

Children's Early Math Problem-Solving: The Role of Parent Numeracy Practices, Numeracy Expectations, and Math Attitudes

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Supplementary Materials: Materials [see [Index of Supplementary Materials](#)]



Abstract

This study allows for the examination of associations between components of the home mathematics environment – including parents' formal numeracy practices, math attitudes, and numeracy expectations – and children's development of math problem solving skills following the transition into formal school. Sixty-six children from three schools in the Southeastern United States were assessed six times across kindergarten and first grade using a battery of academic and cognitive measures – including a task that evaluated children's strategy use and accuracy while solving basic arithmetic problems. Parents reported the frequency with which they engaged in formal numeracy practices in the home, their attitudes towards mathematics, and their numeracy expectations for their child. Results from growth curve models, controlling for parents' education and children's working memory, revealed that neither parents' numeracy practices nor their expectations accounted for differences in children's development, but that children with parents who held more negative views towards math entered kindergarten with lower math problem-solving skills (both accuracy and strategy use) than their peers. However, children who entered kindergarten with lower skills demonstrated greater improvement in their scores over the course of the two years. Findings highlight the importance of examining aspects of the home mathematics environment other than numeracy practices – such as parents' math attitudes – as they relate to children's mathematical development.

Keywords

arithmetic problem-solving, strategy use, home math environment, kindergarten, first grade, parent math attitudes

Children's early numeracy skills have been associated consistently with long-term academic success (Duncan et al., 2007; LeFevre et al., 2010). Specifically at kindergarten entry, substantial variability can be observed in children's mathematical knowledge and skills (Entwisle & Alexander, 1989; Starkey & Klein, 2007). Accordingly, researchers have explored potential contextual predictors of this variability, such as the home mathematics environment (Niklas & Schneider, 2014; Thompson et al., 2017). The home mathematics environment encompasses a wide range of factors, including parents' personal attitudes, affective responses to mathematics, and activity choices (Zippert & Rittle-Johnson, 2020). Multiple studies have found positive associations between home numeracy learning practices – such as the frequency of parental scaffolding and access to educational materials – and children's mathematical performance. However, recent evidence has suggested that this association is more nuanced than previously understood (Skwarchuk et al., 2022) and that caregivers' personal attitudes towards mathematics may be important for children's development,



as these attitudes may contribute to the quality of numeracy activities that are taking place in the home (del Río et al., 2017). For this reason, further investigation is required in order to understand the unique roles that parents' mathematical attitudes, expectations, and numeracy practices play in the development of children's mathematical skills during early elementary school. These home-based factors may be particularly important for foundational arithmetic abilities, such as the use of addition strategies.

Children's Early Mathematics Skills: Strategy Use in the Context of Addition

Addition is one of the first mathematical skills that children learn in kindergarten and provides a foundation for the development of more complex and abstract mathematical systems, such as algebra (Baroody & Ginsburg, 1983; Carpenter et al., 2003; Knuth et al., 2006). During early elementary school, children are taught rules, procedures, and problem-solving strategies that assist in their mastery of arithmetical concepts. According to Siegler and colleagues' strategy choice model, strategies have been defined as procedures that are (a) *nonobligatory*, in that they are not the only way to solve a problem and (b) *goal-directed*, in that they are intended to accomplish a specified purpose (Siegler, 1986; Siegler & Jenkins, 1989; Siegler & Robinson, 1982; Siegler & Shrager, 1984). Children employ addition strategies when they are unable to retrieve a solution from memory – and in this sense, retrieval of a known solution is not considered a strategy, as it reflects an automatized process that does not require additional effort.

Within the existing literature that examines the strategy choice model, findings suggest that even at a young age, children understand that if they do not know the solution to a problem, they can employ a variety of strategies in an attempt to solve it. These strategies differ in terms of the time required for execution, the probability of producing the correct answer, and the demands placed on working-memory resources (Siegler, 1986). Across preschool and elementary school, children employ techniques such as counting fingers or decomposing sets of numbers. See Table 1 for a complete list of addition strategies (adapted from Siegler & Jenkins, 1989). The use of these strategies is thought to develop over time in a wave-like manner. Indeed, as children learn *new* strategies, they use strategies that they learned previously less often and sometimes refrain from using them altogether (Ashcraft, 1982; Baroody & Ginsburg, 1986; Fuson, 1982; Siegler, 1986, 1987; Siegler et al., 1996; Siegler & Jenkins, 1989; Siegler & Robinson, 1982; Svenson & Sjoberg, 1983). Moreover, as children demonstrate proficiency in using more than one strategy they eventually shift towards more advanced techniques (Siegler, 1986).

The Common Core State Standards adopted by most public schools in the United States explicitly list the acquisition of strategy use, such as decomposition and counting on (e.g., referred to as the *min* or *max* procedure by Siegler & Jenkins, 1989), as developmental requisites housed under the Operations and Algebraic Thinking component of mathematics instruction for kindergarten and first grade students (California Department of Education, 2013; North Carolina Department of Public Instruction, 2021; Wisconsin Department of Public Instruction, 2021). Therefore, it is important to understand the developmental progression of strategies utilized by children during the first two years of formal school, along with the contextual factors that may play a role in this development. With the exception of a few studies – such as those that examine associations between parent–child reminiscing conversations and mathematical strategy development (e.g., Hudson et al., 2018) – limited empirical research has examined how children's early exposure to mathematical concepts in the home and parental attitudes are associated with intra-individual change in arithmetic strategies and subsequent mathematical performance during this specific developmental period.

The Home Mathematics Environment

The home mathematics environment (HME)¹ is a multidimensional construct that encompasses a range of context-level factors, person-level factors, and processes related to children's mathematical development (Hornburg et al., 2021). Although researchers have conceptualized the HME in various ways, the majority of attention has been directed towards processes, such as parent–child interactions, that are intended to support children's mathematical development. Theoretically, these interactions can target a range of mathematical competencies in young children (Zippert & Rittle-

1) The Home Mathematics Environment is sometimes referred to as the more narrow Home *Numeracy* Environment. However, for the purposes of this paper, we refer to parents' numeracy practices, attitudes, and expectations as all existing within the broader mathematics environment.

