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Parent-Child Math Talk:

How Expectations and Conversational Patterns Predict Fraction  
Learning

By

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### Abstract

Parental beliefs and interaction styles play a critical role in predicting children's early math development. This study examined how parents' expectancy-value beliefs and conversational behaviors during a brief parent-child math conversation predicted children's learning improvements in fraction understanding. A total of 105 parent-child dyads (child age:  $M = 5.83$  years,  $SD = 0.69$ ) participated in a structured online task that included a pretest, a fraction conversation using a provided prompt, a posttest, and a parent belief survey. Parent-child conversations were transcribed and coded for feedback types, question formats, and turn-taking balance (i.e., the relative distribution of speaking turns between parent and child, coded as balanced if both contributed roughly equally, and unbalanced if one speaker dominated). Regression analyses showed that parents' expectancy beliefs—their confidence in their child's math ability—significantly predicted children's learning improvement, even after controlling for pretest performance. In contrast, value beliefs—how important parents felt math was for their child—did not predict learning outcomes, though they were associated with a higher proportion of open-ended questions. None of the four feedback types (encouraging, confirmatory, corrective, elaborated) significantly predicted learning when considered simultaneously. These findings highlight the importance of separating expectancy and value beliefs and suggest that parental confidence in a child's abilities may relate to math outcomes more directly than value beliefs or specific interaction styles. Implications for future research on home learning environments and parent-led instruction are discussed.

*Keywords:* parental expectations, expectancy-value theory, parent-child interaction, early math learning, feedback, fraction understanding

## **Parent-Child Math Talk: How Expectations and Conversational Patterns Predict Fraction Learning**

Parent-child interaction is a key factor in children's cognitive development, especially in early math learning. Through meaningful conversations, parents help children build a foundation of math concepts, and this interaction in early childhood is a critical predictor of future math outcomes (Elliott et al., 2017; Gibson et al., 2020; Carrazza & Levine, 2025). However, the quantity and quality of these interactions varies across families, influenced by multidimensional factors including math expectations, math-related beliefs, and the specific contents of mathematical talk (Silver et al., 2024). Parental expectations and values have been demonstrated to influence both children's motivation and the learning environment parents create (Simpkins et al., 2012; Wilder, 2014). While existing research has separately established the roles of parental expectations and conversational patterns in children's math development, few studies have examined how these two factors intersect. Prior research has shown that parental expectations are robust predictors of children's academic beliefs and outcomes (Parsons et al., 1982; Simpkins et al., 2012), and that the quality of parent-child math conversations, including question types, feedback, and turn-taking, plays a critical role in shaping early math learning (Duong et al., 2021; Carver et al., 2022; Fenyi & Nyarkoh, 2022). However, these two lines of research have typically been studied separately. As a result, less is known about how parental beliefs and real-time conversational behaviors interact—and how this interaction relates to children's measurable learning improvements during specific math tasks. The current study addresses that gap by investigating the ways that parental beliefs and real-time interaction styles jointly relate to measurable learning improvements—specifically in fraction knowledge among early primary school children.

Early childhood and the transition into primary school represent a critical developmental period for acquiring foundational mathematical knowledge. Children around this age (5 to 7 years old) are not only rapidly expanding their numerical understanding but also developing the cognitive and social capacities to engage meaningfully with more abstract math concepts.

Fractions are a cornerstone of mathematical development because they challenge students to extend their understanding of numbers beyond whole-number rules. Rather than a discrete shift, Siegler, Thompson, and Schneider (2011) propose a continuous developmental framework in which children progressively refine their grasp of numerical magnitudes, including those of fractions. Supporting this view, intervention studies such as Gabriel et al. (2013) demonstrate that targeted training with number lines can enhance fraction magnitude understanding in upper elementary students. Research consistently shows that fraction magnitude understanding predicts overall mathematics achievement beyond procedural skill alone and even after controlling for factors like IQ and working memory (Siegler et al., 2012; Bailey et al., 2012). This makes fractions uniquely predictive of later success in algebra and broader mathematical thinking. Moreover, without a solid conceptual foundation in fractions, students often fall into persistent errors, such as misapplying whole-number logic or misjudging relative sizes (Gabriel et al., 2013; Perry, 2023). Effective instruction in fractions—particularly through emphasizing number lines and magnitude representations—can therefore lay the groundwork for advanced learning and help close gaps that might otherwise widen through middle and high school (Liu, 2017; Siegler et al., 2012). Thus, studying fractions is not merely a curriculum checkpoint, but a critical developmental milestone in mathematical cognition.

Extensive research highlights the importance of parent-child interactions in supporting early math learning, especially through meaningful conversations and responsive engagement.

For instance, multiple studies have established that both the quantity and quality of number-related talk positively predict children's growth in math knowledge (Gunderson & Levine, 2011; Levine et al., 2010). Building on this, Gibson et al. (2020) provided causal evidence that numeracy-rich parent talk during early childhood directly enhances children's number skills, highlighting the power of informal, home-based learning.

