



# Parental Motivational Beliefs Predict Science Learning Opportunities in Early Years

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## Abstract

This study examined parents' beliefs and potential links with their children's (1) interest in science, (2) competence in learning science, and (3) science learning opportunities offered to their children. The study included a sample of 1,490 parents who had young children enrolled in U.S. preschool (3 years old, 55.9%) and pre-kindergarten (4 years old, 44.1%) classes. Data were collected via online surveys, which included three components: Perceived Science Motivation for Children-Parents Form, Parental Expectation and Support for Learning Science Questionnaire, and socio-demographic questions about parents and their children. Based on rankings of science and other curricular areas, parents' responses were classified into three groups: Low, Moderate, and High Preference for Science. Few parents prioritized science over other curricular areas in early learning classrooms, and parents' preferences for science were not associated with their incomes, levels of education, or the children's ages or sex. Parents' gender, however, was related to their preferences for science. Their beliefs about children's interest in science and competence to learn science were associated with home science resources, science-related conversations, and parental preferences for learning science in early childhood classrooms. Results from this study suggest that parents' beliefs about children's interest in science and competence to learn science predict the science learning opportunities provided to their children.

**Keywords** Early science education · Parental beliefs · Motivational beliefs · Home science learning

Previous studies suggest that limited time is devoted to science learning opportunities in typical preschool and kindergarten classrooms (Early et al., 2010; Greenfield et al., 2009; Nayfeld et al., 2011; Saçkes et al., 2011; Saçkes, 2014a). To date, most studies utilized teacher related variables to explain the scarcity of science learning opportunities provided in early childhood classrooms (Kallery & Psillos, 2001; Maier et al., 2013; Pendergast et al., 2017; Saçkes, 2014a; Sundberg et al., 2018). Nevertheless, other possible factors (e.g., parents' beliefs about early childhood science

teaching and learning) that might influence the frequency and type of science learning opportunities children receive in and out of school have remained understudied (Junge et al., 2021; Saçkes, 2014b; Saçkes et al., 2019). Extant literature suggests parents and caregivers can play a critical role in young children's early science learning, and parents' beliefs about children's interests in and competence to complete certain tasks might be related to parents' decisions about the type of learning experiences or opportunities they offer their children (Dunton et al., 1988; Jacobs & Bleeker, 2004; Junge et al., 2021; Miller, 1995; Saçkes, 2014b). Parents who believe their young children are interested in science, are capable of learning science-related concepts, and are able to develop science process or inquiry skills might be more likely to make science materials available at home and engage their children in science-related conversations. These parents might also prefer that their children engage in science-related experiences and learn science concepts in their early childhood classrooms.

Previous studies that examined the association between children's motivation to learn science and science learning

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opportunities presented to them measured children's science interest using a few items that targeted how often children engage with science related activities at home (Alexander et al., 2008, 2012). Although, measures of science motivation are available through teacher reports and by direct assessment of children (e.g., Oppermann et al., 2018; Patrick & Mantzicopoulos, 2015). To our knowledge, measures of children's science motivation, in the dimension of interest and competence, from the perspectives of parents are unavailable. The present study addresses this limitation in the literature by developing a new measure to assess children's interest and competence in learning science through parental reports. In the current study, we report the psychometric properties of the newly developed measures and investigate the hypothesized relation between parents' beliefs about children's interests in and competence to learn science and their decisions about the type of learning opportunities they offer to their children. The present study aimed to test this hypothesis by focusing on parents' beliefs and potential links to (1) children's interest in science, (2) children's competence to learn science, and (3) science learning opportunities offered to the children.

## Beliefs About Children's Interests in Science and Competence to Learn Science

Social-cognitive theories of motivation suggest that individuals' perceptions and beliefs influence their actions and behaviors (Bandura, 1986; Eccles & Wigfield, 2002; Elliot, 2005; Ryan & Deci, 2017; Weiner, 1992). Beliefs are critical constructs because they can determine an individual's effort, persistence, and enjoyment. Research has shown that parents' beliefs about science are associated with their children's motivation to learn science and pursue STEM careers (Chen, 2001; Dierking & Falk, 1994; Ferry et al., 2000). Parents' beliefs about their children's interest and competence in various activities can potentially influence children's own perceived motivation to learn (Frome & Eccles, 1998; Jacobs & Eccles, 1992). Therefore, examining parental beliefs about science learning in the early years may provide valuable information for our understanding of individual differences in young children's scientific literacy.

From infancy, children demonstrate preferences for certain objects (e.g., cars, dolls, dinosaurs, tea sets) and activities (DeLoache et al., 2007; Serbin et al., 2001). As their motor and language skills develop, children demonstrate and follow their interests in more noticeable ways, which provides parents ample opportunities to recognize their children's interests in and competence to use various objects and complete activities (Alexander et al., 2008; Chi & Koeske, 1983; DeLoache et al., 2007; Johnson et al., 2004; Leibham et al., 2013; Shirefley et al., 2020).

Studies demonstrated that children as young as 4 years of age begin to exhibit measurable motivational beliefs, through self-report, parental or teacher observations, about learning science (Leibham et al., 2013; Mantzicopoulos et al., 2008; Oppermann et al., 2018; Patrick et al., 2009; Patrick & Mantzicopoulos, 2015). Children openly and eagerly express their interest in science through their attention to and curiosity about the natural world and objects in their environments. As such, children provide their parents and early childhood educators with many clues about their dispositions toward science. They ask a wide range of diverse questions about natural phenomena. They also engage in science-related activities, show interest in and enjoyment of reading books about science-related topics, and integrate science themes into their play (Early et al., 2010; Leibham et al., 2013; Mantzicopoulos & Patrick, 2010; Mantzicopoulos et al., 2013; Patrick & Mantzicopoulos, 2015; Price et al., 2012; Saçkes et al., 2011).

