THE UNIVERSITY OF CHICAGO

Parent-Child Fraction Talk in Home Numeracy Environment: The Role of Parental Perceptions in Predicting Parental Scaffolding Practices

By

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August 2025

A paper submitted in partial fulfillment of the requirements for the
Master of Arts degree in the
Master of Arts Program in the Social Sciences

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Abstract

The home numeracy environment (HNE) is critical to understanding why some children start school more prepared to learn math than others. The current study investigated parent-child interactions which featured discussion of fractions, contextualized in a broader study design conducted via online, at-home data collection. Specifically, this study addressed a gap in existing HNE literature by examining the unique role of parental enjoyment and parental math self-efficacy (PMSE) on scaffolding behaviors in conversation with their children. Key results showed that parental enjoyment positively predicted positive emotional scaffolding, with a gender moderation effect such that the relationship was stronger for parents of girls than boys. Additionally, child pretest performance negatively predicted explanatory cognitive scaffolding, and none of the PMSE items were correlated with any particular type of conversational scaffolding behaviors. This combination of results will inform the design of parent-focused math interventions by emphasizing the role of parental enjoyment in promoting emotionally supportive math talk, particularly for daughters.

Children's math skills as early as kindergarten entry are strong predictors of their later academic performance in mathematics (e.g., Duncan et al., 2007; Jordan et al., 2009). Among the various mathematical concepts children are expected to learn, fractions, which is a part of the Common Core State Standards starting from Grade 3, represent a particularly critical and challenging domain. Research has consistently shown that fractions are a major stumbling block for elementary school children and are especially difficult to learn (Gabriel et al., 2013). Moreover, competence with fractions has been identified as a key predictor of later math success (Siegler et al., 2011). For instance, Bailey et al. (2013) found that sixth grade fractions concepts measure predicted one-year gains in mathematics achievement. Additionally, elementary school students' knowledge of fractions and of division uniquely predicted those students' knowledge of algebra and overall mathematics achievement in high school 5 or 6 years later (Siegler et al., 2012). Extending this line of research, studying how preschool children begin to understand fractions before receiving formal schooling may offer valuable insights into both the challenges and potential supports that impact early fraction learning.

The home numeracy environment (HNE), which includes play and educational activities involving math-related elements within the home, is therefore critical to understanding why some children start school more prepared to learn math than others (Elliott et al., 2023). Eason et al. (2022) proposes a broad family math environment model which identifies five facets of family engagement associated with children's math learning, including math talk. Recent years have seen an increase in the amount of research investigating math talk, consistently showing a positive relationship between the frequency and diversity of parents' math talk and children's early math learning and development as well as later math outcomes (Levine et al., 2010; Silver et al., 2024). For example, parents' number talk involving counting or labeling sets of visible objects is related to children's later cardinal-number knowledge (Gunderson & Levine, 2011). A randomized controlled trial also established causal relationships between parent number talk and 3-to-4-year-old children's number knowledge (Gibson et al., 2020). These findings signal the potential for math talk to also support early fraction learning, a topic that has not been systematically studied.

Beyond math talk, literature on the HNE has shown that higher parental involvement, particularly scaffolding practices in home math activities such as worksheet problem-solving, board scoring games, and role-playing, predicts better math outcomes for children ranging from 5-9 years old, such as geometric and arithmetic learning (Anghileri, 2006), formal and informal math abilities (Huang et al., 2022), and discipline-specific academic competence (Mattanah et al., 2005). However, very little research has specifically examined parental scaffolding behaviors during parent-child math talk, particularly in conversations about fractions.

Parental Scaffolding in the Home Numeracy Environment

Initially proposed by Vygotsky (1978), parental scaffolding represents a support structure for parents for their children to learn new things that are beyond their current capabilities (Wood & Wood, 1996). Scaffolding in the home environment can take a variety of forms ranging from parent contingent response to verbal input during interactions with their child (Mermelshtine, 2017) and can thus be enacted in a variety of mediums, such as conversation, informal games, and structured activities (Elliot et al., 2023). Neitzel and Stright (2003) identified three key aspects of parental scaffolding during parent-child learning interactions which support different goals: cognition, emotion, and autonomy. Cognitive scaffolding (Zhang & Whitebread, 2017) is described as parental involvement that aids children's thinking processes through metacognitive strategies or other cognitive-enhancing approaches. Emotional scaffolding (Sun & Tang, 2017) is identified as the positive and negative emotional feedback of parents during children's trials. Autonomy scaffolding (Belsky et al., 2008) is defined as instances when parents foster autonomous participation and show respect for their children's preferences and decisions.