Johnson, 2020); however, particular focus has been placed on *numeracy practices* which involve numbers, quantity, or arithmetic (Skwarchuk et al., 2014). Parents may engage their children in numeracy activities that either directly teach skills and concepts (e.g., counting together) or incidentally involve math learning, although this is not the main focus of the activity (e.g., playing number board games or measurement activities required in cooking and crafts). Importantly, findings regarding the role of numeracy practices in children's mathematics outcomes are mixed (Mutaf-Yildiz et al., 2020). Some studies have evidenced positive linkages between formal numeracy practices and children's later math skills in early elementary school (e.g., LeFevre et al., 2010; Manolitsis et al., 2013), whereas others have failed to find such associations or have found that only certain types of numeracy practices are related to children's performance (e.g., Elliott et al., 2023; Dunst et al., 2017; Missall et al., 2015; Susperreguy et al., 2020).

One potential reason for contradictory findings within the HME literature has to do with what specific mathematical skills are assessed as outcomes of interest. For example, only a handful of studies have investigated activities in the home that may support the development of math skills *other than numeracy* (e.g., Zippert & Rittle-Johnson, 2020) due to the current conceptualization of the math skills children are typically thought to learn during the early years (Milburn et al., 2019). However, given the extant literature's emphasis on the role of caregivers in children's development of self-regulated learning skills (e.g., executive function, strategic memory, metacognition; Pino-Pasternak & Whitebread, 2010), that have been found to underlie children's math competencies (Efklides & Schwartz, 2024), the exploration of how components of the HME may relate to other mathematical skills – such as strategy use – remains an important next step for researchers.

Exploring other aspects of the home math environment (HME), beyond numeracy practices, may help clarify these contradictory findings. Both foundational, domain-general (e.g., Bronfenbrenner & Morris, 2006) and more recent, domain-specific (e.g., Eason et al., 2022) theoretical perspectives differentiate *individual-level factors* – such as parents' beliefs and cognitions – from *behavioral interactions between parents and children themselves* – such as participating in math-related activities. As a result, recent findings have begun to suggest that not only direct behavioral interactions, but also individual cognitive and affective characteristics of parents should be included in the conceptualization and measurement of the HME (for a discussion on the HME, see Hornburg et al., 2021). Two such characteristics are parents' attitudes toward math – positive or negative feelings about math – and their numeracy expectations – the importance placed on their child achieving certain academic benchmarks by a specific grade level. These components of the HME are separate from but related to numeracy practices, as they are thought to underlie (a) the strength and direction of numeracy practices (del Río et al., 2017; LeFevre et al., 2002, 2010) as well as (b) children's own math attitudes and motivation as they progress through elementary school. Thus, examining how these HME indicators relate to one another – as well as to children's math outcomes *simultaneously* – remains an important area for further investigation.

The Present Study

Despite a vast literature that reports linkages between the home mathematics environment and child outcomes, there are specific gaps that persist. First, much of the literature has focused on *behavioral* aspects of the home mathematics environment – such as parents' numeracy practices and use of educational materials – and less work has focused on other components of children's early mathematics experiences in the home – such as parents' attitudes, beliefs, and expectations (for reviews, see Hart et al., 2016; Daucourt et al., 2021). Second, few studies have assessed children's *intra-individual change over time* spanning more than one academic year or more than 3 time points (e.g., Schmitt et al., 2017). Additionally, the majority of studies have focused on development across the preschool and kindergarten years. Because of this, the role of the HME as children develop over time during the first two years of formal school is less well understood. Finally, few studies have examined the role of HME practices, attitudes, and expectations in children's development of *strategy use* – as opposed to achievement or performance – in the context of mathematics.

The current investigation was designed to explore these issues by leveraging growth curve modeling in order to examine children's growth in math problem-solving skills across six timepoints during the kindergarten and first-grade school years as a function of parents' numeracy expectations, math attitudes, and numeracy practices. Because of the present study's focus on the transition to formal school, we examine the role of *formal* numeracy practices (opposed to informal numeracy practices) – such as teaching children simple sums and counting activities – that are thought to

underlie math problem-solving skills. We predicted that children with parents who had higher numeracy expectations, more positive math attitudes, and who reported more frequent numeracy practices would enter kindergarten with higher math problem-solving skills. Additionally, based on previous research that showed that children who enter formal school with lower initial numeracy knowledge and skills (as a function of components of the HME) are unlikely to catch up to their peers, even after being exposed to formal instruction (Jordan et al., 2009), we predicted that children with parents who had higher numeracy expectations, more positive math attitudes, and who reported more frequent numeracy practices would develop math problem-solving skills more rapidly than their peers.

Method

Participants and Procedure

Parents and children were recruited as participants in the Classroom Memory Study, a longitudinal study focusing on cognitive and academic development in school settings. A sample of 76 children was recruited from 3 schools in one school district in a southeastern state and tracked across the kindergarten and first-grade years. Families with children in participating classrooms received a letter of invitation to participate in the study, and all children who returned consent forms were enrolled, with no criteria for exclusion. The participants were administered a battery of cognitive and academic achievement assessments, and the current sample includes all children of parents who completed the background questionnaire. The resulting sample was composed of 66 children (53% female) ranging in age from 4.93 years to 6.43 years ($M = 5.71$) at the first time point. The diversity of the sample was representative of the school district from which the participants were drawn, with 62% of the children identifying as European American, 18% as more than one race, 9% as Asian/Pacific Islander, 9% as African American, and 2% declining to report. Of the primary caregivers taking part in the study, 89% identified themselves as mothers, 9% were fathers, and 2% identified as other caregivers. Caregivers also provided information about their educational background, revealing that 87% of primary caregivers in the sample completed a bachelor's degree or higher. Approximately 9% of children in the current study qualified for free or reduced school lunch.

Children participated in after-school assessments in which they were administered a battery of various cognitive and academic achievement measures; we focus here on a math problem-solving task. Assessments were administered in the fall (Time 1), winter (Time 2), and spring (Time 3) of kindergarten, as well as the fall (Time 4), winter (Time 5), and spring (Time 6) of the first-grade year. On average, the assessments were 3.42 months apart ($SD = 1.55$). All assessments were video-recorded and later coded by trained research assistants. In the spring of kindergarten, primary caregivers completed a comprehensive background questionnaire that focused in part on parents' academic expectations, math attitudes, and formal home numeracy practices.