Some parents may observe their children's enjoyment of science-related activities (e.g., using a magnifying glass, observing birds or the moon, pondering the origin of rain) while other parents may notice that their children avoid or are unwilling to engage in similar activities (Saçkes et al., 2010; Tenenbaum & Leaper, 2003). Parents' ongoing and casual observations of their children's activities and curiosity may inform and reinforce parents' beliefs about their children's interests and their competency to perform activities or tasks. The development of these types of parental beliefs appears to be influenced by the children's ages and sex (Leibham et al., 2013; Miller, 1988, 1995). When parents observe their children being highly engaged in science-related activities and the children appear to be competent in accomplishing associated tasks, the parents likely perceive their children as being highly interested in science and capable of learning science concepts (Alexander et al., 2012).

Parental beliefs about children's interest in science and competence in learning science concepts might be related to parents' expectations and practices at home (Miller, 1988; Saçkes et al., 2016). Previous studies reported that parents who offer supportive play and learning opportunities encourage their children's involvement in various activities and interest in different objects (DeLoache et al., 2007; Johnson et al., 2004; Neitzel et al., 2019; Saçkes et al., 2016). Parents who believe their children are interested in science and competent to learn science concepts might provide more opportunities for their children to engage with related science materials and participate in science-related activities (Alexander et al., 2012). They also might engage their children in more conversations about science topics, and parents might prefer that their children's early learning experiences include more science learning opportunities (Saçkes, 2014b; Tenenbaum & Leaper, 2003). Children's science interests were strong predictors of later science learning opportunities

at home, but science learning opportunities were not a predictor of later science interest (Alexander et al., 2012). Hence, parents' beliefs about children's interest in science and competence to learn science concepts may influence whether their children will be exposed to an environment that supports learning science at home and beyond.

Researchers have used a variety of methods to measure young children's motivation to learn science including a set of items administered individually in an interview format (e.g., Mantzicopoulos, et al., 2008; Oppermann et al., 2018; Patrick et al., 2009), observations of children's activity choices in formal and informal learning environments (e.g., Nayfield et al., 2011), and adult (teacher or parent) ratings of children's motivation (e.g., Alexander et al., 2012; Andre et al., 1999; Mantzicopoulos et al., 2013; Patrick & Mantzicopoulos, 2008). Few studies have attempted to measure young children's motivation to learn science using parental reports. In these studies, researchers either used a single item to assess parental expectations of their children's science performance (Andre et al., 1999) or used a few open-ended items to identify science related activities in which children engaged and then used them as indicators of children's motivation to learn science (Alexander et al., 2012; Johnson et al., 2004; Leibham et al., 2013). Due to the nature of the assessment tools employed, these previous studies did not report information on the psychometric properties of these measures.

Parents have extensive opportunities to make casual observations of their children's activities, which can provide many clues about children's dispositions toward science. Thus, parents can provide valuable information about their children's motivation to learn science that may not be captured by teacher reports and interviews with the child (Patrick & Mantzicopoulos, 2015). Although measures that produce valid and reliable scores have been developed for parents to assess children's motivation to learn in different domains including reading, sports, music, and arts, to our knowledge, no measure has been developed specifically for the domain of science motivation based on parental reports (Fredricks & Eccles, 2002; Wigfield et al., 1997). The present study addresses this gap in the literature by developing a measure that produces valid and reliable scores for young children's motivation to learn science using parental reports.

### Home Science Resources and Conversations

Studies have shown that the availability of educational materials for learning at home and parent–child conversation on mathematics, literacy, and science are significantly associated with children's cognitive outcomes (Barnett et al., 2020; Ma et al., 2016). Science-related conversations between parents and children and the use of science-related materials within the context of science activities at home

support children's interest in science and learning of science concepts (Callanan et al., 2002, 2020; Carter et al., 1999; Ennes et al., 2023; Junge et al., 2021; Leichtman et al., 2017; Tenenbaum et al., 2005). Studies suggest that there is a large variation in children's science knowledge before they enter kindergarten, and if not addressed, this knowledge gap tends to widen by the end of elementary school (Kähler et al., 2020; Koerber & Osterhaus, 2019; Morgan et al., 2016, 2024; Saçkes et al., 2013). Thus, researchers have suggested that efforts to address the science knowledge gap among preschoolers should begin prior to kindergarten and include supportive home learning environment (Junge et al., 2021; Morgan et al., 2016, 2024; Saçkes et al., 2011; Zucker et al., 2021). Therefore, examining science resources and science-related conversations at home is important to the development of science literacy and has potential to inform the development and design of interventions to support early science learning.

By providing relevant science-related objects and materials to their children and engaging them in conversations about the natural world, parents encourage and facilitate their children's early learning experiences about science (Alexander et al., 2012; Junge et al., 2021; Saçkes, 2014b; Strickler-Eppard et al., 2019). Despite the lack of empirical evidence to the contrary, parents, in general, expect boys to perform better in science than girls, and they tend to believe that girls are less interested in science and less competent to learn science than boys (Andre et al., 1999; Herbert & Stipek, 2005; Spelke, 2005; Tenenbaum et al., 2005). Consequently, parents tend to provide boys with more science-related toys and materials that help them engage with science phenomena and support the development of their scientific thinking (Alexander et al., 2012; Freeman, 2007; Simpkins et al., 2005; Tracy, 1987). During conversations with their children, parents ask questions, offer clues, and provide explanations that facilitate their children's understanding of science phenomena, including concepts in the domains of Earth/Space, Life, and Physical Science. Parents also support their children's development of scientific thinking (Callanan et al., 2002; Cumming, 2003; Jipson & Callanan, 2003; Rigney & Callanan, 2011; Tenenbaum & Callanan, 2008; Tenenbaum et al., 2005). Yet boys, when compared to girls, seem to have more opportunities to participate in conversations about science topics, and they tend to be challenged more often during parent–child discussions (Crowley et al., 2001). Home science resources (i.e., science-related materials and toys), shared science and nature related picture book reading, and parent–child conversations about scientific phenomena, which are key components of science-related cultural capital, have potential to encourage and facilitate children's early science learning and development of science process skills (Archer et al., 2015; Junge et al., 2021). The child's sex appears to be one of the moderators

that influence the amount and type of access children have to science resources as well as the nature of parent–child science-related conversations. Parents' educational attainment, non-minority status, and parents own interest in science were also identified as predictors of the science learning opportunities provided at home (Junge et al., 2021).