Extensive evidence suggests that parents' use of scaffolding predicts cognitive performance for children across the age span, measured by the Mental Development Index (MDI) for infants (Lemelin et al., 2006) and mathematical competency tests for first-graders (Niklas & Schneider, 2014). Parents' scaffolding support, such as suggestion, metacognition, and praising, are found to promote children's cognitive development (Niklas & Schneider, 2014). More specifically, an observational study by Huang et al. (2022) found that both maternal and paternal scaffolding in applicational math activities significantly predicted children's formal math ability even after controlling for background variables. Therefore, examining the specific use and effectiveness of parental scaffolding in the HNE is important for advancing our understanding of early math development by unpacking the mechanisms through which home-based parenting influences learning.

Parental Perceptions: Enjoyment and Math Self-Efficacy

Beyond direct parental behaviors involved in math activities and math talk, another important aspect of the HNE is parents' math attitudes and expectations. As highlighted by Levine and Pantoja (2021), key socializers' (e.g., parents' and teachers') math attitudes and behaviors are linked to their children's math attitudes as well as math achievement. Some well-studied constructs in this branch are math anxiety, belief of the importance of math, and parent's math-related expectations of their children (Maloney et al., 2015; Hildebrand et al., 2023; DeFlorio & Beliakoff, 2015). The current study focused on two specific types of parental perceptions: parental enjoyment of math and parental math self-efficacy (PMSE).

Parental enjoyment of math speaks to the potential for educational activities to be entertaining, amusing, or otherwise fun for not only children, but also their supervising parents. Previous research has revealed that some math activities are perceived as more enjoyable by parents than others (Eason & Ramani, 2020) and that different numerical game formats can result in different combinations of parental scaffolding behaviors (Schnieders & Schuh, 2022). Moreover, parents' positive numeracy attitudes (e.g., their enjoyment of numeracy) predicts their children's non-symbolic arithmetic skills in an object quantity matching task involving hidden object addition and subtraction using a toy barn setting (Skwarchuk et al., 2013). In a similar vein, Zimmer-Gembeck et al. (2015) reported that most parenting practices (e.g. warmth, autonomy support, rejection, coercion) were associated with parents' perceptions of competence and their enjoyment of parenting. These findings suggest that parental enjoyment of math activities could be related to their conversational behaviors and their children's early math outcomes.

Parental self-efficacy (PSE) refers to a parent's belief that one can successfully parent a child, which affects one's willingness to take on the role of their child's first teacher (Bojczyk et al., 2018). Existing studies presented strong evidence linking PSE, more generally, to parent-child relationship, parental mental health, and child development (Albanese et al., 2019). A review by Jones and Prinz (2005) reports a strong association between PSE and parental competence and also suggests that PSE impacted child adjustment (e.g., socio-emotional learning, school achievement) both directly and indirectly via parenting practices and behaviors.

Specifically, in a home numeracy environment, parental math self-efficacy

(PMSE) indicates how confident a parent is to take on mathematics-related home activities with their children. Previous studies found that among five principal components of parental involvement, parental self-efficacy had the largest direct effect on elementary school-aged children's math achievement (Liu & Leighton, 2021). For example, Bartley and Ingram (2018) found a significant positive correlation between parental mathematics self-efficacy and their children's emotional arousal to mathematics when parents assisted their children's mathematics homework. Correspondingly, parental self-reported efficacy in supporting their child's early math learning is related to the number of related informal activities their children participate in (Hightower et al., 2022). Snyder et al. (2024) also reported a unique positive relationship between parent Science, Technology, Engineering, and Mathematics (STEM) self-efficacy and child STEM media use, signaling the importance of promoting parental self-efficacy related to children's science learning. This synthesized evidence exemplifies the significance of parental math self-efficacy and its associations with children's math learning and development.

Current Study

The literature reviewed shows that while early math skills, particularly understanding of fractions, are foundational for later academic success, little is known about how children begin learning fractions before formal schooling. Research on the home numeracy environment (HNE) highlights the importance of parent-child math talk and scaffolding in shaping early learning, yet this work has rarely focused on fraction-specific conversations. Furthermore, although parents' enjoyment of math and their math self-efficacy have been linked to children's outcomes, little attention has been given to how such parental perceptions are expressed through distinct math-related parenting practices within the home context.

The current study sought to address this gap by examining the connections between parental perceptions and specific scaffolding behaviors, aiming to provide a more nuanced understanding of parent-child interactions in the HNE. The following overarching research question guided this study: how do parental enjoyment of math and math self-efficacy relate to the presence of parental scaffolding behaviors in the home numeracy environment, in particular through math-focused parent-child conversations about fractions? In relation to this framing, we proposed the following hypotheses:

- In general, we expected greater parental enjoyment and higher levels of parental math self-efficacy to be associated with increased use of scaffolding behaviors in conversation.

  More specifically, we hypothesized that:

1. First, higher parental enjoyment would be positively associated with greater emotional scaffolding. We anticipated that when parents find an activity enjoyable, they are more likely to offer positive emotional support to their children.
2. Second, higher parental math self-efficacy would be positively associated with greater cognitive scaffolding. Parents who feel confident in their ability to support their children's math learning are more likely to provide explanations and guide problem-solving, which primarily constitutes cognitive support.
3. Finally, we considered child pre-existing math knowledge as another potential factor which could influence parental scaffolding. It is reasonable to expect that the more a child already knows about a given math topic, the fewer opportunities and the lower the need is t for parents to provide additional instructional support. Accordingly, we predicted that child preexisting

knowledge would be negatively associated with parental scaffolding, particularly with cognitive scaffolding.