Synthesizing all related findings, Silver et al. (2024) conducted a meta-analysis, confirming that despite heterogeneous measurement methods, math talk reliably captures math-related home interactions. Their results further reinforced the statistically significant association between parent math talk and children's achievement, particularly in naturalistic or longer-duration contexts. Notably, parental practices in math talk vary significantly, and these individual differences are closely tied to children's mathematical development (Elliott et al., 2017). Among the various factors contributing to variability in children's early math experiences, two key factors relevant to the current project have been identified: (1) parental expectations and beliefs about their child's mathematical ability and the importance of math, and (2) their conversation patterns (interactional style) when engaging in math-related conversations. These two factors were chosen because they represent complementary dimensions of influence: the first captures internal parental beliefs that shape motivation and support, while the second reflects how those beliefs may be enacted during real-time interactions with the child. Together, they allow for a more comprehensive understanding of both what parents believe and how they behave in learning moments.

### **Parental Expectations and Value - EVT**

Parental expectations—defined as parents' beliefs about their child's current competence and future academic potential—play a critical role in shaping children's motivation, confidence,

and engagement with mathematics. Rooted in the Expectancy-Value Theory (EVT) framework (Eccles & Wigfield, 2020), expectations influence children both directly and indirectly by shaping the home learning environment and parent–child interactions. EVT proposes that parents’ beliefs about their child’s likelihood of success, along with the subjective value they place on a domain like mathematics, drive the kinds of support and opportunities they provide (Eccles et al., 1983; Wigfield & Eccles, 1992). These expectations may influence how much parents invest in math-related dialogue, how they frame math challenges, and the emotional tone they use when discussing mathematics.

Empirical evidence supports the pivotal role of expectations across diverse family contexts. Parsons et al. (1982), in a seminal study tracking children from late elementary school through high school, found that mothers’ expectations for their children’s math ability significantly predicted children’s own self-concepts and future aspirations in math, even more strongly than prior academic performance. Notably, this effect was especially pronounced among girls, suggesting that parental expectations can both shape and differentiate motivational beliefs across genders. Extending to younger age groups, Simpkins et al. (2012) conducted a longitudinal study spanning middle childhood (Grades 1–6) and demonstrated that maternal expectations were strong predictors of children’s evolving value beliefs about math and their academic behaviors over time. This underscores that expectations are not mere reflections of existing abilities, but dynamic forces that actively shape children’s motivational orientations during key developmental stages. Focusing specifically on early developmental transitions, Loughlin-Presnal and Bierman (2017) focused on a low-income cohort from first to fifth grade and employed cross-lagged longitudinal models to examine bi-directional associations between parent academic expectations and child academic performance. Their findings revealed that

expectations and achievement influence each other, particularly in early grades. Importantly, the study identified a developmental shift in the mechanisms through which expectations exert influence: during the early elementary years (Grades 1–3), parent expectations predicted children’s learning behaviors (e.g., persistence, attention), which in turn promoted achievement. By the later years (Grades 2–5), the influence was channeled through children’s self-perceived academic competence. These results suggest that while parent expectations remain influential across childhood, the way they shape learning adapts to the child’s developmental stage—first externally through behavior, and later internally through self-concept.

Furthermore, meta-analytic evidence from Fan and Chen (2001) revealed that among various forms of parental involvement, expectations had the strongest correlation with academic achievement, more than direct instructional help or school-based volunteering. Other research has shown that not only the level but also the accuracy of expectations matters. Miller, Manhal, and Mee (1991) found that parents who had more accurate assessments of their child’s abilities tended to have children who performed better, suggesting that attuned expectations may help align support with the child’s needs. Even implicit beliefs about ability—such as a fixed mindset—can influence parenting behavior in ways that are not always consciously expressed. For example, Gunderson et al. (2012) noted that parents with a fixed mindset about math ability tended to use more controlling or evaluative language, which may, in turn, undermine a child’s confidence or willingness to persist—a potential implication of their findings.

### **Conversation Patterns in Math Talk**

Beyond holding expectations, the ways in which parents verbally interact with their children—through questioning, feedback, or balancing of turns—have also been identified as key mechanisms that support children’s math learning. A growing body of research has examined

parental questioning style, highlighting that not all questions are equally beneficial. For example, Duong et al. (2021) distinguish between low cognitive demand (CD) questions (e.g. labeling or identifying) and high-CD questions (e.g. explaining or predicting), showing that the frequency of high-CD questions is significantly associated with preschoolers' spatial, math, and language abilities, even after controlling for child age and socioeconomic status. These high-CD questions appear to support mathematical thinking by encouraging cognitive abstraction and verbal reasoning, especially when embedded within rich conversations. Similarly, Spruijt et al. (2020) found that training parents to use more open-ended and explanatory questions significantly enhanced their children's reasoning skills, suggesting that adaptive verbal scaffolding in home settings can be modified and improved to support early learning.

In addition to questioning, feedback types play a distinct role in shaping children's math outcomes. Carver et al. (2022) found that affirmative and elaborative feedback—such as praise or building on a child's idea—was positively associated with children's math growth, while corrective feedback was negatively linked to performance, even after controlling for talk quantity and child age. Van der Kleij et al.'s (2015) meta-analysis also showed that elaborated feedback (e.g. providing explanations or correct answers) had stronger effects than simple correctness-based responses, especially for conceptual understanding.

The last central pattern is turn-taking, which reflects the degree of balance and reciprocity in a dyad's interaction. Balanced turn-taking, where both parent and child share control of the conversation, has been linked to greater engagement and cognitive improvements. In many classroom and home learning contexts, adults tend to take the lead in structuring conversations, with children positioned primarily as responders. While such adult-led interactions can provide clarity and structure, they may also limit opportunities for children to engage in generative

thinking, ask questions, or take ownership of the learning process. In contrast, interactions that allow children to contribute ideas, clarify their thinking, or initiate exchanges have been associated with more dynamic and reciprocal learning environments (Feyzi & Nyarkoh, 2022). Rather than suggesting that more child input is always better, the literature emphasizes the value of mutual engagement, where both adult guidance and child contributions are balanced to support deeper learning.

