated with learning and career pathways that require high motivation and persistence, particularly for women who often face systemic obstacles in these pursuits (Degol et al., 2017; Wang & Degol, 2013). Thus, our mediation finding is an interesting extension of existing evidence that mothers who have obtained a STEM career feel more confident in facilitating early STEM learning that, in turn, influences these parents' decision to engage in science and math learning with their preschooler. There are increasing models of effective STEM interventions designed to increase parental self-efficacy (Hollingsworth-Latimer, 2020) and parents' ability to show the value and relevance of STEM to their child (Rozek et al., 2017).

Parental expectations of the child and perceived costs were two EVT factors that were not significantly related to these parents' involvement in STEM. Parents reported few costs/barriers to doing STEM with most parents reporting that it did *not* take too much effort or time to do science and math. Turning to expectations of their child, most parents held positive expectations that their child would do well in science and math. However, these expectancies did not relate to parental involvement as we would have expected, based on the strength of this factor as a robust and longitudinal predictor of various outcomes in past research (e.g., Froiland et al., 2013; Thomas & Strunk, 2017). It is worth noting that parents perceived higher average STEM value than expectancies for their child. Parents in this study also more consistently reported high value of STEM, whereas expectancy was more heterogeneous. In particular, items assessing whether parents expected their preschool child would go into a math or science career were the lowest ranked items within this construct, perhaps reflecting that it is hard to imagine what a young child's career aspirations might entail. Thus, these null findings could reflect a measurement issue related to items that ask parents to make projections about their youngster's very distant career aspirations.

Another noteworthy finding was that parents in this sample did not appear to have different STEM motivation or involvement with their preschool-age girls compared to boys. Although we did not directly measure parents' endorsement of stereotypes, parent behaviors may be influenced by belief in gender stereotypes (Eccles, 1993). However, parents' gender stereotypes may begin to impact their behavior with children more around late elementary or middle school (Eccles et al., 1990). STEM gender stereotypes may not be a relevant matter to address with parents until their students are older elementary school-age or young adolescents (Muenks et al., 2020; Rozek, Hyde, Svoboda, Hulleman, & Harackiewicz, 2015). An alternative explanation for these null findings is that the parents in our sample did not show differences based on child gender because highly educated, middle- and upper-class American parents are more likely to be gender egalitarian (Dorius & Alwin, 2011; Scott, 2008). We could not find studies on parents from a lower socioeconomic backgrounds and potential differences in their STEM interactions with preschool girls versus boys. Future research should examine whether these findings generalize to parents from different backgrounds and seek to confirm if parents of preschool-age children are less impacted by gender stereotypes in how they interact with their child. If this finding of no differences in patterns between preschool age boys and girls is replicated, then it indicates that STEM

programs need not address issues of stereotypes until elementary- or middle-school ages (Šimunović & Babarović, 2020; Tiedemann, 2000).

To summarize our EVT findings, when parents espouse high value of STEM this should be maintained because it links to STEM involvement; in addition when parents perceive heterogeneous expectancies about their child's STEM trajectory, this might be enhanced via empowering parent communications and family engagement programs that help parents to see their child as future scientists, engineers, healthcare providers, etc. Interventions that promote value are different from those that aim to enhance expectancy or reduce costs. For example, to increase parents' self-efficacy for facilitating science and math experiences, interventions should help parents gain information on engaging STEM activities and learn practical ways to embed talk about science and math in everyday routines (Garibay, 2007; Thippappa, Elliott, Gehman, Libertus, & Libertus, 2020). In contrast, if we had seen high costs and barriers to doing STEM, then interventions might provide STEM-related materials so parents feel that doing science or math takes less effort. But for parents in this sample, costs and value were not the issues. Instead, parents' broad expectations appeared to be critical factors to address, since parent's self-efficacy was higher for mothers in STEM careers and because there was heterogeneity in parents' expectations of the child's STEM success. For example, one experimental preschool study with low-income parents found that parental expectancies mediated gains in children's school readiness outcomes, but also demonstrated that parental expectations are malleable (Loughlin-Presnal & Bierman, 2017). Because parents bring conscious and unconscious perceptions about math and science from their own career pathway to parent-child interactions (Dorsen et al., 2006), it may be important to explicitly address these perceptions and explain evidence that *all* parents can be effectively supported to talk about counting, numeracy, and basic operations with their young child (e.g., Thippappa et al., 2020).