Methods

Participants

This study was embedded in a broader study that investigated the effects of different prompts provided to parents for the purpose of discussing fractions with their children. We sampled 105 pairs of parents and children aged 5-7, recruited through the online platform Lookit/Children Helping Science (hosted at childrenhelpingscience.com; Scott & Schulz, 2017). We chose this age group because most children within this age range have not yet received formal fraction education in school, yet are beginning to build informal fraction knowledge (Viegut et al., 2023).

After screening out incomplete responses, 96 parent-child dyads (child Mean_{Age} = 5.81 years, SD_{Age} = 0.69) in total were used for analyses. Among these dyads, 45 of the children were girls, 50 were boys, and 1 child did not specify gender. Of the 92 parents who provided information on their highest level of education, more than half of the participants (57.29%) reported holding a graduate or professional degree, and an additional 28.12% held a four-year college degree. Only a small proportion of parents reported lower levels of education, with fewer than 5% each indicating some or attending high school, a high school diploma or GED, some or attending college, or a two-year college degree. Of the 78 parents who reported family income, the largest proportion (34.38%) fell into the $50,000–$90,000 income range. A smaller portion of the sample reported higher income brackets, with 15.6% falling in the $100,000–$140,000 range, 14.6% falling in the $150,000–$190,000 range, and 11.5% falling above $200,000. Only 5.21% of the sample reported a household income below $40,000. Overall, this sample is predominantly composed of highly educated parents and represents middle- to upper-middle-class households.

Procedure

All data collection sessions were conducted asynchronously online through Lookit without the presence of researchers. Participants were instructed by pre-written and pre-recorded directions and stimuli; children clicked to answer fraction-specific questions and parents clicked to answer end-of-study survey questions. Conversations and behaviors throughout the study were recorded by computer camera and filed for later analysis.

Children were first asked to complete a brief, six-question pre-test on their basic understanding of fractions, adapted from Miura et al. (1999). The percentage of correct answers achieved in the pretest was used as an indicator of the child's preexisting knowledge about fractions. Then, parents and children were provided with one of the four conversation prompts and asked to spend a few moments in discussion. These prompts specified different real-life examples of fractions or a control prompt about favorite foods, including 1) discretized fractions, which are represented by one item, divided (e.g., a pizza cut into slices), 2) continuous fractions, which are represented by one item, not divided (e.g., a glass of water), 3) discretized and continuous examples together, and 4) a non-mathematical control condition which prompted dyads to discuss favorite foods. For the purposes of the current study, only dyads who discussed prompts with fraction content (prompts 1, 2, or 3) were included in analyses, as parental scaffolding of fraction-specific educational conversations and their relation to parent enjoyment of math and efficacy in supporting their children's math learning was our key main research question. After the prompted parent-child discussion, children completed an eighteen-question post-test assessing their understanding of fractions across different representation types (e.g. continuous and discretized rectangles). Finally, parents were asked to answer a few survey questions measuring their enjoyment during the activity and their math self-efficacy. Although administering PMSE questions prior to the task could have avoided confounding parents' responses with their experience of the conversation, we intentionally placed the survey afterward to minimize potential priming effects that might influence how parents approached the interaction. This temporal ordering was designed to preserve the ecological validity of the parent-child conversation.

Although the study employed a structured, prompt-based design, it can still be meaningfully situated within the home numeracy environment (HNE). While the setting was not entirely naturalistic due to the presence of scripted prompts, key characteristics of HNE were preserved. Notably, parents retained agency in how they engaged with their child and how the conversation unfolded, allowing for spontaneous and individualized scaffolding behaviors. Most importantly, all interactions took place in the home setting, free from immediate researcher presence, thus capturing parent-child math talk in a familiar and more ecologically valid context than a laboratory visit. This balance of structure and autonomy supports the interpretation of the study as situated within the broader construct of HNE.

Measures

Parental Enjoyment

To measure parental enjoyment of the conversation they just had, parents were asked to answer one question: *On the scale of 1-5 below, how enjoyable, fun, or interesting do you think the activity of talking to your child about fractions is?* Parents' enjoyment scores ranged from 1 to 5, with an average of 3.47 (SD = 1.12).