Measures

Math Problem-Solving Task

To characterize children's developing mathematical skills, this task was adapted from the assessment protocol of Siegler and Jenkins (1989) and administered across all six timepoints (i.e., fall, winter, spring of kindergarten and first grade). Each child was asked to solve a series of 10 single-digit addition problems (e.g., $1 + 3$ or $9 + 5$). A research assistant read problems aloud (e.g., "What is 1 plus 3?"), and the child was instructed to solve each problem using any method they preferred. Manipulatives, such as paper and pencil, were not provided. Immediately after the child provided a response, the research assistant asked for a report of how the problem had been solved. Both the child's answer to the problem and the strategy reported by the child were recorded. All scores were double coded by two research assistants and any disagreements were brought to a consensus before being entered into the dataset.

Children's performance on this task was characterized by two measures: children's overall *accuracy* (correctly answering the problem) and *strategy use* (how often children utilized a strategy) to reach their answer. As such, two scores were generated for each trial: one for accuracy, or the number of problems answered correctly (out of 10), and one for strategy use, or the number of problems in which the student used a strategy to produce the solution (out

of 10). The strategies that were coded can be seen in Table 1; note that an individual strategy code (e.g., sum, min, decomposition) was assigned for each of the 10 problems, but for the purpose of analysis, a composite strategy use variable was created that represents the *number of problems* on which any strategy was used regardless of whether the strategy produced the correct answer.

Table 1

Definition of Strategic and Non-Strategic Behaviors

Behaviors	Definition (<i>Example in context of 3 + 5</i>)
Strategic	
Sum	Counting each addend separately first, and then all together. (e.g., <i>putting up three fingers and counting "1, 2, 3" and putting up five fingers and count "1, 2, 3, 4, 5." Then counting by saying "1, 2, 3, 4, 5, 6, 7, 8."</i>)
Shortcut Sum	Counting both addends together starting from one. (e.g., <i>saying "1, 2, 3, 4, 5, 6, 7, 8" while simultaneously putting up one finger on each count.</i>)
Max	Counting on from the smaller addend. (e.g., <i>saying "3, 4, 5, 6, 7, 8" or "4, 5, 6, 7, 8" simultaneously putting up one finger on each count.</i>)
Min	Counting on from the larger addend. (e.g., <i>saying "5, 6, 7, 8" or "6, 7, 8" while simultaneously putting up one finger on each count.</i>)
Finger Recognition	Using fingers to represent addends without counting. (e.g., <i>Putting up three fingers, then putting up five fingers, and saying "8."</i>)
Decomposition	Using an easier or more familiar problem to achieve the answer to the presented problem (e.g., <i>saying "3 + 5 is like 4 + 4, so it's 8."</i>)
Non-strategic	
Retrieval	The child retrieves the solution without making use of a strategy, generally responding within 2 seconds.
Guessing	Child makes up an answer and it is clear that the child has not engaged in any kind of effortful processes.
Other	Child does a strategy other than those listed above but is clearly using a numbers-related process.
No Response	After the problem is asked, the child responds "I don't know" or does not give any response.
Unclassifiable	The child uses one of the above strategies but due to experimenter error or other reasons it is unclear which specific strategy was used.

Working Memory

Working memory, an index of basic memory capacity, was assessed in the winter of kindergarten (Time 2) using a Backward Digit Span Task following the protocol recommended by McCarthy (1972) and included as a covariate. During this task, children were read a series of numbers and asked to recall the items in reverse order. The first trial began with a span of two numbers and increased by an additional digit during each subsequent trial. If the child was unable to recall

the items correctly, an additional trial of the same length was presented. If two incorrect responses were provided by the child on a given span, the task was ended. Final scores reflect the longest span remembered across two assessments (range = 0 – 6). Two assessors scored the task, and all discrepancies were resolved by consulting the original assessment videos. Past research has found this task to be a valid measure of working memory in this age group, with good test-retest reliability ($r = .74$; St Clair-Thompson, 2010; Williams et al., 2003).

Parent Questionnaire

Parents completed a questionnaire that included demographic questions about their child (e.g., age, gender, racial-ethnic identity) and background information about their family (e.g., languages spoken at home), as well as their academic expectations, numeracy attitudes, and formal home numeracy practices (adapted from Skwarchuk et al., 2009; Skwarchuk et al., 2014).

Parent Education – Parents reported on the highest level of education attained by the child's primary caregiver (0 = *no post-high school education*, 1 = *some vocational or technical training*, 2 = *some college*, 3 = *vocational or associated degree*, 4 = *bachelor's degree*, 5 = *master's degree*, 6 = *advanced professional degree such as a PhD, JD, or MD*). This was included as a covariate in the final analyses, in order to control for the strong associations between parental education and children's academic performance (Awada & Shelleby, 2021; Davis-Kean, 2005).

Math Attitudes – Parents rated their agreement/disagreement (0 = *strongly disagree* to 4 = *strongly agree*) with three statements from the work of Skwarchuk et al. (2009), such as “*I find math activities enjoyable*”, with an additional question about parents' career choices (see Cook et al., 2025S for all items). The observed internal reliability (Cronbach's α) was .83 across the four items. A composite score was created by averaging across all four items to capture parents' overall feelings or attitudes towards mathematics.

Numeracy Expectations – Parents indicated the importance (0 = *unimportant* to 4 = *extremely important*) that children achieve 6 numeracy benchmarks before they start first grade (e.g., “count to 100”; see Cook et al., 2025S). Some items were extremely advanced for children of this age (e.g., “count to 1000”) to minimize response biases (e.g., selecting extremely important ratings for all benchmarks) and were not included in the final measure. In line with the work of Skwarchuk et al. (2014), three primary items were included in the overall numeracy expectations score: *Count to 100*, *Read printed numbers up to 100*, and *Know simple sums* (e.g., $2 + 2$). A composite score was created by averaging across three primary items before being entered into models. The observed internal reliability (Cronbach's α) was .82 across the three items.