Nonetheless, the contribution of other variables, beyond the children's sex (i.e., parental motivational beliefs regarding their children's interest in science and competence to learn science concepts), to the children's access to science learning opportunities has yet to be considered. Parents' beliefs about their children's interest in science and competence to learn science might predict whether the parents offer science-related objects and materials to their children and converse with them about the natural world.

### Parental Priorities for Science

Studies on parental beliefs regarding science learning in preschool and kindergarten curricula are scarce. Typically, previous research studies have focused on parents' beliefs regarding the relative importance of traditional academic domains (i.e., literacy, mathematics) in preschool and kindergarten curricula (Hewitt & Maloney, 2000; Kernan & Hayes, 1999; Knudsen-Lindauer & Harris, 1989). Parents' perceptions about science teaching and learning during the early childhood years was the focus of recent studies, which included samples of Turkish, U.S., German, and Irish parents (Gilligan et al., 2020; Junge et al., 2021; Saçkes, 2014b, Saçkes et al., 2019). The findings of these studies demonstrated that parents rarely selected science as a priority over other curricular areas. While we are not suggesting that science or any other area should be prioritized over others, coherently organized science content can serve as the hub of an integrated approach to early childhood curricula that integrate literacy, mathematics, social studies, and the arts (French, 2004).

When asked to rank science among other curricular areas, a small percentage of Turkish (6%) and U.S. (5.6%) parents prioritized science among their top three choices (Saçkes et al., 2019; Saçkes, 2014b). In contrast, seventy percent of the Irish parents ( $n = 85$ ) believed that science should be taught in preschool (Gilligan et al., 2020). This high percentage of endorsement among Irish parents might be due to sampling bias as the respondents were attending a science workshop. German parents had a low mean score (less than 3 out of 12) on beliefs about science education in the preschool scale. Parental beliefs about the importance of learning science in preschool was not a statistically significant predictor of science learning opportunities provided at home (Junge et al., 2021). This finding is not surprising as limitations in parental confidence and skills in managing and responding their children's science and nature related

inquiries prevent many parents from providing science learning opportunities at home (Gilligan et al., 2020). The low preference for science among parents of young children might be due to beliefs that they are not able to understand science concepts or develop related science process skills. Thus, parents might believe that teaching young children science concepts is developmentally inappropriate (Saçkes et al., 2019; Saçkes, 2014b;).

### Theoretical Framework

An opportunity–propensity framework (Byrnes & Miller, 2007; Byrnes & Wasik, 2009; Jones & Byrnes, 2006) informed the design of this research study, and the researchers used this framework to examine parental beliefs regarding children's interest in science and competence to learn science concepts and the potential influence of these beliefs on the science learning opportunities provided to their young children. An opportunity–propensity framework suggests that the learning of any academic content domain relies on two main factors: opportunity (i.e., opportunities to learn science) and propensity (i.e., ability and motivation to learn from the opportunities provided) (Byrnes & Miller, 2007; Byrnes & Wasik, 2009; Saçkes et al., 2011, 2013). Antecedent factors typically include socio-economic status and sex to account for variations among children's propensity factors as well as the types of learning experiences to which they are exposed (Byrnes & Wasik, 2009). In the current study, socio-economic status was controlled via the study design (the sample of the study included high SES parents) and the gender variable was controlled using multiple group path analysis. Previous studies that used the opportunity–propensity framework included two types of antecedent factors: child-level (i.e., child's sex) and teacher-level (i.e., years of experience) (Byrnes & Miller-Cotto, 2016; Lewis & Farkas, 2017; Saçkes et al., 2013). In the present study, the researchers incorporated parent-level antecedent factors (i.e., perceived interest and competence of their child) into the framework to examine how parental beliefs predict the learning opportunities provided to their children (i.e., science-related materials provided to children at home, science-related conversations parents and their children engaged in at home, and parents' preferences for learning science in preschool and pre-kindergarten classrooms).

### Purpose of the Study

The foci of this research study included:

- (1) Examine psychometric properties of the instruments, which were designed to assess parental beliefs about children's interest in science and competence to learn

- science, and identification of materials provided to encourage and facilitate science learning at home;
- (2) Test the hypothesized relation between parents' beliefs about children's interest in science and competence to learn science and the science learning experiences provided to young children.

## Methods

### Sample

The sample for this study ( $n = 1,490$ ) included caregivers (i.e., parents and other family members or adults) who had children enrolled in private preschool (3 years old, 55.9%) and pre-kindergarten (4 years old, 44.1%) classrooms in the United States. Most participants self-identified as mothers of the children (81.1%), with smaller groups of respondents identifying as fathers (18%) or other caregivers (e.g., foster parents, grandmothers, etc.). Since most caregivers who responded to the surveys were parents (99.1%), "parents" encompasses all caregivers in this study. In other words, the use of the term "parents" refers to all adult caregivers (i.e., grandparents, foster parents, uncles, aunts).

The mothers' average age was 33 years (Median = 32 years) compared to 37 years for the fathers (Median = 36 years). The vast majority of participants had earned post-secondary degrees (associate's, 9.2%; bachelor's, 45.4%; Master's, 31.1%; Doctoral, 11.7%), and very few participants did not report their level of education (2.6%). The majority of participants (67%) reported monthly household incomes of more than \$6251, compared to smaller percentages with reported monthly incomes of \$4201–6250 (18.7%) or \$2501–4200 (14.4%). The majority of participants reported having two children in the household (53.3%) compared to households with a single child (35.3%) or three or more children (11.2%). About a third of participants (29%) reported previous enrollments and attendance of their older children in preschool. The gender of the children was about evenly split (Girls = 50.8%, Boys = 49.2%).