### **Current Study**

This study examines how parental expectations and conversation patterns during a structured math dialogue relate to children's improvements in understanding fractions, a foundational yet often challenging concept introduced in early primary school. The study focuses on children aged 5.5 to 7.5 years and uses a three-part design: a pre-test, a parent-child math conversation task, and a posttest, followed by a parent expectations survey aligned with Expectancy-Value Theory (Eccles & Wigfield, 2020). Specifically, this study investigates:

1. To what extent do parental expectations predict children's math knowledge improvements after a parent-child conversation?
2. Are conversation features (e.g., turn-taking, question type, feedback style) associated with improvements in fraction understanding?
3. Do specific conversation features (e.g., feedback style, question format, or turn-taking balance) moderate the relationship between parental expectations and children's math learning outcomes?

We hypothesize that (1) higher parental expectations will be associated with greater math improvements, (2) elaborative, encouraging, and balanced conversational styles will predict

stronger posttest performance, and (3) the quality of interaction may serve as a pathway through which expectations influence outcomes.

## Method

### Participants

Participants were 105 parent–child dyads recruited through the Children Helping Science/Lookit online platform (CHS, hosted at [childrenhelpingscience.com](http://childrenhelpingscience.com); Scott & Schulz, 2017). Children ranged in age from 5.5 to 7.5 years ( $M = 5.83$ ,  $SD = 0.69$ ), a developmental window in which children begin forming informal fraction concepts (Viegut et al., 2023) but typically have not received formal instruction on fractions in U.S. public schools. This window allows researchers to capture the early, parent-guided foundations of fraction understanding before formal teaching begins. The sample included 47 girls, 55 boys, and 1 child whose gender was not specified. Most children were in kindergarten or first grade: 35 were age five (likely kindergarten), 51 were age six (likely first grade), and 17 were age seven (likely early second grade). Grade level was not directly used in analyses, but age in years was modeled continuously to account for developmental variance. Parental demographic information was collected for exploratory purposes but was not used in the main analyses. Of note, however, the sample was primarily composed of highly educated, middle- to upper-income families, with the majority of parents holding at least a bachelor’s degree. This overrepresentation may limit the generalizability of the results to more diverse socioeconomic backgrounds. Descriptive statistics for all key study variables are reported in the Results section.

### Procedures

Children and their parents participated in the experiment online and asynchronously, without a researcher present. This study is embedded within a larger project where parent-child

pairs are randomly assigned to one of four experimental conditions, where parents are provided with different prompts to discuss the concept of fractions using real-world examples that vary in similarity and representation type: (1) discretized examples (e.g., pizzas), where a single object is visibly divided into countable pieces; (2) continuous examples (e.g., glasses of water), where the quantity must be mentally partitioned and is not physically segmented; (3) combined examples that include both discretized and continuous representations; or (4) a control group with a non-mathematical conversation prompt. For the purposes of the current study, only data from parent-child dyads who discussed prompts containing fraction-specific content (prompts 1, 2, or 3) were analyzed, as these conversations were designed to be educational fraction experiences. To account for potential variability introduced by the different conversation prompts, prompt type was included as a control variable in the analyses. This ensures that the findings reflect the nature of parental expectations as they relate to conversational patterns, independent of the specific examples used in parent-child interactions.

Each child began by completing a six-question pretest assessing basic fraction knowledge, adapted from Miura et al. (1999). Then, parents and children received one of the conversation prompts and were asked to engage in a few minutes of conversation about the prompt they were presented with. This conversation was video-recorded for later conversational coding by researchers. Following the conversation, children completed an eighteen-question posttest with fraction questions to measure their post-conversation fraction knowledge. Finally, parents were invited to answer a survey containing questions which assessed their expectations and values for their child's math performance.

## **Measurement**

Parental expectations regarding their children’s math abilities were measured using a five-item questionnaire adapted from Schaeffer et al. (2018), which assesses parents’ beliefs about their child’s current performance in math, expected future performance, perceived natural talent, and the current and future importance of math for their child. These items reflect core dimensions of Expectancy-Value Theory, including expectancies for success (via current and future performance and talent beliefs) and task value (via perceived current and future importance of math). The full survey items are presented in Table 1.

**Table 1**

*Parent Math Expectancy-Value Questionnaire Items*

Item No.	Survey Item	Scale Labels
1	How is your child doing in math?	1 = Not well at all, 5 = Very well
2	How well do you think your child will do in math in the future?	1 = Not well at all, 5 = Very well
3	How much natural talent does your child have in math?	1 = Not much at all, 5 = Very much
4	How important do you think math is for your child?	1 = Not much at all, 5 = Very much
5	How important do you think math will be for your child’s future career?	1 = Not much at all, 5 = Very much

*Note.* Participants responded using a 5-point Likert scale. Items 1–3 assess expectancy-related beliefs; Items 4–5 assess value-related beliefs.