Numeracy Practices – Adapted from the work of Skwarchuk et al. (2014), parents indicated how frequently (0 = *rarely or never* to 4 = *most days per week*) they engaged in 13 different formal, home numeracy activities that were appropriate for the children entering kindergarten – such as teaching their child to recognize printed numbers, helping their child to recite numbers in order, and helping their child learn simple sums. The observed internal reliability (Cronbach's α) was .89 across the 13 items. Means, standard deviations, and ranges for individual items are found in Cook et al., 2025S. A composite score was created by averaging across all 13 items to describe parents' numeracy practices, shown in Table 3.

Missing Data

Retention rates were high throughout the study, with 94% of measurements collected on both outcome variables of children's accuracy scores and strategy effectiveness. This resulted in a total of 371 data points. Within the span of the two school years, 7 students moved (1 during kindergarten, 6 prior to first grade). All observed cases for the outcome variables were retained in the analyses under the standard assumption that the data were missing at random (MAR). In line with recommendations for handling small amounts of missing covariate data (one child missing working memory, approximately 2% of sample), this child was omitted from analyses (Grund et al., 2018; van Buuren, 2018). Missing data resulting from repeated measures were addressed using the restricted maximum likelihood (REML) estimation method.

Transparency and Openness

The data, code, and materials that support the findings of this study are available from the corresponding author, upon reasonable request. The study and analyses presented here were not preregistered.

Results

In the sections below, we first present descriptive findings for child-level outcome variables (i.e., problem-solving accuracy and strategy use) in order to characterize patterns of growth over time. Next, we provide descriptive findings for the three primary predictor variables in the current study – parents' academic expectations, math attitudes, and formal home numeracy practices – as well as parent- and child-level covariates. Finally, hierarchical linear models (HLMs) were estimated to examine children's growth in math problem-solving skills across the first two years of elementary school while considering home-level factors. These methods were applied using model building, testing, and evaluation strategies described by Raudenbush and Bryk (2002) alongside methods proposed by Curran et al. (2004, 2006) for testing and probing higher ordered interactions within growth curve models. Accordingly, we first present unconditional growth models without predictors, followed by conditional models that include relevant predictor variables in order to explore our main research aims.

Descriptive Statistics

Children's Mathematical Performance

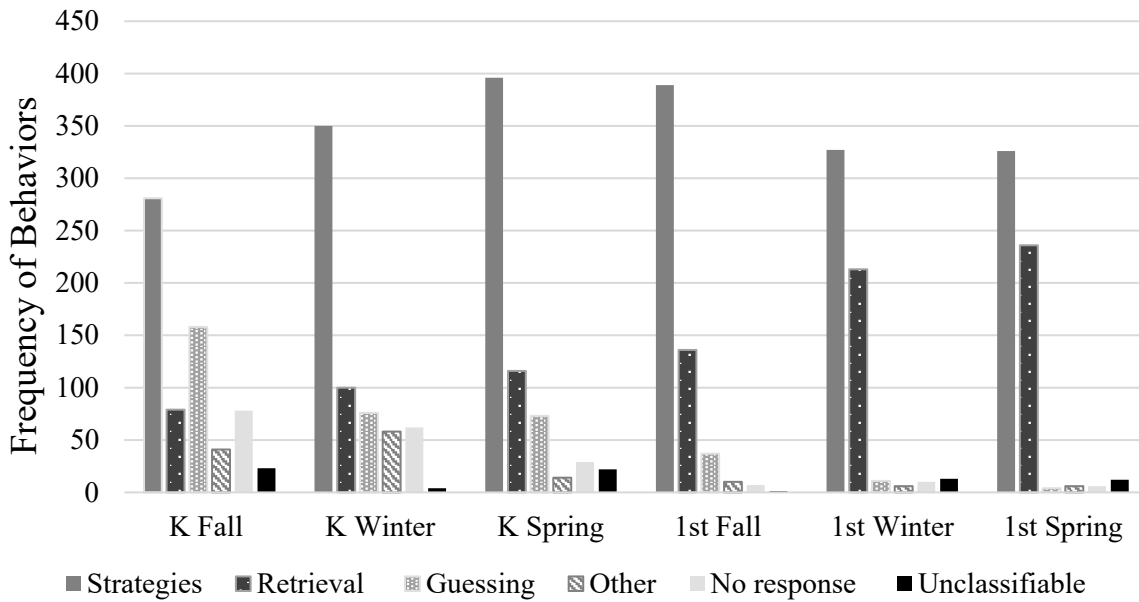
Children's performance on the mathematical problem-solving task (Siegler & Jenkins, 1989) was characterized by great variability in the fall of kindergarten. Across the entire sample, children engaged in *guessing* on a total of 158 problems, in *retrieval* on a total of 79 problems, and *did not respond* for 78 problems. As can be seen in Figure 1, children's use of retrieval increased from 79 times at kindergarten entry, to 136 problems at first-grade entry, to 236 problems at the end of first grade. Instances of retrieval were not included in the operationalization of strategy use, as retrieval reflects an automatized process that involves recalling answers from memory without making deliberate use of a procedure to solve an unknown problem². As is shown in Figure 1, the number of problems that was solved by using a strategy increased over the course of the kindergarten year (Fall = 281; Winter = 350; Spring = 396), remained stable into the fall of first grade (Fall = 389), then slightly decreased into the winter (Winter = 327) and again remaining stable into the spring of first grade (Spring = 326).

For problems that were solved by children's deployment of a strategy, individual strategy codes were assigned (e.g., sum, min, decomposition, see Table 1). As can be seen in Figure 2, children employed a variety of strategies across the kindergarten and first-grade years. For example, at each of the time points in kindergarten, the *shortcut sum* strategy was the most-often used strategy, occurring between 144–164 out of total of 660 problems. The *min* strategy was used to solve 47 problems at the beginning of kindergarten, but then for 113 and 114 problems during the winter and spring, respectively. By the beginning of first grade, the *min* strategy was the most-often used strategy and was employed for answering 160 problems. However, in the winter and spring of first grade, *decomposition* strategies became the most-often applied strategy, used to answer 147 and 148 problems, respectively.