### Data Collection

Data were collected through online surveys. Parents and other caregivers who had children enrolled in one of 335 private preschools were invited, via email, to participate in the research. The data were collected within a 2-month period. The survey, which respondents completed online, included three components: Perceived Science Motivation for Children-Parents Form, Parental Expectation and Support for Learning Science Questionnaire, and questions

about parents' and their children's socio-demographic characteristics. The data used in this study were deidentified secondary data obtained from an evaluation project of a regular school program.

### Instruments

As mentioned above, the online survey package included three components: Perceived Science Motivation for Children-Parents Form (assessment of parental beliefs about children's interest in science and competence to learn science), Parental Expectation and Support for Learning Science Questionnaire (where parents were asked to report the availability and usage of science-related materials at home [*Home Science Resources Scale*], describe science-related talks at home [*Home Science Talk Scale*], and prioritize eleven areas, including science, in a descending order [*Parental Priorities for Science*]), and questions about parents' and their children's socio-demographic characteristics.

#### Perceived Science Motivation for Children-Parents Form (PSMC-P)

This scale was developed by the researchers for the current study. Initially, a total of 12 items were generated based on a theoretical framework of interest (Alexander et al., 2008; Hidi, 1990; Hidi et al., 2004; Johnson et al., 2004; Krapp, 1999) and competency beliefs literature (Bandura, 1986; Patrick & Mantzicopoulos, 2015; Patrick et al., 2009; Wigfield & Eccles, 1994). The scale items that targeted parental beliefs about children's science-related interests were designed to reflect preschoolers' and kindergartners' dispositions and affective reactions to science-related activities (e.g., My child pretends to be a scientist during play). Items that targeted parents' beliefs about young children's competence to learn science were generated to capture the children's efficacy in performing inquiry/science process skills and understanding science concepts while engaging in parent-child interactions at home (e.g., My child is capable of making observations of science phenomena). A panel of three researchers who held Doctorate degrees in early childhood science education reviewed the instrument items for clarity and content validity. The panel members' suggested revisions for several items to improve clarity and content validity while suggesting removal of two items from the item pool. All suggested revisions were made to finalize the draft scale. The final draft of PSMC-P consisted of two-subscales: Interest and Competence each included five items. The final version of the PSMC-P included seven items. Parents responded to each item by using a five-point scale, which ranged from 1 (never) to 5 (always). The scores obtained from the PSMC-P had sound psychometric properties, and

detailed information about the psychometric properties of the scale follows in the results section below.

### Parental Expectation and Support for Learning Science Questionnaire (PEQ)

This instrument was developed for the current study and consisted of three parts: *Home Science Resources*, *Home Science Talk*, and *Parental Priorities for Science*.

*Home Science Resources Scale (HSRS)*: The first part of the scale included 16 items targeting science-related materials provided to children to support their science learning at home. Parents reported the availability and usage of common and specific science-related materials on a three-point scale (1 = “Never owned or used”, 2 = “Own”, and 3 = “Own and Used by child”). The following materials were included in the Scale: Maps, Magnifying glass, Picture books with a science focus, Microscope, Ruler, Yard/meter stick, Weight scale, Compass, GPS, Measuring cups, Weight (bathroom) scale, Timer, Thermometer, Chemistry or science kit, Lego blocks, and other Building blocks (K'nex/ Goldieblox). The final version of the HSRS included 11 items. The scores obtained from the HSRS had sound psychometric properties, and specific psychometric properties details from the *Home Science Resources Scale* follow in the results section.

*Home Science Talk Scale (HSTS)*: The second part of the questionnaire included a single open-ended item targeting science-related conversations in which parents and their children engaged at home. “Do you talk about scientific phenomena (Rain, Day and Night, Living Things, Properties of Objects, etc.) with your child? If so, please describe your conversations with your child.” Parents’ responses to this question were coded as either 0 or 1 under three science domains (e.g., Earth/Space, Life, Physical Science).

*Parental Priorities for Science (PPS)*: The final section, *Parental Priorities for Science*, was based on the questionnaire developed by Saçkes and colleagues (2014b, 2019). This questionnaire required parents to prioritize, in descending order, eleven curriculum areas. Respondents ranked their top curriculum priority (i.e., the most important area for their children to learn) at number 1, and their lowest priority (i.e., least important area) was ranked at number 11 on the survey (Saçkes et al., 2019).

*Demographic Information*: The last component of the online survey included socio-demographic questions about the respondents’ sex and level of education and monthly household income along with their children’s ages and sex.

### Data Analysis

Before data analysis, the researchers inspected the data for any missing values, which ranged from 1.2% to 2.7%. The researchers used the Expectation–Maximization imputation

method (SPSS version 24) to impute missing data, and all analyses used the imputed data set.

The psychometric properties of the scales used in the study were examined using a two-step EFA/CFA approach. Initially, the researchers randomly split the data set into two halves. They analyzed the first set, which included responses from 745 parents, using a Principal Component Analysis (PCA) while analyzing the second set, which included 745 parents’ responses, with a Confirmatory Factor Analysis (CFA). The researchers used R software version 2.10.1 (R Development Core Team, 2012) to perform PCA on Polychorich correlation matrices, and they used Varimax rotation to interpret the PCA results. The researchers used traditional (Kaiser Rule and Scree Plot) and contemporary empirical approaches (Parallel Analysis) to decide on the number of components to retain. Items with cross loadings and loadings with less than 0.32 were eliminated to derive empirically and theoretically sound measures. The researchers used MPLUS version 6.12 (Muthen & Muthen, 1998–2011) to conduct CFA on Polychorich correlation matrices using Weighted Least Squares with Mean and Variance Adjustment (WLSMV) method of estimation. They used the following fit indices to examine the fit of the CFA models: Chi-Square Model Fit ( $\chi^2$ ), Root Mean Square Error of Approximation (RMSEA), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Weighted Root Mean Square Residual (WRMR).