Parent–child math conversations, conducted during the structured task, were video-recorded, transcribed, and coded to analyze conversational patterns. To ensure reliability, two independent coders jointly coded the first 20 videos, achieving strong interrater agreement (Cohen’s  $\kappa = 0.985$ ). Following this, coders proceeded to code the remaining data independently. Coding captured the degree of balance in turn-taking, identifying whether the flow of dialogue reflected reciprocal exchanges or is dominated by one speaker. Turn-taking balance was assessed

by calculating the relative proportion of speaking turns taken by the parent versus the child across the full conversation. A dyad was coded as balanced if each party contributed between 40% and 60% of the total turns—that is, if neither participant’s share exceeded the other’s by more than 20%. This threshold was chosen to reflect a reasonable tolerance band for conversational equity, consistent with general practices in dyadic interaction research where perfect symmetry is rare, but deviations greater than 20% may reflect clear dominance by one speaker (e.g., parent-led or child-passive exchanges).

Each parental turn was further coded for feedback type and question type. Feedback was categorized into four types: (1) *encouraging* feedback that fosters independent thinking through reflection or open-ended support, (2) *confirmatory* feedback indicating correctness or incorrectness, (3) *corrective* feedback that directly identifies and corrects errors, and (4) *elaborative* feedback that expands on the child’s thinking with added explanation or reasoning. Coding was conducted at the turn level, such that each parental turn was evaluated for the presence of any of the four feedback types. If a turn contained one or more feedback moves—whether of a single type or multiple—it was counted once toward the total number of turns that contained any feedback. For each dyad, the proportion of turns that contained each feedback type was calculated relative to the total number of feedback-containing turns, yielding a ratio score for each feedback type. In parallel, all parental questions were coded as either open-ended, inviting elaboration or multiple possible responses, or closed, prompting a short, specific answer. For each dyad, the ratio of open-ended questions was calculated by dividing the number of open-ended questions by the total number of questions asked by the parent. These dimensions were analyzed to quantify the nature and frequency of parents’ instructional support across dyads; results are presented in the following section (see Appendix for detailed coding manual).

Children's fraction knowledge was assessed through a set of 6 pre- and 18 posttest items administered via the Lookit platform. Accuracy scores were calculated for both assessments, and math improvement was modeled by using posttest accuracy as the outcome variable while controlling for pre-test performance.

## Results

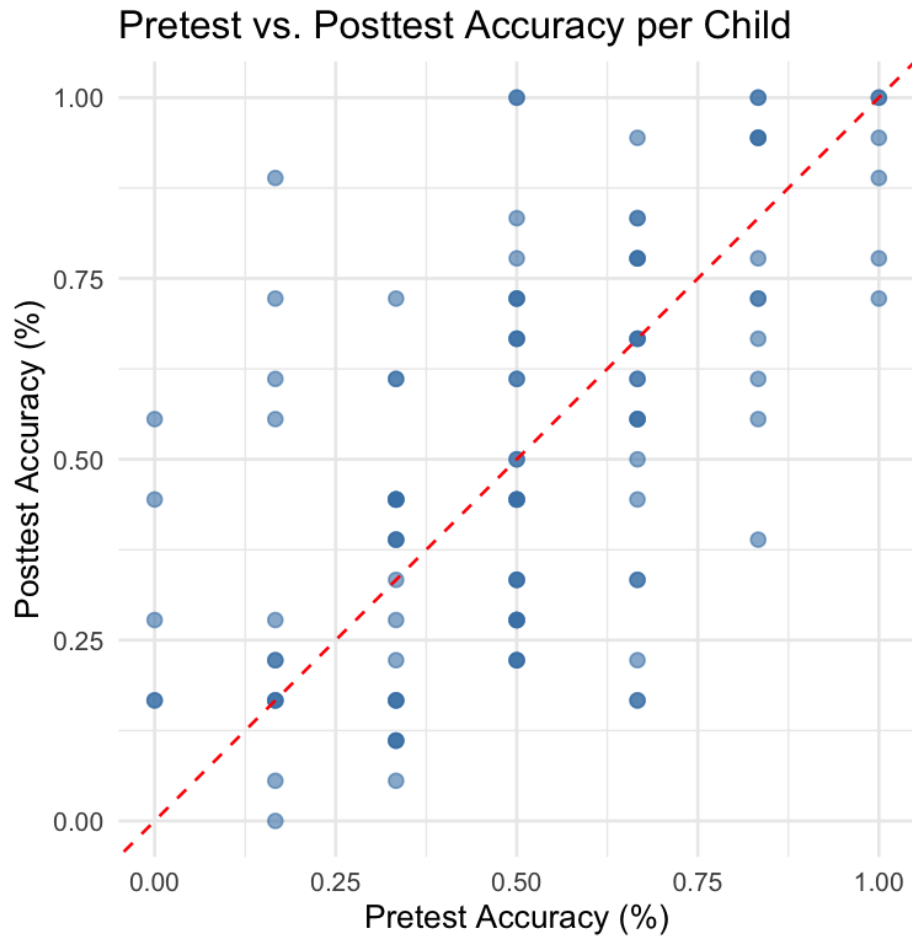
### Descriptive Statistics

At the outset of the current study, children demonstrated some fraction knowledge, with a mean pretest accuracy of 50.5% ( $SD = 22.3\%$ ). Overall, the sample's mean posttest accuracy was 51.6% ( $SD = 22.1\%$ ), yielding a small average improvement of 1.1 percentage points ( $SD = 17.2\%$ ). This pattern is visualized in Figure 1, which shows individual children's performance on pre- and posttest assessments. The mean expectancy and value scores from the parental belief survey were 4.18 ( $SD = 0.80$ ) and 4.28 ( $SD = 0.64$ ), respectively. The average composite EVT score was 4.20 ( $SD = 0.74$ ).