2) It should be noted that Siegler and colleagues viewed retrieval—in the sense of recall of a fact that was previously learned, often accompanied by a statement such as “I just knew it”—as a strategy. Given our emphasis on the deliberate and effortful nature of children's strategy use, we did not include instances of retrieval in our analyses. Retrieval typically develops as a consequence of exposure to different problems and extended experience in calculation. As such, we considered retrieval to be an automatized process that involves recalling answers from memory without engaging in deliberate strategy use (e.g., Siegler & Jenkins, 1989).

Figure 1

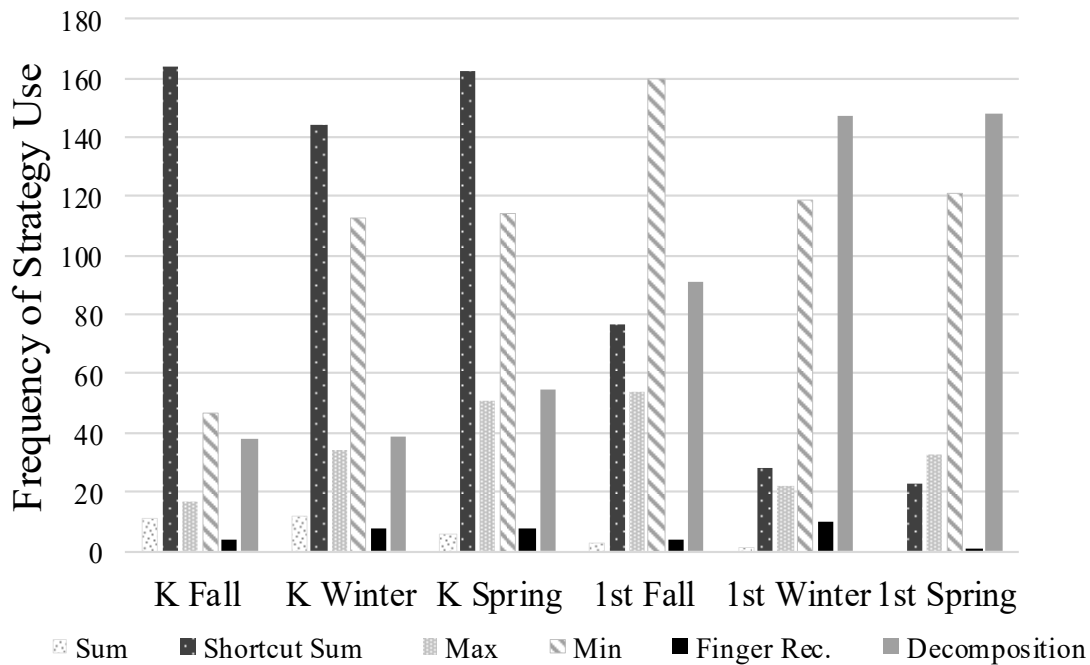
Children's Behaviors on the Mathematical Problem-Solving Task



Note. Every time point has a maximum possible value of 660, as there are 66 children, and each were presented with 10 problems per timepoint.

Figure 2

Strategies Utilized by Children Across Kindergarten and First Grade



Note. Every time point has a maximum possible value of 660, as there are 66 children, and each completed 10 problems per timepoint.

In order to characterize children's performance on the mathematical problem-solving task (Siegler & Jenkins, 1989), we focus on two indicators of performance: *strategy use* and *accuracy*. Children's *strategy use* was operationalized as the number of times a child used any strategy (sum, shortcut sum, max, min, finger recognition, and decomposition) to produce an answer, regardless of accuracy. Time-specific means for both indicators of children's math problem-solving skills are displayed in Table 2, characterizing within-child change over time in mathematical problem-solving skills, later serving as the basis for the hierarchical linear growth curve models. As can be seen in Table 2, children's strategy use increased from the beginning of kindergarten ($M = 4.26$, $SD = 3.38$) to the end of the year ($M = 6.09$, $SD = 2.63$). The average number of strategies children used peaked in the fall of first grade ($M = 6.71$, $SD = 2.30$) and then slightly decreased in the winter ($M = 5.64$, $SD = 2.10$), but remained stable through the spring ($M = 5.53$, $SD = 2.14$). These findings are consistent with rates of strategy use among elementary school-aged children previously reported in the literature (e.g., Kerkman & Siegler, 1997; Hudson et al., 2018). Children's early accuracy scores increased in a similar fashion, increasing from the beginning of kindergarten ($M = 4.24$, $SD = 3.04$) to the end of the year ($M = 6.98$, $SD = 2.71$). Children's accuracy continued to increase to an average of 9.07 problems answered correctly ($SD = 1.60$) during the winter of first grade but then remained relatively stable for the remainder of the year ($M = 8.92$, $SD = 1.62$).

Table 2

Descriptive Statistics for Math Problem-Solving Accuracy and Strategy Use Scores

Variable	N	Min	Max	M	SD
Accuracy					
K fall	66	0	10	4.24	3.04
K Winter	65	0	10	5.51	3.29
K Spring	65	1	10	6.98	2.71
1 st Fall	58	1	10	8.12	2.23
1 st Winter	58	3	10	9.07	1.60
1 st Spring	59	2	10	8.92	1.62
Strategy Use					
K Fall	66	0	10	4.26	3.38
K Winter	65	0	10	5.38	3.19
K Spring	65	0	10	6.09	2.63
1 st Fall	58	1	10	6.71	2.30
1 st Winter	58	0	10	5.64	2.10
1 st Spring	59	0	10	5.53	2.14

Note. Accuracy and Strategy Use scores have a possible range of 0 to 10.

Children's Working Memory and Parents' Education as Covariates

Children's working memory performance ranged from 0 to 6 with students recalling 2.94 digits backwards on average ($SD = 1.01$). Described previously, the current sample originates from a highly educated area, with over 80% of primary caregivers holding a bachelor's degree or higher. The mean parental education level was 4.70 ($SD = 1.46$; *range* = 0 – 6), indicating that on average, primary caregivers had some graduate work beyond a bachelor's degree. Both of these covariates were entered into HLMs at level 2 (the child level).

Parents' Numeracy Expectations, Math Attitudes, and Numeracy Practices

Means, standard deviations, and ranges for all items on questionnaire subscales can be found in Cook et al., 2025S. Descriptive statistics for each predictor variable (composite indexes – averaging across each item) and covariate are provided in Table 3. All three of these predictors were entered into HLMs at Level 2 (the child level).