The researchers used a Chi-square test to examine the associations between the demographic information and the parents’ rankings of science. They used two-way ANOVAs to look at age and sex relations with motivational beliefs, home science resources, and home science conversations. Univariate analyses were performed using SPSS version 24. The researchers used multiple group path analytic approach to test the theoretical model (i.e., parental beliefs about their children’s motivation for science learning and the relation to early science learning opportunities provided to children). Initially, the model was tested in two groups of children (Girls and Boys samples) separately. Then, the unconstrained model where all path coefficients were freely estimated and the constrained model where all path coefficients were forced to be equal were tested. Chi-square difference test was used to compare model fit, and Wald test was used to compare the strength of the path coefficients between the samples of boys and girls. The following fit indices were used to examine the fit of the path models: Chi-Square Model Fit ( $\chi^2$ ), Root Mean Square Error of Approximation (RMSEA), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Standardized Root Mean Square Residual (SRMR).

## Results

### Psychometric Properties of the Perceived Science Motivation for Children-Parents Form (PSMC-P)

The researchers deemed the first data set acceptable for PCA based on results from the Barlett’s test of Sphericity (BTS) and the Kaiser–Meyer–Olkin test (KMO). Based on eigenvalues larger than 1, two components emerged, and three items had cross loadings based on the results of the initial analysis. After the removal of the three identified items loading on two factors, the researchers repeated the analysis with the seven items that remained. The researchers identified two components with eigenvalues greater than 1 (factor 1: eigenvalue = 3.87, variance = 55.28%; factor 2: eigenvalue = 1.30, variance = 18.5%). The range for the Varimax rotated factor loadings was from 0.81 to 0.90 for the Competence subscale and 0.75 to 0.82 for the interest subscale. The researchers retained two components based on the results of Kaiser’s criterion, parallel analysis, the scree test, and theoretical soundness. The first component included four items while the latter included three items. The four-item competence subscale yielded a Cronbach’s alpha of  $\alpha = 0.88$ , compared to  $\alpha = 0.67$  for the three-item interest subscale.

The researchers used the second data set to conduct a confirmatory factor analysis to validate the model, which emerged in the preceding principal component analysis. The results supported the two-factor model ( $\chi^2 = 52.076$ ,  $df = 13$ ,  $p < 0.001$ ; RMSEA = 0.064, % 90 CI = 0.046–0.082; TLI = 0.99; CFI = 0.99; WRMR = 0.72).

### Psychometric Properties of the Home Science Resources Scale

The results of the KMO and BTS indicated that the first data set was suitable for principal component analysis. Three components emerged with eigenvalues larger than 1. However, a two-factor solution was appropriate for the data based on parallel analysis (component 3: eigenvalue = 1.145, parallel analysis component 3: eigenvalue = 1.2). In the initial

analysis, five items loaded on two or more components. The researchers eliminated the cross loaded items, and they reperformed the analysis with the remaining 11 items. Two components with eigenvalues greater than 1 emerged (factor 1: eigenvalue = 3.76, variance = 34.18%; factor 2: eigenvalue = 2.06, variance = 18.8%). The range for Varimax rotated factor loadings were from 0.53 to 0.83 for the Common subscale and 0.57 to 0.81 for the Specific subscale. The researchers retained two components based on the results of Kaiser’s criterion, parallel analysis, the scree test, and theoretical soundness. The seven-item Common subscale had a Cronbach’s alpha of  $\alpha = 0.88$  and  $\alpha = 0.67$  for the four-item Specific subscale.

The researchers used the second data set to perform a confirmatory factor analysis to validate the model that emerged in the preceding principal component analysis. The results supported the two-factor model ( $\chi^2 = 128.08$ ,  $df = 43$ ,  $p < 0.001$ ; RMSEA = 0.052, % 90 CI = 0.041–0.062; TLI = 0.96; CFI = 0.97; WRMR = 1.16).

### Comparison of Motivational Beliefs and Home Science Resources Scores

Table 1 provides the means and standard deviations of the perceived interest and competence scores and common and specific home science resources scores for the overall sample of children. Subgroup results (e.g., ages [preschool, 3 yrs old and pre-kindergarten, 4 yrs old], sex [girls and boys],) are also presented in Table 1. In general, boys and older children (i.e., pre-kindergartners) scored higher on all measures (except competence) when compared to girls and preschoolers.

The researchers examined the potential influence of children’s ages and sex on motivational beliefs and home science resources by conducting a series of two-way ANOVA tests using two levels for the children’s ages (preschoolers [3 yrs old] and pre-kindergartners [4 yrs old]) and two levels for children’s sex (boys, girls). The results indicated that the main effects of age ( $F_{1,1486} = 10.54$ ,  $p = 0.001$ ,  $\eta^2 = 0.01$ ) and sex ( $F_{1,1486} = 5.14$ ,  $p = 0.024$ ,  $\eta^2 = 0.01$ ) were statistically significant, while there was

**Table 1** Means and standard deviations of motivational beliefs and home science resources scores

	Interest		Competence		Common HSR		Specific HSR	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
All	8.41	2.57	14.58	3.42	15.47	2.34	6.50	2.09
Girls	8.27	2.59	14.64	3.43	15.38	2.33	6.37	2.02
Boys	8.56	2.54	14.51	3.40	15.56	2.34	6.64	2.15
Preschoolers	8.22	2.58	14.02	3.58	15.33	2.39	6.15	1.91
Pre-Kindergartners	8.66	2.54	15.28	3.04	15.65	2.25	6.95	2.21