Parental Math Self-Efficacy (PMSE)

Parents' self-efficacy for teaching math was measured with a 4-item questionnaire capturing how capable and efficacious they feel in supporting their child's math learning created by Carrazza (2021, see Appendix A), which was adapted from a scale used to measure teacher's self-efficacy (Midgley et al., 2013). Parents rated each item on scale from 1 ("not true of me") to 5 ("very true"). The Cronbach's alpha for this scale in Carrazza's study (2021) increased from .49 to .72 when the third item was removed so parents' score was the average of the other three items. In this study, we began by constructing a PMSE composite by averaging four self-efficacy items ($\alpha = 0.62$). Parents' PMSE score ranged from 2 to 5, with an average of 3.62 ($SD = 0.60$). This reliability was below the conventional acceptable 0.70 cutoff, possibly due to the homogeneity of this sample by demographic features (Nunnally & Bernstein, 1994). When we dropped the third item, α rose modestly to 0.67; however, all relationships with scaffolding measures remained stable. We therefore retained the full 4-item scale.

Parental Scaffolding

To measure parental scaffolding, this study adopted a combined quantitative and qualitative content analysis approach to code scaffolding behaviors from the conversation text (see Appendix B for detailed coding manual). Adapting the coding scheme utilized by Huang et al. (2023), parental scaffolding was coded at the sentence level in terms of the frequency (e.g., the raw count) of emerging themes from three dimensions: (1) cognitive support, (2) emotional support, and (3) autonomy support, each dimension encompassing specific codes indicating the functional or affective valence of the scaffolding language. Cognitive scaffolding contained two categories of suggestion (e.g., "How many pieces of pizza do you see there?") and explanation (e.g., "When you cut the pizza into three pieces, each piece is a third."). Emotional scaffolding was composed of positive and negative types (e.g., "Well done!" and "No, that's wrong"). Autonomy scaffolding was divided into respect (e.g., "Do you want to go first?") and adoption (e.g., "Okay, let us do as you say."). We also tracked the number of total utterances in each conversation as an indicator of the conversation length. An utterance was defined as a unit of meaning into which the stream of speech could be separated (Crookes, 1990). For example, if the parent says: "If you cut the pizza into three pieces… each piece is called a third and… thirds are smaller than halves." Then two utterances should be counted no matter where or how long the parent pauses in the sentence. This length measure takes advantage of spoken content but avoids misleading inflation due to long pauses that would be present if the measure was solely a total runtime of the conversation.

To ensure reliability in the qualitative coding, two trained raters independently and blindly coded a subset of 20 video recordings. Utterances of various scaffolding types and the total count of utterances were coded. Global inter-rater reliability of all variables was assessed using Cronbach's alpha ($\alpha = .96$) and Cohen's Kappa ($\kappa = .85$), indicating excellent agreement between coders. Total cognitive scaffolding was calculated by adding up raw counts of suggestion and explanation, total autonomy scaffolding by adding up raw counts of respect and adoption, and total scaffolding by adding up all six types of scaffolding. Parents' total scaffolding count ranged from 5 to 80, with an average of 23.34 (SD = 14.85).

Results

Descriptives and Correlations

Table 1 displays the descriptive summary for scaffolding variables in conversations. In conversation, the two cognitive scaffolding types, suggestion (M = 7.98, SD = 5.82) and explanation (M = 10.27, SD = 8.11), were the most frequently used, whereas negative emotional scaffolding was used the least (M = 0.51, SD =

1.60). Conversation length also varied widely, as indicated by utterances (M = 29.05, SD = 17.98; range 5–89).

Table 1

Descriptive Statistics for Scaffolding Variables (N = 96).

Variable	***M***	***SD***	***Min***	***Max***
Utterance	29.05	17.98	5	89
Cognitive - Suggestion	7.98	5.82	0	28
Cognitive - Explanation	10.27	8.11	0	44
Emotional - Positive	2.33	2.64	0	13
Emotional - Negative	0.51	1.60	0	14
Autonomy - Respect	1.03	0.98	0	4
Autonomy - Adoption	1.22	1.46	0	7

Note. M = mean; *SD* = standard deviation; *Min* = minimum; *Max* = maximum.

Correlations between conversational scaffolding patterns, parental enjoyment, and PMSE are shown in Table 2. Notably, utterance count was strongly associated with almost every scaffolding behavior, ranging from suggestion ($r = .85$, $p < .001$) and explanation ($r = .78$, $p < .001$) to positive emotional support ($r = .58$, $p < .001$), negative emotional support ($r = .41$, $p < .01$), and autonomy respect ($r = .34$, $p < .05$), but not with autonomy adoption ($r = .18$, $p>.05$). This means that longer conversations tended to have more scaffolding behaviors in general, maybe because more time in conversation allowed for more scaffolding, or that conversations with more scaffolding were longer.

Parental math self-efficacy (M = 3.62, SD = 0.60) correlated with enjoyment ($r = .39$, $p < .01$), indicating that parents who felt more efficacious also enjoyed the task more. However, PMSE was not correlated with any scaffolding behaviors, counter to our hypotheses. Conversely, enjoyment was related to positive emotional scaffolding in conversation ($r = .33$, $p < .01$), suggesting that parents who enjoyed the task more provided more positive emotional support. Finally, child pretest performance was negatively associated with explanation scaffolding ($r = –.31$, $p < .01$). Within the six scaffolding types, the two cognitive strategies of suggestion and explanation were tightly linked ($r = .56$, $p < .001$), and each showed moderate ties to emotional supports, especially positive ones ($r = .45$, $p < .001$ for suggestion; $r = .31$, $p < .01$ for explanation), whereas autonomy behaviors, especially adoption, were more weakly connected to both cognitive and emotional scaffolding (e.g., $r = .05$, $p > .05$ for suggestion; $r = .20$, $p > .05$ for positive emotional support).