Table 3*Descriptive Statistics of Parent-Level Predictors and Parent- and Child-Level Covariates*

Variable	N	Min	Max	M	SD
Numeracy Expectations	66	1	4	3.06	.85
Math Attitudes	66	.50	4	2.67	1.01
Numeracy Practices	66	.42	3.75	2.10	.89
Parent Education	66	0	6	4.70	1.46
Child Working Memory	65	0	6	2.94	1.01

Note. Parents' possible responses for (a) numeracy expectations range from 0 = *unimportant* to 4 = *extremely important*, (b) math attitudes range from 0 = *strongly disagree* to 4 = *strongly agree*, and (c) numeracy practices range from 0 = *rarely or never* to 4 = *most days per week*.

Numeracy Expectations – In line with previous research (Skwarchuk et al., 2014), three out of the six items administered to parents were used to create a composite measure of parents' numeracy expectations. On average, parents felt that it was very important for children to know how to count to 100 ($M = 3.35$, $SD = 0.86$), read printed numbers up to 100 ($M = 2.78$, $SD = 1.11$), and know simple sums ($M = 3.13$, $SD = 0.95$) before entering first grade ($M_{\text{composite}} = 3.06$, $SD_{\text{composite}} = 0.85$).

Math Attitudes – On average, parents tended to agree that they were good at math when they were in school ($M = 3.03$, $SD = 1.14$), that they enjoyed math when they were in school ($M = 2.76$, $SD = 1.28$), and that they currently find math activities enjoyable ($M = 2.78$, $SD = 1.19$). However, parents neither agreed nor disagreed with the statement “The career path I've chosen is math-related” ($M = 2.18$, $SD = 1.36$). Shown in the second row of Table 3, composite scores indicated that on average, parents held neutral-to-positive attitudes towards math ($M = 2.67$, $SD = 1.01$).

Numeracy Practices – All 13 items evidenced sufficient variability and normal distributions and were considered in the development of a composite variable. Descriptive statistics for items can be found in Cook et al., 2025S; in general, parents reported engaging in numeracy practices – such as teaching their child to recognize printed numbers ($M = 2.35$, $SD = 1.36$), helping their child to recite numbers in order ($M = 2.00$, $SD = 1.37$), and helping their child learn simple sums ($M = 2.69$, $SD = 1.10$) – several days per week ($M_{\text{composite}} = 2.10$, $SD_{\text{composite}} = .89$).

Linkages Between Parent-Level Predictors and Children's Math Problem-Solving Skills

Correlations Between Predictor Variables

Prior to examining associations between parent-level predictors and children's outcomes, basic correlations were calculated between the composite variables of parents' numeracy expectations, math attitudes, and numeracy practices. Parents' numeracy expectations were positively correlated with their math attitudes ($r = .30$; $p = .01$) but unrelated to parents' numeracy practices ($r = .23$; $p = .06$). Moreover, parents' math attitudes were unrelated to their self-reported frequency of numeracy practices ($r = .07$; $p = .60$).

Model Building Overview

A series of hierarchical linear models were constructed in order to examine differences in children's developmental trajectories as a function of their parents' math attitudes, math expectations, and numeracy practices. Analyses were conducted using the PROC MIXED procedure in SAS 9.4 (SAS Institute Inc., 2023) and missing data resulting from repeated measures were addressed using the restricted maximum likelihood (REML) estimation method. A series of nested models were estimated to determine the best-fitting unconditional model for the data and research questions (Raudenbush & Bryk, 2002). First, the nested structure of these data – time, nested within children – was explored. In these models, *accuracy* and *strategy use* scores were the repeated measure (Level 1) nested within children (Level 2). In all conditional growth curve models, parent-level predictors, as well as covariates, were first centered on the basis of their mean and then entered at Level 2 (the child level) in order to analyze between-child effects.

We next estimated a series of unconditional models in order to capture individual growth trajectories (intercepts and slopes) of children's math problem-solving skills over time. These models were estimated in order to establish the amount of variance that could be attributed to between-child differences in math problem-solving skills, determine if the intercept was statistically significant from 0, and assess if there was statistically significant growth in these skills over time. Due to our interest in children's math problem-solving skills at formal school entry, time was coded so that the intercept represented the mean of the outcome in the fall of kindergarten (Time 1) in all models. Prior to entering in predictor variables, we explored improving model fit by allowing for a quadratic model of growth. Random effects associated with less restricted models that allowed for quadratic growth were small and non-significant (*Accuracy Random Effect* ($\hat{\tau}_{22}$) = 0.01, $p = .26$; *Strategy Use Random Effect* ($\hat{\tau}_{22}$) = 0.01, $p = .38$), indicating that model fit was not improved, therefore, a linear model was retained.

After estimating the unconditional models, predictor variables were entered into models, resulting in conditionalized models of children's growth. Models 1 – 3 include one primary predictor per model (Model 1 Predictor = numeracy expectations, Model 2 Predictor = math attitudes, Model 3 Predictor = numeracy practices). Because a variety of individual- and home-level factors may be related to the development of math problem-solving skills, two control variables were included in our analytical models of growth in kindergarten and the first grade. Children's working memory was included as a covariate to control for basic cognitive capacity and parental education was included as a covariate to account for variability between parents not explained by the HME. A final model, Model 4, included all three predictor variables (as well as interactions and covariates) in order to identify unique contributors to children's math problem-solving skills.

Unconditional Growth Curve Models

As seen in Table 4, the model-implied average number of strategies used was 5.03 (out of 10) at kindergarten entry. The estimate of the linear slope was .23, indicating an increase in the number of strategies used across kindergarten and first grade ($p < .001$). Also shown in Table 4, children's model-implied accuracy was 4.63 correct problems (out of 10) on average and the estimated linear slope was 1.01 ($p < .0001$). This suggests that on average, children increased their math accuracy scores by 1 additional problem solved correctly per one unit increase in time. Moreover, the random effects for both the intercepts (*Strategy Use* $\hat{\tau}_{00} = 6.88$; *Accuracy* $\hat{\tau}_{00} = 7.99$) slopes (*Strategy Use* $\hat{\tau}_{11} = .43$; *Accuracy* $\hat{\tau}_{11} = 0.17$) were significant ($ps < .05$), suggesting there are between-child differences in problem-solving skills and rates of change that may be predicted by other variables ($ICC_{Accuracy} = .74$; $ICC_{StrategyUse} = .60$). The final unconditional growth model included significant fixed and random effects for both the linear slope and intercept.