Interest scores ranged from 3 to 15, Competence scores ranged from 4 to 20, Common HSR scores ranged from 7 to 21, and Specific HSR scores ranged from 4 to 12

no significant interaction between age and sex. Boys and pre-kindergartners had higher interest scores than girls and preschoolers. The results for the competence scores indicated that only the main effect of age ( $F(1,1486) = 51.78$ ,  $p = 0.001$ ,  $\eta^2 = 0.03$ ) was statistically significant. Pre-kindergartners had higher competence scores than preschoolers. Likewise, the results for the common home science resources scores indicated that only the main effect of age ( $F(1,1486) = 6.95$ ,  $p = 0.008$ ,  $\eta^2 = 0.01$ ) favoring pre-kindergartners was statistically significant. On the other hand, for the analysis of specific home science resources scores, the main effects of age ( $F(1,1486) = 6.28$ ,  $p = 0.012$ ,  $\eta^2 = 0.04$ ), favoring pre-kindergartners, and sex ( $F(1,1486) = 56.95$ ,  $p = 0.001$ ,  $\eta^2 = 0.01$ ), favoring boys, were statistically significant.

### Home Science Talks

Parents' responses to the question "Do you talk about scientific phenomena (Rain, Day and Night, Living Things, Properties of Objects, etc.) with your child? If so, please describe your conversations with your child" were coded under three science content domains (e.g., Earth/Space, Life, Physical Science) and scored as either 0 (No) or 1 (Yes). Table 2 illustrates that parents identified the Earth/Space Science phenomena as the most popular content area (49.2%) to talk about with their children, and the Physical Science phenomena were identified as the least popular (7.8%) science domain for family conversations. A linear combination of these responses was calculated using principal component analysis to create a composite Home Science Talks variable with a mean of zero and standard deviation of one. The results of a two-way analysis of variance test of age and sex on home science conversation scores revealed no statistically significant main effects.

**Table 2** Parents talking about scientific phenomena

	Frequency	Percent	Valid percent
Earth & space science			
No	757	50.8	50.8
Yes	733	49.2	49.2
Total	1490	100.0	100.0
Physical science			
No	1374	92.2	92.2
Yes	116	7.8	7.8
Total	1490	100.0	100.0
Life science			
No	1291	86.6	86.6
Yes	199	13.4	13.4
Total	1490	100.0	100.0

### Parental Priorities for Science

The researchers used descriptive statistics to examine the parents' rankings of the 11 academic and developmental areas. The results identified that parents ranked their highest preferences as (1) ethics and moral values (27.8%), (2) social skills (27.6%), (3) pre-reading (20.3%), (4) pre-writing (7%), (5) physical development (7.8%), and (6) mathematics (5.4%). Parents' lowest preferences were ranked (7) social studies (0.07%), (8) second language (0.6%), (9) science (0.47%), (10) music (0.40%), and (11) arts and esthetics (2.62%). Less than six percent of parents (5.6%) identified science within their first three choices of preferred academic content areas. The researchers classified parents into three groups according to where they ranked science among the other curricular areas: Low, Moderate, and High Preference for Science. Parents who selected science within their first-three preferences were classified into the High Preference for Science group (5.6%), while parents who selected science within their last-three preferences were classified into the Low Preference for Science group (32.9%). The remaining parents were classified into Moderate Preference for Science group (61.5%).

The Researchers used a Chi-Square test to examine the relation between demographic data and group membership. When the expected frequencies were less than five, categories were collapsed. Parents' preferences for science were not associated with parents' income ( $\chi^2(4, N = 1490) = 1.36$ ,  $p = 0.85$ ) or level of education ( $\chi^2(6, N = 1490) = 4.97$ ,  $p = 0.55$ ), and child's sex ( $\chi^2(2, N = 1490) = 0.83$ ,  $p = 0.66$ ) or age ( $\chi^2(2, N = 1490) = 2.17$ ,  $p = 0.34$ ). Parents' gender ( $\chi^2(2, N = 1151) = 6.52$ ,  $p = 0.038$ ,  $\phi = 0.07$ ), however, was related to parental preferences for science. More specifically, mothers were less likely than fathers to be categorized in the High Preference for Science groups. Also, parents in the Low Preference for Science group ( $\chi^2(2, N = 1490) = 22.66$ ,  $p = 0.001$ ,  $\phi = 0.12$ ) were less likely than parents in the High and Moderate Preference groups to talk about Physical Science phenomena with their children.

### Motivational Beliefs and Early Science Learning Opportunities

The researchers used multiple group path analyses to test the theoretical model, which reflected parental beliefs and potential links with their children's (1) interest in science, (2) competence to learn science, and (3) science learning opportunities offered to their children. Initially, the hypothesized model was tested separately in two groups of children (Girls  $n = 757$  and Boys  $n = 733$  samples). The model chi square values were not statistically significant, and the fit indices were in an acceptable range for the samples of girls and boys (See Table 3). The results suggested that the model

**Table 3** Fit indices for the models

Model Fits	Model 1		Model 2. Unconstrained Model	Model 3. Fully Constrained Model
	Girls n = 757	Boys n = 733	n = 1490	n = 1490
Chi-Square	10.71 DF:5 P:0.057	3.06 DF:5 P:0.69	13.77 DF:10 P:0.184	21.03 DF: 19 P:0.335
RMSEA	0.039 90% C.I. 0.00–0.071	0.00 90% C.I. 0.00–0.039	0.022 90% C.I. 0.00–0.049	0.012 90% C.I. 0.00–0.035
CFI	.96	1.00	0.99	0.99
TLI	.90	1.00	0.97	0.99
SRMR	0.018	0.018	0.018	0.028

fits the boys’ sample slightly better than the girls’ sample. Nevertheless, the model fits both samples’ data well. Then, the unconstrained model was tested where all path coefficients were freely estimated for the samples of boys and girls simultaneously. The results indicated that the model chi square value was not statistically significant, and the fit indices were in an acceptable range, suggesting that the unconstrained model fits the data well (See Table 3). Finally, the constrained model where path coefficients were forced to be equal for both samples was tested. The results indicated that the model chi square value was not statistically significant, and the fit indices were in an acceptable range suggesting that the constrained model fits the data well. The results of the chi-square difference test that was used to compare the unconstrained and constrained model fits indicated no statistically significant difference between the two models ( $\chi^2 = 7.26, df = 9, p = 0.61$ ).