Regression Analyses

To examine the relationship between parental perceptions and scaffolding, we regressed the six types of scaffolding as well as total scaffolding score on enjoyment and parental math self-efficacy, controlling for child pretest performance and total number of conversation utterances. To address our multiple comparisons, we applied a Bonferroni correction. We present key regression results in Table 3.

Results revealed a consistent and robust effect of parental utterance count, which significantly predicted all scaffolding types and composite scores, except autonomy-adoption scaffolding. For instance, utterance was the strongest predictor of cognitive suggestion ($\beta = 0.28$, $p < .001$), cognitive explanation ($\beta = 0.34$, $p < .001$), and the total cognitive scaffolding score ($\beta = 0.62$, $p < .001$). These results suggest that, overall, longer parent-child conversations are more likely to contain a greater number of scaffolding behaviors.

Enjoyment significantly predicted positive emotional scaffolding ($\beta = 0.70$, $p < .01$) and also emerged as a positive predictor of autonomy-respect ($p = .031$) and the total autonomy score ($p = .014$), although the latter did not remain significant under

Table 2

Correlations Between Conversational Patterns, Parental Enjoyment, and PMSE

	Cognitive - Suggestion	Cognitive - Explanation	Emotional - Positive	Emotional - Negative	Autonomy - Respect	Autonomy - Adoption	Utterance	PMSE	Enjoyment	Pretest
Cognitive - Suggestion	1									
Cognitive - Explanation	0.56***	1								
Emotional - Positive	0.45***	0.31**	1							
Emotional - Negative	0.25*	0.47***	0.10	1						
Autonomy - Respect	0.23*	0.15	0.37***	-0.04	1					
Autonomy - Adoption	0.05	0.03	0.20	0.08	0.24*	1				
Utterance	0.85***	0.78***	0.58***	0.41***	0.34***	0.18	1			
PMSE	0.07	0.05	0.07	0.07	-0.07	-0.12	0.06	1		
Enjoyment	0.14	0.02	0.33**	-0.08	0.20	0.14	0.11	0.39***	1	
Pretest	-0.02	-0.31**	-0.03	-0.08	0.08	0.08	-0.13	-0.07	0.00	1

Note. p-values shown in this table are Bonferroni-corrected p-values.

* = $p < .05$, ** = $p < .01$, *** = $p < .001$.

Bonferroni correction. No other emotional or cognitive scaffolding outcomes were significantly associated with enjoyment.

Table 3

Summary of Regression Results Predicting Scaffolding Outcomes from Parental Perceptions, Utterance, and Child Pretest Performance

Outcome	PMSE	Enjoy	Utterance	Pretest	R^2
Cognitive - Suggestion	ns	ns	.28***	ns	.74
Cognitive - Explanation	ns	ns	.34***	-6.74***	.66
Emotional - Positive	ns	.70**	.08***	ns	.42
Emotional - Negative	ns	~ –	.04***	ns	.20
Autonomy - Respect	~ –	.20*	.02***	ns	.18
Autonomy - Adoption	~ –	~ +	~ +	ns	.09
Total Cognitive	ns	ns	.62***	-4.72*	.85
Total Autonomy	-.76*	.45*	.03**	ns	.19
Total Scaffolding	ns	ns	.77***	~ –	.90

Note. PMSE = perceived math self-efficacy; Pretest = child pretest performance.

ns = not significant, ~ = marginal ($p < .10$), + indicates a positive coefficient; – indicates a negative coefficient.

* = $p < .05$, ** = $p < .01$, *** = $p < .001$.

Child pretest performance negatively predicted cognitive explanation (β = –6.74, p < .001) and total cognitive scaffolding (β = –4.72, p = .021), suggesting that parents offered less explanatory support when children demonstrated stronger prior knowledge.

Notably, parental math self-efficacy (PMSE, M = 3.62, SD = 0.60) did not significantly predict any scaffolding outcome, except for a marginal negative association with the total autonomy score ($\beta = -0.76$, $p = .024$), which also did not survive Bonferroni correction. Across models, PMSE was consistently not significant, failing to predict cognitive, emotional, or autonomy-related scaffolding when controlling for enjoyment, utterance, and child pretest ability.