Table 4

Unconditional Fixed and Random Effects for Growth Curve Models

Estimated Effects	Coefficient	SE	<i>t</i> / <i>z</i>	<i>df</i>	<i>p</i>	95% CI	
						<i>LL</i>	<i>UL</i>
Strategy Use							
Fixed Intercept	5.03	.38	13.41	65	< .001	4.28	5.78
Fixed Slope	.23	.10	2.23	304	.02	.03	.44
Random Intercept	6.88	1.64	4.19		< .001		
Random Slope	.43	.13	3.38		< .001		
Accuracy							
Fixed Intercept	4.63	.38	12.21	65	< .001	3.87	5.38
Fixed Slope	1.01	.07	14.00	304	< .001	.87	1.15
Random Intercept	7.99	1.67	4.78		< .001		
Random Slope	.17	.25	2.77		< .001		

Note. Intercept specified to the fall of Kindergarten (T1).

Conditional Growth Curve Models

Given the presence of variability in both the intercepts and slopes, covariates and three predictors were entered into separate models in order to estimate conditional models of growth in children's strategy use and accuracy scores: parents' numeracy expectations (Model 1), math attitudes (Model 2), and numeracy practices (Model 3). Fixed effects are presented in Table 5 and Table 6.

Table 5

Results of Models 1-4 Predicting Children's Accuracy Scores

Variable	Model 1 Expectations			Model 2 Attitudes			Model 3 Practices			Model 4 Combined Model		
	Coeff.	SE	p	Coeff.	SE	p	Coeff.	SE	p	Coeff.	SE	p
Fixed Effects												
Intercept	-1.40	1.37	.31	-1.32	1.26	.30	-2.00	1.30	.13	-1.07	1.34	.43
Slope	1.41***	.30	< .001	1.48***	.29	< .001	1.59***	.29	< .001	1.37***	.30	< .001
Working Memory	1.26***	.32	< .001	1.30***	.31	< .001	1.32***	.33	< .001	1.24***	.32	< .001
WM × Slope	-.12	.07	.10	-.13	.07	.06	-.13	.07	.06	-.11	.07	.11
Parent Ed	.49*	.23	.04	.45	.22	.05	.58*	.23	.01	.43	.23	.07
Parent Ed × Slope	-.01	.05	.79	-.02	.05	.72	-.04	.05	.43	-.01	.05	.92
Expectations	.47	.40	.24							.29	.41	.48
Expectations × Slope	-.13	.09	.13							-.11	.09	.24
Attitudes				.80*	.31	.01				.75*	.32	.03
Attitudes × Slope				-.14	.07	.05				-.11	.07	.12
Practices							-.20	.37	.58	-.29	.36	.43
Practices × Slope							.03	.08	.73	.05	.08	.52
Random Effects												
Intercept	5.05***	1.19	< .001	4.55***	1.10	< .001	5.17***	1.21	< .001	4.64***	1.14	< .001
Slope	.13***	.06	.009	.13**	.06	.01	-.91***	.25	< .001	.13**	.06	.01
df			61 (301)			61 (301)			61 (301)			59 (299)

Note. Numeracy Expectations, Math Attitudes, and Numeracy Practices were mean centered before being entered into models.

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

Children's Accuracy Scores – Results from Models 1 – 3 (Table 5) revealed that, controlling for working memory and parent education, children's accuracy scores at kindergarten entry were significantly associated with parents' math attitudes ($\gamma = .80$, $p = .01$), but not with parents' numeracy expectations ($\gamma = .47$, $p = .24$), or numeracy practices ($\gamma = -.20$, $p = .58$). Specifically, children of parents with higher math attitudes entered kindergarten with higher accuracy scores than their peers with parents who held more negative views towards math. However, neither parents' numeracy expectations, nor their numeracy practices, could account for between-child differences in accuracy scores at the beginning of kindergarten. Moreover, results from Models 1 – 3 revealed that no parent-level predictors accounted for the between-child differences in rates of change over time in accuracy scores. The same patterns – surrounding intercept and slope effects – were evident in Model 4, when considering all main and interaction effects in the same model, in that parents' math attitudes were positively associated with children's accuracy scores at kindergarten entry, but no parent-level predictors could account for between-child differences in rates of change over time in accuracy scores.

To further examine these findings that highlight the role of parental math attitudes, model-implied simple intercepts were calculated one standard deviation above the mean (i.e., high), at the mean (i.e., medium), and below the mean (i.e., low) in terms of parents' math attitudes. Results indicate the effect of parent math attitudes on children's accuracy scores at kindergarten entry held only at low ($\gamma = -4.13$, $p = .02$) and medium ($\gamma = -3.37$, $p = .03$) levels of parent math attitudes – or instances in which children had parents who evidenced comparatively negative or neutral (as opposed to positive) math attitudes – resulting in an average of 3 to 4 fewer problems answered correctly than their peers.