The results demonstrated that the observed strength of the path coefficients varied among the samples of boys and girls (See Table 4). For example, two path coefficients were not statistically significant in the boys’ sample (path from interest to common home science resources and path from

interest to home science talks), but these paths were statistically significant in the girls’ sample. A series of Wald tests was used to examine whether the observed differences in path coefficients between the samples of boys and girls were statistically significant. The results indicated that none of the differences in the strength of the path coefficients between the samples of boys and girls were statistically significant ( $p > 0.05$ ), suggesting that the observed differences were trivial. These results provided further evidence that the results for the constrained model can be used for the combined samples and the theoretical model did not vary based on children’s sex. Figure 1 illustrates the standardized path coefficients for the model tested by the researchers.

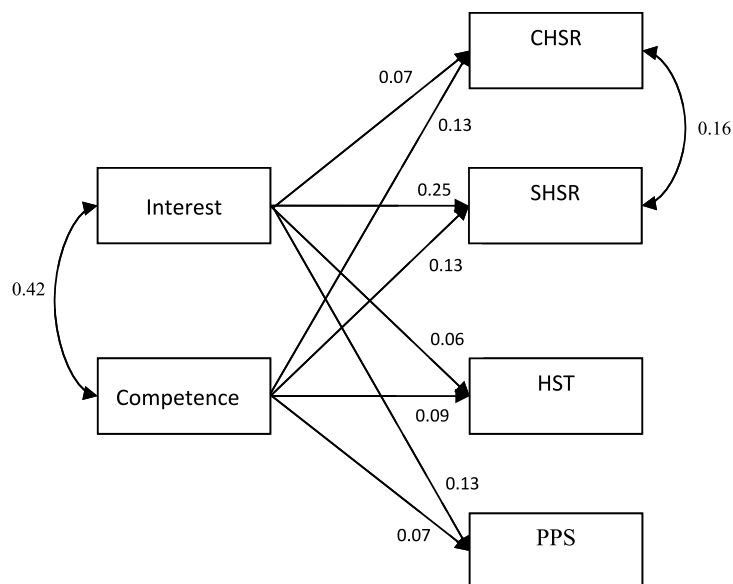
The hypothesized direct effects of perceived science interest on common home science resources ( $\beta = 0.07, t = 2.30, p < 0.05$ ), specific home science resources ( $\beta = 0.25, t = 9.17, p < 0.05$ ), home science conversations ( $\beta = 0.06, t = 2.34, p < 0.05$ ), and parental priorities for science ( $\beta = 0.13, t = 4.54, p < 0.05$ ) were statistically significant. The results also indicated statistical significance for direct effects of perceived science competence on common home science resources ( $\beta = 0.13, t = 4.24,$

**Table 4** Path coefficients for the models

Variables	Path Coefficients Girls	Path Coefficients Boys	Path Coefficients Constrained Model Girls and Boys
Interest → CHSR	.079*	.039	.061*
Interest → SHSR	.177*	.232*	.201*
Interest → PPS	.024*	.022*	.023*
Interest → HST	.037*	.011	.024*
Competence → CHSR	.070*	.112*	.089*
Competence → SHSR	.092*	.068*	.082*
Competence → PPS	.013*	.014*	.013*
Competence → HST	.027*	.025*	.026*
Interest ↔ Competence	3.37*	4.057*	3.73*
CHSR ↔ SHSR	0.687*	0.861*	0.68*

\*Unstandardized Path coefficient is significant at .05

**Fig. 1** The results for the hypothesized model of motivational beliefs and early science learning opportunities



$p < 0.05$ ), specific home science resources ( $\beta = 0.13$ ,  $t = 5.16$ ,  $p < 0.05$ ), home science conversations ( $\beta = 0.09$ ,  $t = 3.32$ ,  $p < 0.05$ ), and parental priorities for science ( $\beta = 0.07$ ,  $t = 2.30$ ,  $p < 0.05$ ). The model explained variance in: common home science resources (3%), specific home science resources (11%), home science conversations (2%), and preference for science (3%). The effects sizes for all standardized path coefficients and explained variance corresponded to a small effect (Cohen, 1992).

We further examined the associations between the individual perceived science interest and competence items and common and specific home science resources, home science conversations, and parental priorities for science scores using Spearman correlations. We only considered reporting typical or medium ( $r = 0.20$  or higher) correlation coefficients, which have practical implications (Gignac & Szodorai, 2016). Although, statistically significant, due to a large sample size, none of the correlation coefficients between perceived science interest and competence items and common home science resources were at or above 0.20. On the contrary, correlations between all five perceived science interest items and specific home science resources were above 0.20, ranging 0.20 and 0.29 ( $p < 0.001$ ). Only two competence items (My child is capable of understanding science phenomena and My child is capable of using tools. (e.g. magnifying glasses)) had correlation coefficient at or above the threshold, 0.21 and 0.25 respectively. Although, statistically significant, all correlation coefficients between interest and competence items and home science conversations, and parental priorities for science were below the threshold, ranging from 0.07 and 0.15.

## Discussion

The results of the research reported here support the hypothesized link between parental beliefs and potential links with their children's (1) interest in science, (2) competence to learn science, and (3) science learning opportunities available at home. In other words, the findings of this research demonstrated that parents who believed their young children were interested in and capable of learning science concepts and developing science process skills were more likely to make science materials available to children at home. These parents also were more likely to discuss scientific phenomena with their young children, and they preferred that early childhood classrooms offer science learning opportunities for their children.