Interactions

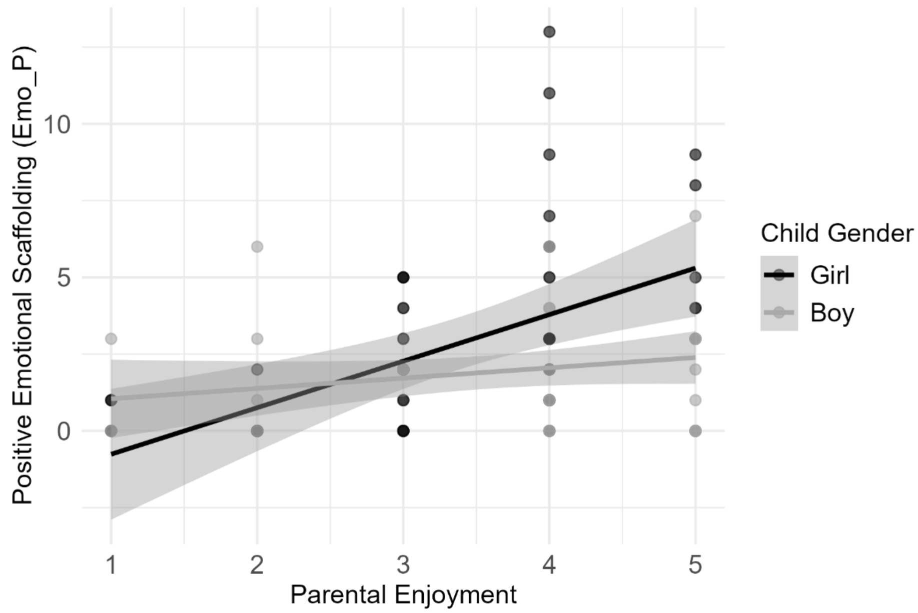
Following the main regression analyses, we conducted a series of exploratory interaction models to further investigate potential moderators of the observed effects. Specifically, we examined whether parent gender interacted with key predictors in shaping scaffolding behaviors. Among these models, one statistically significant interaction emerged: gender moderated the relationship between parental enjoyment and positive emotional scaffolding. A linear model predicting emotional scaffolding from enjoyment, gender, and their interaction revealed a significant interaction effect ($B = -1.18$, $SE = 0.45$, $p = .010$), indicating that the strength of the enjoyment effect differed by gender. As illustrated by the model, parental enjoyment had a stronger positive association with emotional scaffolding for parents of girls than for parents of boys. The main effect of enjoyment remained significant ($B = 2.70$, $p < .001$), and the interaction accounted for a modest but meaningful portion of the variance in emotional scaffolding (Adjusted $R^2 = .19$). Figure 1 plots the regression lines for both genders. Compared to parents of boys, parents of girls exhibited larger variations in positive emotional scaffolding across different enjoyment levels.

Discussion

This study contributed to the literature of home numeracy environment and early math development by examining whether parental enjoyment and parental math self-efficacy predicted specific scaffolding practices.

Figure 1

Enjoyment and Gender Interaction on Positive Emotional Scaffolding



Note. This figure illustrates the interaction effect between enjoyment and gender on positive emotional scaffolding. $B = -1.18$, $SE = 0.45$, $p = .010$.

Enjoyment

First, we found a significant positive relationship between parental enjoyment and positive emotional scaffolding. This finding aligns with our hypothesis and suggests that parents who enjoyed the fraction talk task more provided greater emotional encouragement and affirmation to their children during the conversation. This finding signifies the importance of "fun" math, not only for children, but also for parents. While the motivational role of enjoyment in math learning has been widely documented, much of this literature has focused on students rather than parents. For example, Sağkal & Sönmez (2022) reported math enjoyment as a mediator between parental support perceived by the child and student math engagement. Our study extends this line of work by showing that parental enjoyment also plays a critical role in shaping a more supportive home numeracy environment. It is also possible that parents' enjoyment during math talk is influenced by their child's engagement or enthusiasm. When children respond positively, parents may feel more motivated and encouraged, creating a feedback loop of mutual enjoyment and support. Similarly, a study conducted on parents of adolescent children from low-income communities found that when parents were nudged to do activities that did not include any formal curricular content with their children at home, the parent-student interactions were significantly more frequent, and students' math grade significantly increased (Santana et al., 2019). These findings suggest the importance of providing families with math activities that are not only developmentally appropriate and engaging for children, but also engaging for parents.

Second, we found that gender interacted with the relationship between parent enjoyment and positive emotional scaffolding: the relationship was stronger for parents of girls than boys. One explanation for this difference is gendered parenting (Leaper, 2005). Parents often hold beliefs that girls benefit more from affective support, whereas boys are expected to rely more on cognitive guidance, and accordingly, parents give daughters more praise and warmth (Leaper & Farkas, 2015). Furthermore, parents' and teachers' math-related gender stereotypes demonstrate significant influences on home and classroom interactions (Gunderson et al., 2012). A review synthesizing observational studies found a tendency for controlling strategies (i.e., focused on dominance, negativity, and power) to be used preferably with boys, and autonomy-supportive strategies (i.e., focused on warmth, affiliation, and interpersonal closeness) to be used more with girls (Endendijk et al., 2016). In this study, when parents feel particularly engaged or pleased by the interaction, those gendered expectations may become even more pronounced than usual, translating their enjoyment into extra emotional scaffolding with girls but not as much with boys.