Parents asked an average of 8.06 questions during the task. Of these, 9.4% were open-ended (open question ratio  $M = 0.094$ ), and 86.7% were closed-ended (closed question ratio  $M = 0.867$ ). On average, parents provided 5.90 encouraging, 3.32 confirmatory, 0.87 corrective, and 3.59 elaborated feedback turns. Encouraging feedback, which fosters independent thinking through reflection or open-ended support, accounted for the largest proportion of all feedback-containing turns ( $M = 0.624$ ), while elaborated feedback (expanding on the child's thinking with added explanation or reasoning), confirmatory feedback (indicating correctness or incorrectness), and corrective feedback (directly identifying and correcting errors) had proportions of 0.463, 0.373, and 0.102, respectively (see Figure 2).

### Figure 1

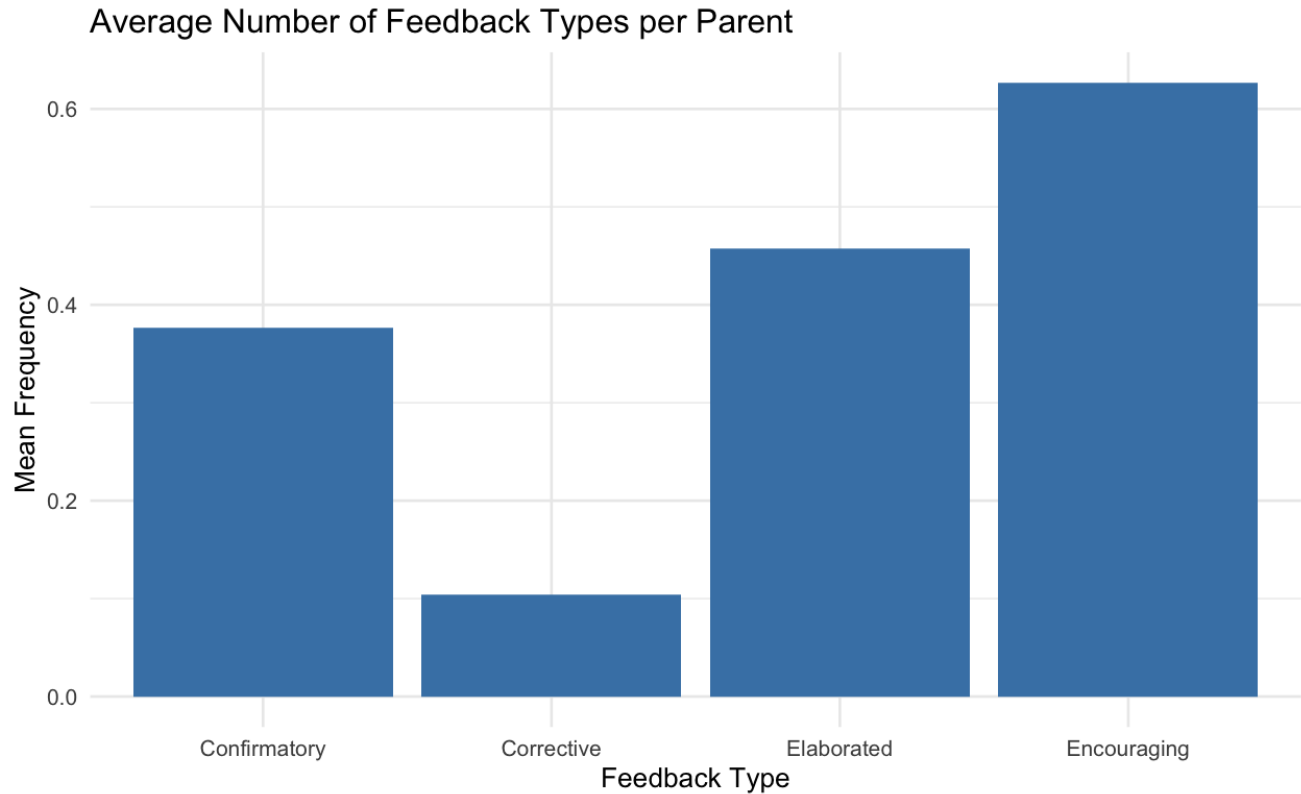
*Pretest and posttest accuracy for each child*



*Note.* Each point represents one child. The red diagonal line indicates equal performance on pretest and posttest assessments. Points above the line reflect improvement.

**Figure 2**

*Mean number of each feedback type provided by parents*



*Note.* Encouraging feedback was the most frequently used, indicating parents often supported children's thinking without directly evaluating correctness. Elaborated and confirmatory feedback were also common. Corrective feedback was least frequent.

### **Predicting Math Improvement from Parental Expectation**

Multiple linear regressions were conducted to examine whether parental expectations predicted children's learning improvements. To isolate learning improvement, posttest accuracy was used as the dependent variable while pretest accuracy was included as a covariate. In the first model, average EVT scores significantly predicted higher posttest performance ( $\beta = 0.166$ ,  $p < .001$ ), after accounting for children's pre-intervention performance.