#### Limitations and future research

A key limitation of this study is its limited generalizability. Although we controlled for family income, because this U.S. sample includes mostly middle-class parents with Bachelor's degrees or higher and incomes above the poverty threshold, this work should be replicated with lower-SES samples. Moreover, this sample of parents may have been uniquely motivated - and findings may not generalize to a broader U.S. sample of parents - because these families were recruited from a children's museum and from users of an online family activity website; thus, these parents were seeking informal learning resources. There is a need to replicate these questions with more diverse families, as it may be important to match STEM programs to different profiles of parents who differ in baseline perceptions or access to resources.

Second, there were limitations to the specific items in our surveys. Our items measuring costs did not elucidate significant barriers preschool parents experience in doing science and math at home. Yet cost is an important factor and understudied factor (Flake et al., 2015). Therefore, future research should use additional approaches, including qualitative sources, to understand barriers and opportunity costs parents face in doing STEM. Although we added items about parent involvement in science and math activities beyond the initial items in the FACES and ECLS surveys, future studies could consider a more comprehensive set of STEM items. For example, given time for more comprehensive items, researchers could ask about how often parents and children: look at how things are made; take things apart to see how they work; try to fix broken objects together; talk about textures of materials; cook with your child; talk about how things change when you mix things; talk about changes when you apply heat/apply cold; or discuss STEM-related media (e.g., television, YouTube, etc.). Finally, an oversight in our item wording was asking about the mother's and father's occupation, which was not inclusive of more diverse family structures (e.g., asking about primary and secondary caregiver's occupations).

A third limitation is the reliance on parents' self-report of

involvement in STEM, rather than also including direct observation of parent-child interactions to examine the extent to which parents support STEM-related activities at home or within everyday routines. Future studies might consider how differences in both parents' and young children's motivation for STEM relate to: (a) children's science and math achievement, (b) the quality of parent-child discourse during STEM tasks, or (c) children's immediate neural responses during STEM tasks (cf., Callanan et al., 2017; Kim, Marulis, Grammer, Morrison, & Gehring, 2017; Ramani et al., 2015). It is possible that our findings may have differed if we had explicitly named aspects of STEM that are present in many daily activities (e.g., cooking, weather) and in many careers (e.g., construction, nursing); future studies should educate respondents on what "counts" as STEM (Ballard, Lesser, Reich, & Takahashi, 2019). These more diverse methodological approaches could also explain mechanisms for interest, persistence, and achievement in STEM.

### Conclusion and implications

Taken together, these findings point to the potential power of interventions that rely on motivation theory to: (a) explain to parents the value and relevance of STEM to children's academic and later career success, and (b) enhance parents' self-efficacy to perceive themselves as capable of facilitating informal STEM learning within their everyday activities. There is heterogeneity in effectiveness of preschool parent education programs (Castro et al., 2015; Grindal et al., 2016) that might be improved if programs were tailored to address parents' unique perceptions, rather than simply providing information or STEM experiences that do not address parent-child motivation. For example, a short, baseline EVT survey could help informal science educators understand how to adapt their messaging to address particular parent concerns that could include limited parental self-efficacy, high perceived costs/barriers to doing STEM, or weak expectations for their child's science and math achievement. By tapping into parents' relatively high value of STEM and desire to help their child reach their full potential, future EVT-based interventions could help parents see how they can play a key role in immersing their child in STEM beginning in early childhood.

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### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appdev.2021.101320>.

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