Another reason that might account for this gender interaction may be that girls have greater emotional sensitivity and reciprocity in parent–child exchanges. For example, Denham et al. (2010) reported girls seemed particularly susceptible to parental socialization of emotion. Therefore, girls may be better at picking up on subtle affect cues and responding in ways that elicit further parental warmth. Such gendered sensitivity was evidenced in an empirical study by Bhanot and Jovanovic (2005), where girls were more sensitive to intrusive parental support with homework, especially when math was involved. In our data, this dynamic likely magnifies the slope for girls: as parents enjoy the fraction conversation, daughters' receptivity fuels a positive feedback loop of emotional support. Oppositely, as parents enjoy fraction conversation less, their daughters may engage less.

Theoretically, these results highlight the role of child gender in parental scaffolding practices, yet the lack of research pertaining to child gender and scaffolding calls for further investigation (Mermelshtine, 2017). Future studies can explore parents' different propensities of supporting boys and girls in math tasks and if girls benefit more from emotional scaffolding than boys. Practically, these results suggest that interventions aiming to bolster parents' affective engagement in early math talk should address underlying gender norms and equip parents to recognize and nurture boys' emotional receptivity as well.

Parental Math Self-Efficacy (PMSE)

This study found no significant correlations between parental math self-efficacy (PMSE) and any type of scaffolding behavior, contrary to our original hypothesis. One plausible explanation for this null finding lies in the limited internal consistency of the PMSE scale in this sample (Cronbach's $\alpha = .62$), which falls below the conventional threshold for acceptable reliability (Nunnally & Bernstein, 1994). Low reliability reduces the precision of the scale and increases the measurement error, thereby attenuating the strength of any true relationships between PMSE and observed behaviors.

The low reliability may result partly from specific implementation of this scale in the current study. Although the scale was validated in prior work (Carrazza, 2021), it was primarily used in pure quantitative survey-based and test-session contexts. In contrast, parents in this study completed the PMSE items after engaging in a fraction conversation with their child, which may have influenced how they reflected on and rated their efficacy. Importantly, PMSE is theorized to reflect a relatively long-term stable trait, which is parents' general belief in their math-supporting capabilities, rather than their current performance in a specific task. While most parents rated themselves moderately high (M = 3.62, SD = 0.60), it is possible that many felt underprepared for the fraction-related prompts used in this study, especially if they lacked recent exposure to such content. Therefore, there could be a lack of relationship between general PMSE and specific scaffolding in this fraction conversation. If parents were asked specifically about how capable they are in supporting the fraction conversation, then self-efficacy might have stronger correlations with the scaffolding types.

A second issue involves potential bias in self-perception. Self-reported measures of parental self-efficacy are inherently susceptible to over- or underestimation. Some parents may have overreported their PMSE to appear competent or to align with socially desirable norms. Conversely, parents with high confidence may have underreported their self-efficacy as a form of modesty or self-effacing behavior (Jones & Prinz, 2005). Prior research has documented parental positivity and egocentric biases in reporting children's emotional well-being (Lagattuta et al., 2012), and similar distortions may exist in how parents assess their children's math abilities and their own role in shaping them. These results underscore the need for systematic investigations into parental self-report biases, especially in contexts involving observed behavior. Future research should work toward validating the PMSE scale across diverse contexts.

Preexisting Knowledge and Utterance

We found that children's pretest performance significantly predicted explanatory cognitive scaffolding, such that parents provided fewer explanations when their child demonstrated higher prior knowledge about fractions. This finding accords with the theory that parents adjust their level of scaffolding in response to the child's cognitive ability, a dynamic commonly referred to in the literature as "contingent shifting" (Wood, 1980). In this process, instructional support is calibrated to the child's needs: when a task exceeds the child's current capabilities, parental guidance increases; as the child becomes more competent, parents gradually reduce their support to promote independent problem-solving (Carr & Pike, 2012). Our results indicate that this adaptive pattern of scaffolding is also present in the home numeracy environment, particularly within parent-child math talk. This contributes to the growing body of evidence that parents can responsively adjust their instructional behaviors even in informal, everyday settings. Future research may extend this line of inquiry by examining whether contingent scaffolding also varies with other child characteristics, such as temperament, motivation, or gender. For instance, do parents exhibit more controlling scaffolding behaviors toward girls compared to boys, accounting for child prior math knowledge?