A follow-up model separated EVT into expectancy (e.g., beliefs about current and future math ability) and value (e.g., perceived current and future importance of math). When

controlling for pretest accuracy and demographic variables, expectancy emerged as a significant predictor of posttest performance ( $\beta = 0.117, p = .002$ ), whereas value did not ( $\beta = 0.039, p = .30$ ). These results suggest that parents' belief in their child's math ability was more strongly associated with post-interaction learning improvements than the importance they placed on math itself.

### Associations Between Parental Expectations and Conversation Patterns

To explore how parental beliefs related to real-time conversation behavior, regression models were conducted using each conversational feature as an outcome. As shown in Table 2, after applying Bonferroni correction for multiple comparisons, only one significant relationship remained: higher EVT-value subscores predicted a greater proportion of open-ended questions ( $\beta = 0.089, p = .033$ ), suggesting that parents who placed more value on math tended to use a more exploratory questioning style. No significant associations were found between EVT (or its subcomponents) and the proportions of elaborated, encouraging, confirmatory, or corrective feedback. Additionally, turn-taking balance was not significantly related to any parental belief variable.

**Table 2**

*Regression Results Predicting Conversational Features from Parental Expectancy and Value*

Outcome	EVT-Expectancy ( $\beta$ )	p	EVT-Value ( $\beta$ )	p
Open-Ended Question	-0.046	.307	<b>0.089</b>	<b>.033</b>
Encouraging Feedback	0.051	.405	-0.046	.416
Elaborated Feedback	-0.074	.327	-0.130	.069
Confirmatory Feedback	0.084	.168	-0.073	.196
Corrective Feedback	0.039	.289	-0.027	.426
Turn-taking Balance*	-0.446	.753	-0.885	.498

\* Logistic regression model used for Turn-taking Balance (binary outcome).

*Note.* Each row represents a separate regression model predicting the specified conversational outcome from parental expectancy and value beliefs, controlling for child age, gender, household income, parental education, and neighborhood density. *p* values < .05 are bolded. After Bonferroni correction for the four feedback outcomes ( $\alpha = .05 / 4 = .0125$ ), no feedback effects remained significant.

### **Predicting Math Improvement from Conversational Features**

To examine whether parental conversational styles predicted children's math improvements, all feedback ratios (encouraging, confirmatory, corrective, and elaborated) were entered simultaneously into a regression model, controlling for pretest accuracy and demographic covariates. None of the feedback types emerged as significant predictors of posttest performance. Within the context of a brief parent-child conversation, no single feedback style independently predicted children's learning improvements. This may indicate that short-term learning during informal interactions is less influenced by feedback type alone, and potentially more dependent on child readiness or broader motivational and contextual factors.

### **Predicting Math Improvement from Child Demographic Features**

Child age significantly predicted math improvement ( $\beta = 0.0995, p = .018$ ), with older children showing greater improvements. Gender and other demographic controls (e.g., number of siblings, education level) did not emerge as significant predictors.

## **Discussion**

This study examined how parental expectations and conversation patterns during a brief, structured math discussion predicted children's learning improvements in understanding fractions, testing both direct and interactive hypotheses. The findings contribute to our

understanding of the behavioral and belief-based mechanisms that support early math learning in informal settings. The key findings indicate that (1) parental EVT—particularly expectancy beliefs—significantly predicted posttest performance; (2) conversational features showed minimal association with math improvement; and (3) hypothesized interaction effects between belief and behavior were not supported. These results suggest that while beliefs about ability contribute to shaping learning outcomes, the role of conversational behavior may be more diffuse or context-dependent, particularly in brief, semi-structured tasks. The absence of a clear association between observed behavior and underlying belief highlights the importance of capturing richer or more extended forms of parent–child engagement in future studies.

### **Findings and Implications**

The current study found that average parental expectancy-value scores were strong predictors of children’s learning improvements, even after controlling for pretest performance. This result aligns with a robust body of research demonstrating that parents’ beliefs about their child’s academic potential are positively linked to motivation, engagement, and achievement outcomes (Parsons et al., 1982; Simpkins et al., 2012; Eccles & Wigfield, 2020), both directly and indirectly, via socialization processes such as parental involvement and encouragement (Guo et al., 2015). Their work also reinforces the notion that expectancy beliefs are not just abstract attitudes but translate into meaningful outcomes for children’s academic development.

More importantly, this study extended prior work by distinguishing between expectancy (belief in child’s ability) and value (importance placed on math) and found that only expectancy significantly predicted learning gains. This separation was not merely statistical—it revealed meaningful psychological differences in how each belief type may operate. Supporting this distinction, Taskinen et al. (2015) found that parental expectations were more strongly associated

than parental values with adolescents' science motivation, achievement, and career aspirations. Their stepwise regression analyses showed that while both types of beliefs contributed positively, parental expectations—child-specific beliefs about the child's future success—explained a much larger portion of the variance in student outcomes. Notably, Taskinen et al.'s study was conducted with adolescents, whereas our study focused on children aged 5 to 7. This age difference highlights a potentially novel extension of expectancy-value dynamics into early childhood; however, further research is needed to confirm whether the same developmental mechanisms operate similarly across age groups.

Furthermore, the lack of observed association between expectancy beliefs and observable conversational features (e.g., feedback or questioning style) in this study aligns with findings by Guo et al. (2015), who argue that much of the impact of expectations may be transmitted through broad motivational support and emotional tone, rather than discrete behaviors. This suggests that beliefs may guide parenting at a more diffuse or implicit level, shaping how children experience math learning rather than what exactly is said.