The results indicated that parents who perceived that their youngsters were interested in and competent to learn science were more likely to provide science-related materials at home. Perceived interest in science appeared to be more important than perceived competence in predicting whether children were provided specific science-related materials at home. Researchers reported a similar trend in early literacy studies where parental perceptions of their children's interests were strong predictors of home-based early literacy practices (Saçkes et al., 2016). A logical question stems from these results: Why are parents' beliefs about children's interests better predictors than parents' competency beliefs? While the former construct (i.e., parental beliefs about their children's interests) appears to be well-formed even in the early years, the latter construct (i.e., parents' beliefs about children's competency) might

remain as an emerging construct (Alexander et al., 2008; Johnson et al., 2004). Parents may have more opportunities to make observations of their children's activities, which may inform the development of parents' beliefs about their children's interest in science and science learning (Alexander et al., 2012). Once parents make decisions regarding their young children's interests in science, they might be more inclined to make observations and assessments of their child's performances in science-related activities (Leibham et al., 2013). These observations and related assessments might subsequently support the development of their beliefs regarding children's science learning competency. The construction of parents' beliefs regarding children's science interests might serve as a precursor for the development of their beliefs about children's science learning competency (Alexander et al., 2012; Saçkes et al., 2016). Furthermore, parents might lack the required science capital (i.e., social and cognitive resources that promote science learning) to assess their children's understandings of science concepts and development of science process skills, which may limit their judgments of their children's competence to learn science (Archer et al., 2015; Mantzicopoulos et al., 2013; Saçkes, 2014b; Siegel et al., 2007; Zady & Portes, 2001). Due to a cross-sectional design of the current study, the temporal order of the formation of parental beliefs cannot be empirically tested. Further research employing cross-lagged longitudinal design are needed to examine the temporal order of the formation of parental beliefs about their children's competency and interest in learning science.

Parents who perceived that their children were interested in science and competent to learn science were more prone to engage in conversations about science topics with their children. Both interest and competency beliefs seemed to be equally important in predicting parents' engagement of children in science-related conversations. Our data indicated that the most common topic of parent–child science-related conversations focused on Earth/Space Science phenomena. Few parents reported that they talk about Life Science concepts and even fewer reported talking with their children about Physical Science concepts. These findings signal a cause for concern as the extant research literature clearly indicates that Physical Science concepts are the least represented phenomena in home science activities and early childhood classrooms as well as in picture books about science topics (Saçkes et al., 2009, Saçkes, 2014a; Tenenbaum & Leaper, 2003). The results of this study suggest that young children's limited exposure to Physical Science concepts in their early science experiences seems to begin at home. Since young children's opportunities to learn about Physical Science concepts appear to be limited at home as well as in early childhood classrooms, students' reports of feeling less competent in Physical Science areas and the findings that

young children do not differentiate physical and life science domains in evaluating their motivational beliefs regarding learning science is not surprising (Andre et al., 1999; Oppermann et al., 2018). As educators design science experiences for early learners, curricula should be balanced to include Physical Science concepts.

In the present study, parents who believed that their youngsters were interested in science and competent to learn science were more likely to rate science as a higher priority, and they expressed a preference that their young children be offered science learning opportunities in their early childhood classrooms. When parents considered curricular options, their children's perceived interest in science appeared to be a more important factor than parents' perceptions of children's competency to learn science. In a recent study with German parents, parental beliefs about the importance of learning science in preschool was found to be not a statistically significant predictor of home science activities including shared science and nature related picture book reading and engaging science and nature related talks with children (Junge et al., 2021). Parents might appreciate the importance of learning science in early childhood classrooms for their youngsters. Nonetheless, the limitations in parental confidence and skills in managing and responding to their children's science and nature related inquiries may prevent them from providing science learning opportunities at home (Gilligan et al., 2020). Moreover, many parents might have limited science content knowledge and knowledge of pedagogical practices to support their children's understanding of science concepts and development of science related skills (e.g., Archer et al., 2015; Gilligan et al., 2020; Mantzicopoulos et al., 2013). The findings of the current study demonstrated that parental beliefs regarding their children's interest in and competence to learn science might be better predictors of home science learning opportunities (providing science-related conversations and materials) than their beliefs about the importance of learning science in preschool. Parental perceptions regarding their children's motivational beliefs to learn science might predict both formal and informal science learning opportunities children have. A growing body of research has accumulated regarding the parental role in providing informal science learning opportunities to preschool children at home, museums, and science exhibits where parents of children at these younger ages have a predominant role (e.g., Callanan et al., 2002, 2020; Gilligan et al., 2020; Hightower et al., 2022; Raynal et al., 2022). However, limited attention has been devoted to the parental role in preschoolers' and kindergartners' learning of science in formal learning settings. Further studies are needed in this understudied area of research.

In summary, the overall findings of this study suggest that parents' beliefs about their children's interest in science and children's competence to learn science appear to result

in variations in early science learning opportunities offered to the children at home and in their classrooms. Thus far, previous research studies focused on teacher related variables to explain the limited science learning opportunities for young children in preschool and kindergarten classrooms. Other possible factors, such as parental beliefs, have remained understudied (Gilligan et al., 2020; Junge et al., 2021; Saçkes, 2014b). The results presented here provide preliminary evidence that parents' beliefs regarding early childhood science teaching and learning associate with the nature and frequency of science learning opportunities provided to children both in school and at home. The sample of the present study mainly consisted of parents with high income and educational attainment. Therefore, the results cannot be generalized to the parents from lower income or lower educational attainment levels. The model tested in the current study should be further tested with samples of parents from diverse backgrounds including parents with low and moderate SES and parents with children attending public schools. The findings of this study call for additional research to further examine possible causal relations between parental beliefs and variations in the quantity and quality of young children's early science learning opportunities and how these variables may associate with children's later academic success and future career choices.

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## Declarations

**Competing interests** The authors have not disclosed any competing interests.

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