Another key finding was the consistent predictive effect of utterance count on nearly all types of scaffolding, except autonomy–adoption. It is intuitively expected that longer conversations should contain more scaffolding attempts, as parents tend to initiate and continue conversation when they know what to say to help their child learn fractions. However, the lack of association between utterance count and autonomy-adoption can be explained by the nature of this scaffolding type. Autonomy-adoption refers to moments when parents follow the child's lead and adopt the child's perspective or interests. Thus, it typically occurs in response to child-initiated contributions. Because this type of scaffolding reflects child-driven interaction, rather than sheer parent talkativeness, it is not necessarily tied to the total volume of parental utterances. This distinction highlights the importance of considering the directionality and source of initiative in parent-child dialogue when interpreting scaffolding patterns. It is also worth noting that not all utterances in the conversation were coded as scaffolding. Many may have served social, logistical, or topic-shifting purposes. Future analyses could examine what proportion of total utterances were classified as scaffolding and whether non-scaffolding content also relates to child outcomes. This would help clarify whether it is specifically scaffolding behaviors or conversation quality more broadly that supports learning.

Limitations and Future Directions

This study has several limitations that raise and offer important directions for future research. First, the sample was demographically skewed, with most parents reporting high levels of education and income, and all conversations conducted in English. This limits the generalizability of the findings to families from more diverse socioeconomic and cultural backgrounds. Future studies should aim to include participants from a broader range of linguistic, financial, and educational contexts to better capture variability in home numeracy environments (HNE). Second, the online format, while logistically efficient, constrained the depth of contextual information available for analysis. Our qualitative coding primarily relied on speech transcripts from video recordings, therefore excluding potentially meaningful nonverbal cues such as tone, facial expression, and gestures, which are often crucial factors in interpreting scaffolding behaviors. Naturalistic in-home observations may offer a richer, more holistic view of parent-child math interactions. Third, the study relied solely on parent self-report to measure enjoyment and math self-efficacy. Self-reported data are prone to social desirability and self-perception biases, which may not accurately reflect actual capabilities. For instance, a parent may feel confident in their math support, while the child experiences their help as confusing or overly directive. In turn, the child's disengagement or lack of cooperation may prompt the parent to increase their scaffolding efforts, creating a feedback loop that is not captured through parent self-report alone. Future research may benefit from incorporating triangulated measures, such as child-reported perceptions of parental math support, to enhance validity and better capture the reciprocal nature of parent-child educational interactions.

Conclusions

This study utilized both behavioral and survey data to examine how parental enjoyment and math self-efficacy are associated with specific scaffolding behaviors during parent-child fraction talk in a home numeracy environment. Findings revealed that parental enjoyment was positively associated with positive emotional scaffolding, whereas parental math self-efficacy (PMSE) did not predict any type of scaffolding. Additionally, children's preexisting fraction knowledge was negatively associated with explanatory cognitive scaffolding, suggesting that parents adjust their instructional input based on their child's competency. A significant interaction effect further showed that the relationship between enjoyment and emotional scaffolding was stronger for parents of girls than boys, highlighting potential gendered dynamics in emotional responsiveness during math interactions. These results have both theoretical and practical implications.

While PMSE did not emerge as a significant predictor in this study, this result should be interpreted with caution. The null finding may reflect methodological or sampling limitations, such as the relatively low reliability of the PMSE measure, little variability in this measure, and the homogeneity of the sample. Future research should continue to investigate the role of parental self-efficacy in scaffolding, ideally using more robust and context-sensitive measures, and in more diverse populations. These efforts will deepen our understanding of how parental perceptions translate into their everyday math scaffolding practices over time.

In terms of real-world application, these findings highlight the importance of affective engagement in shaping effective math interactions at home. Parents seem attuned to their child's current level of knowledge when offering support. However, encouraging them to approach home math activities with a sense of enjoyment, and sharing that having fun together can enhance the quality of their scaffolding, may help them enhance the HNE. Informal math talk serves not only educational goals but also offers a joyful, collaborative opportunity to strengthen both learning and the parent–child relationship.

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Appendix A

Survey Questions for Parental Math Self-Efficacy

Instructions: Please choose the option that corresponds to your answer for each question.

Question	Not True at All		Somewhat True		Very True
1. I am good at helping my child learn math.	1	2	3	4	5
2. If I try really hard, I can help my child even when he/she is really struggling in math.	1	2	3	4	5
3. Things that I can't control have a greater influence on my child's math achievement than I do.	1	2	3	4	5
4. How much can you do to motivate your child if he/she shows low interest in math?	None at All (1)	A Little (2)	A Fair Amount (3)	Much (4)	Very Much (5)

Appendix B

Coding Scheme for Parental Scaffolding

Dimensions	Codes	Descriptions	Examples
Cognitive support	Suggestion	Suggestion on problem-solving strategies	“How many pieces of pizza do you see there?”
	Explanation	Explanations of problem-solving progress	“When you cut the pizza into three pieces, each piece is a third.”
Emotional support	Positive	Praise, encouragement, and consolation	“Well done!” or “You did a good job!”
	Negative	Criticism, rejection, and threat	“No, that’s wrong.”
Autonomy support	Respect	Respecting children’s individuality and pace	“Do you wanna go first?” “Are you able to figure out?”
	Adoption	Adopting children’s perspectives and interests	“Okay, let us do as you say.”