Although parental value beliefs—the importance they attribute to math in their child's present and future—did not significantly predict children's learning gains, they were positively associated with parents' use of open-ended questions during math conversations. This suggests that while value beliefs may not directly enhance short-term learning outcomes, they still influence the interactional style parents adopt, particularly the kinds of cognitive opportunities offered to children. Parents who highly value math may be more motivated to engage in ways that promote reasoning, elaboration, and exploration, even in brief conversations.

This pattern is consistent with findings from Gamage et al. (2021), who showed that parental beliefs about the value of learning were significantly related to the quality of home

learning interactions, including more child-centered and autonomy-supportive behaviors. Specifically, parents who valued education more highly were more likely to report encouraging their children's independent thinking and reasoning, even when not directly instructing. Similarly, Brisson et al. (2017) found that short interventions aimed at reinforcing the value of math led to increased parental support and greater use of cognitively engaging strategies, such as scaffolding and exploratory questioning. These findings reinforce the idea that value beliefs may influence the form of engagement more than immediate learning outcomes. When parents believe math is important, they may adopt interactional behaviors that signal curiosity, encourage dialogue, and open space for child reasoning—even if those behaviors do not yield immediate performance improvements. However, in our study, such behaviors—specifically open-ended questioning—did not significantly predict children's math improvement. This disconnect suggests that cognitively rich conversation features may not yield immediate learning gains in brief, unstructured discussions.

Why, then, did value beliefs not predict learning outcomes in this study? One potential interpretation is temporal: value beliefs may tend to be better predictors of choice, effort, and persistence at longer-term achievement-related activities, rather than immediate performance (Marsh et al., 2005). For example, parents who value math may routinely encourage exploration and provide access to math-related activities over time, which builds skills cumulatively. In contrast, a single short conversation—especially on a novel or unfamiliar topic like fractions—may not be sensitive enough to capture those long-term effects.

Another possibility is that open-ended questions, while useful for supporting reasoning and autonomy, are not always the most effective format for delivering conceptual instruction. In this study, children were grappling with early fraction concepts, which are cognitively

demanding and often misunderstood. If open-ended questioning was not paired with scaffolding or correction when needed, it may have led to confusion or missed opportunities for clarification—consistent with prior cautionary findings by Fyfe & Brown (2017) and Van der Kleij et al. (2015) that feedback and instructional prompts must be both timely and contingent to be effective.

Finally, none of the feedback types—encouraging, confirmatory, corrective, or elaborated—significantly predicted children’s math improvement when entered into the same model. While prior research has highlighted the instructional value of specific feedback forms, such as elaboration or praise, these studies have often been conducted in structured, formal educational settings (Carver et al., 2022; Fyfe & Brown, 2017; van der Kleij et al., 2015). The current findings suggest that such effects may not fully generalize to brief, informal parent–child conversations at home. Rather than contradicting earlier work, this study extends it by emphasizing the importance of context—specifically, the dynamics of naturalistic interactions, where feedback may function differently. In these settings, the effectiveness of feedback may depend less on its form and more on factors such as timing, specificity, and responsiveness to the child’s current understanding. As Hornburg et al. (2021) and Eason et al. (2022) suggest, instructional talk in the home often occurs within broader emotional and relational contexts. This may help explain why specific feedback types did not predict outcomes in the current study—especially given the brief and relatively unstructured nature of the conversation following an open-ended prompt. While no conversational feature predicted fraction gains, strategies like open-ended questioning may cultivate domain-general skills (e.g., hypothesis-testing, self-explanation) that facilitate mathematical development over time. The absence of short-term

effects here does not preclude their value; rather, it suggests their impact may emerge cumulatively or in contexts beyond fraction-specific tasks.

### **Limitations**

While this study contributes novel insights into the role of parental beliefs and conversational styles in early math learning, several limitations must be acknowledged. First, the sample was heavily skewed toward highly educated families. The majority of participating parents held at least a bachelor's degree, with a large proportion reporting professional or advanced degrees. This limits the generalizability of the findings, as Hidayatullah and Csíkos (2024) found that parents' educational background was positively associated with students' math motivation and achievement. The authors suggest that higher-educated parents tend to be more involved and supportive, potentially shaping their children's attitudes and performance in mathematics through more engaged instructional practices. Families with lower formal education may approach math conversations differently, both in terms of confidence and language use.

Additionally, the study relied on a brief, one-time conversation, which may not fully capture parents' typical instructional styles. While this format allows for semi-naturalistic observation and standardization, it limits the ecological validity of findings. Elaborated or corrective feedback may depend on repeated exposure and context-sensitive delivery, which short interactions cannot provide. Furthermore, although we used proportion and frequency metrics to quantify conversational features, these measures do not account for potentially relevant qualitative nuances such as emotional tone, linguistic richness, or temporal contingency.

Finally, although parental expectations were assessed using a validated scale, the measures relied on self-report, which may be subject to social desirability bias or may not fully reflect the implicit beliefs that guide real-time behavior (Pomerantz et al., 2007). Additionally,

the low variability in some measures (e.g., math value ratings were generally high) may have limited the ability to detect effects.

### **Future Directions**

Future research should extend these findings by using fine-grained, time-aligned coding of parent-child interactions to capture not only what is said, but when and how it is said. Eye gaze, prosody, and affective cues could illuminate how expectancy beliefs manifest in nonverbal support. Such detailed analyses would help researchers build more nuanced models of parent-child instructional dynamics, and offer parents clearer guidance on how subtle cues—like tone or timing—can shape learning outcomes.

Second, longitudinal designs can examine whether parental value beliefs, while not predictive of short-term learning, contribute to sustained math interest and skill growth over time. This would allow researchers to trace developmental trajectories beyond immediate test gains and help parents recognize that their long-term attitudes toward math may still foster enduring motivation in their children. Coupling open-ended questioning with timely scaffolding may be a promising instructional pathway. Investigating this approach could provide researchers with a clearer framework for studying responsive teaching moments at home, while also equipping parents with practical conversational tools to encourage independent thinking.

Third, the lack of predictive power for feedback types calls for examining feedback within its contingent context: what preceded it, how the child responded, and whether the feedback aligned with the child's zone of proximal development. Understanding these feedback contingencies could refine theories of instructional responsiveness and empower parents to better recognize and adjust their support in the moment, increasing its effectiveness.

Finally, future studies should incorporate additional belief constructs such as parental math anxiety or epistemological beliefs about learning. These may influence not only what parents believe, but how confident they feel during instructional moments. Understanding these internal dynamics could enrich our grasp of how home-based math support unfolds. For researchers, this would broaden the range of psychological factors considered in home learning models; for parents, it could uncover hidden emotional barriers that impact their ability to support their child effectively.

### **Conclusion**

This study examined how parental beliefs and conversational patterns during brief fraction-focused interactions predict young children's learning gains. Findings revealed that parents' expectancy beliefs—their confidence in their child's math ability—significantly predicted improvements in fraction understanding, even after controlling for pretest performance and demographic factors. In contrast, value beliefs (perceived importance of math) did not predict learning outcomes, though they were associated with parents' use of more open-ended questions. Critically, none of the observed conversational features—including feedback types (encouraging, confirmatory, corrective, elaborated), question formats, or turn-taking balance—significantly predicted children's learning gains in this brief, semi-structured context. Child age consistently emerged as a predictor of improvement, aligning with developmental expectations.

While conversational patterns did not directly explain learning outcomes, their role as potential enactments of parental beliefs warrants further investigation. The absence of behavioral effects may reflect the limitations of brief, one-time interactions or the need for finer-grained analyses of how dialogue unfolds dynamically (e.g., contingent scaffolding). Future studies should employ longitudinal designs to examine whether value beliefs or open-ended questioning

foster long-term engagement, and use micro-coding to capture nuances like emotional tone or feedback timing. Expanding this work to socioeconomically diverse samples is essential, given the current study's highly educated participant pool.

Practically, these findings underscore that parental confidence in a child's abilities—more than the importance ascribed to math or specific conversational tactics—supports early fraction learning. Parents and educators should thus prioritize fostering a supportive belief environment: expressing confidence in children's potential (e.g., "You can figure this out!"), balancing guidance with autonomy, and framing math as explorative. Schools can amplify this by sharing research-backed strategies that empower parents to leverage everyday conversations as learning opportunities, grounded in trust and curiosity.

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## Appendix

### Coding scheme for conversational patterns

Name of var	Type	Description/Example
<b>TURN-TAKING</b>		
C_Turns	Count	Total number of turns taken by the child.
P_Turns	Count	Total number of turns taken by the parent.
TurnBalance	Binary	Indicates whether the conversation has balanced turn-taking (1) or unbalanced turn-taking (0).
C_IC	Count	Total number of child-initiated contributions (questions or comments during the conversation. Not counting simple response like Yes or No)
<b>QUESTION TYPES</b>		
P_OpenQ	Count	Count of open-ended questions posed by the parent during the conversation. For example : "How did you figure that out?" "What do you notice about these fractions?"
P_OpenQ_R	Ratio	Ratio of open-ended questions to total questions posed by the parent during the conversation.
P_ClosedQ	Count	Count of close-ended questions posed by the parent during the conversation. For example : "Which one is a half?" "Is 3/4 greater than 1/2?"
P_ClosedQ_R	Ratio	Ratio of closed-ended questions to total questions posed by the parent during the conversation.
P_TotalQ	Count	Count of total questions posed by the parent during the conversation
<b>FEEDBACK TYPES</b>		

P_FBEnc	Count	Count of encouraging feedback provided by the parent. For example: "Hmm, let's think about this again. How can we split this pizza fairly?"
P_FBEnc_R	Ratio	Ratio of encouraging feedback to total feedback (encouraging + corrective) provided by the parent.
P_FBElab	Count	Count of elaborative feedback provided by the parent. For example: "This is just like when we cut a pizza into slices. If each slice is $\frac{1}{8}$ , and you take two slices plus one slice, you have $\frac{3}{8}$ of the pizza..."
P_FBElab_R	Ratio	Ratio of elaborative feedback to total feedback provided by the parent.
P_FBConf	Count	Count of confirmatory feedback provided by the parent. For example: "Yes, that's correct!"; "No, that's not right."
P_FBConf_R	Ratio	Ratio of confirmatory feedback to total feedback provided by the parent.
P_FBCorr	Count	Count of corrective feedback provided by the parent. For example: "That's not quite right. The correct answer is ...."
P_FBCorr_R	Ratio	Ratio of corrective feedback to total feedback.
P_TotalF	Count	Count of total feedbacks posed by the parent during the conversation