Table 6*Results of Models 1-4 Predicting Children's Strategy Use Scores*

Variable	Model 1 Expectations			Model 2 Attitudes			Model 3 Practices			Model 4 Combined Model		
	Coeff.	SE	p	Coeff.	SE	p	Coeff.	SE	p	Coeff.	SE	p
Fixed Effects												
Intercept	.27	1.42	.85	.14	1.30	.91	-.66	1.37	.63	.64	1.37	.64
Slope	1.22**	.44	.005	1.82***	.43	< .001	1.41***	.41	< .001	1.67***	.49	< .001
Working Memory	1.11**	.34	.001	1.18***	.32	< .001	1.21***	.34	< .001	1.09**	.33	.001
WM × Slope	-.28**	.10	.006	-.29**	.10	.003	-.30**	.10	.003	-.28**	.10	.005
Parent Ed	.31	.24	.21	.29	.23	.21	.45	.24	.07	.24	.24	.31
Parent Ed × Slope	-.04	.07	.63	-.03	.07	.68	-.06	.07	.41	-.02	.07	.82
Expectations	.76	.41	.07							.56	.42	.19
Expectations × Slope	-.16	.12	.18							-.10	.13	.42
Attitudes				.95**	.32	.004				.84*	.33	.01
Attitudes × Slope				-.22*	.10	.02				-.20	.10	.05
Practices							-.17	.38	.66	-.32	.37	.39
Practices × Slope							-.01	.11	.93	.02	.11	.86
Random Effects												
Intercept	4.57***	1.28	< .001	4.04***	1.17	< .001				4.02***	1.20	< .001
Slope	.33***	.11	.002	.30***	0.11	.002				.31***	.11	.002
df			61 (301)			61 (301)			61 (301)			59 (299)

Note. Numeracy Expectations, Math Attitudes, and Numeracy Practices were mean centered before being entered into models.

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

Children's Strategy Use – Similar to the accuracy score findings, results from Models 1 – 3 (Table 6) revealed that, controlling for working memory and parent education, children's strategy use scores at kindergarten entry were significantly associated with parents' math attitudes ($\gamma = .95$, $p = .004$), but not with parents' numeracy expectations ($\gamma = .76$, $p = .24$) or numeracy practices ($\gamma = -.17$, $p = .58$). Parent math attitudes continued to be a unique predictor of strategy use at kindergarten entry in the final model (Model 4), when considering all variables simultaneously ($\gamma = .84$, $p = .01$). Results indicate that children of parents with higher math attitudes entered kindergarten with higher strategy use scores than their peers with parents who held more negative views towards math. However, no between-child differences in strategy use scores were found at the beginning of kindergarten as a function of parents' numeracy expectations or numeracy practices.

Shown in Model 2 in Table 6, parent math attitudes were associated with differences in children's rate of change in strategy use over the two years ($\gamma = -.22$, $p = .02$) – such that children with parents who had more negative views towards math entered kindergarten using fewer strategies, they evidenced steeper increases in strategy use over time than their peers with parents who reported more positive math attitudes. However, parent math attitudes were not a unique predictor of this rate of change over time when considering all predictors in the same model (Model 4, Table 6).

Model-implied simple intercepts were calculated one standard deviation above the mean (i.e., high), at the mean (i.e., medium), and below the mean (i.e., low) in terms of parents' math attitudes. Results indicate that the effect of parent math attitudes on children's strategy use scores at kindergarten entry held only at low ($\gamma = -3.51$, $p = .04$), but not medium or high, levels of parent math attitudes. In other words, children who had parents who evidenced comparatively negative (as opposed to neutral or positive) math attitudes, were estimated as solving an average of 3 fewer trials with a strategy than their peers.

Discussion

This study was the first to examine associations between both numeracy practices and parent-level attitudes and expectations (i.e., indicators of the broader home mathematics environment) and children's intra-individual change over time in math problem-solving skills during the first two years of elementary school. Findings showed that although children increased steadily over time in their accuracy on basic arithmetic problems, their use of strategies increased from kindergarten entry, peaked in the beginning of first grade and then slightly decreased through the end of first grade. This slight decrease suggests that as children grow older and have more experiences in school, they may be retrieving their responses from memory more frequently – rather than relying on a strategy – in order to solve basic addition problems. Of the strategies employed, children began kindergarten relying on basic strategies (e.g., counting on fingers starting from one each time), but then transitioned to more advanced strategies (e.g., counting on from one addend, decomposition) around first grade entry.

Contrary to previous work (del Río et al., 2017; Skwarchuk et al., 2014), parents' numeracy expectations and math attitudes were positively related to one another, and parents' numeracy expectations were unrelated to their numeracy practices. However, consistent with previous findings, parents' math attitudes were unrelated to numeracy practices (del Río et al., 2017; Skwarchuk et al., 2014). Results of growth curve models revealed that parents' math attitudes – but not numeracy practices or expectations – could account for differences in children's accuracy and strategy use at the beginning of kindergarten – even when considering all predictors simultaneously and controlling for children's working memory and parental education. In line with predictions, children with parents who reported more positive views towards math entered kindergarten answering more problems correctly and solving more problems using a strategy than their peers with parents who reported more negative views towards math. When including parent math attitudes as the sole predictor of children's development (including covariates), parent math attitudes could also explain between-child variation in growth trajectories; however, it was not a unique predictor of children's growth in strategy use when considering parents' expectations and numeracy practices. Contrary to predictions, findings revealed that children who entered kindergarten using fewer strategies (predicted by their parents' more negative views towards math) *developed more rapidly* over the two years than their peers who entered kindergarten using more strategies (predicted by their parents' more positive views towards math). However, this pattern also did not hold when considering all aspects of the HME in the same predictive model.

Numeracy Practices and Problem-Solving Skills

These findings replicate and extend previous research on the home mathematics environment (HME) and children's development of mathematical problem-solving skills. Specifically, the findings echo that of many others (e.g., [Blevins-Knabe, 2016](#) for a review) in which no significant linkages between parents' numeracy practices and children's mathematical skills were observed. However, descriptive findings were in line with previous research, in that the frequency of parents' engagement in numeracy practices varied greatly ([LeFevre et al., 2009](#); [Missall et al., 2015](#); [Skwarchuk et al., 2009](#)), with some parents reporting having engaged in these practices daily while others reported that specific mathematics activities did not occur at all. It is important to highlight similarities across studies that focus on the same target age group as the current study: kindergarteners and first graders. Notably, there are similarities and differences between this study's findings and that of the foundational study by [LeFevre et al. \(2009\)](#) (included kindergarten through second grade), in which the most frequently reported numeracy activities by parents included using calendars and dates, counting objects, printing numbers, and talking about money when shopping (e.g., "Which costs more?"). In this study, participants also reported using calendars and clocks as well as teaching children to recognize printed numbers frequently, but unlike [LeFevre et al. \(2009\)](#), the frequently reported activities in this paper also included helping children learn simple sums and encouraging children to do math in their head. It's possible that differences in numeracy practices across studies may reflect a shift in parents' understanding of developmentally- and culturally-appropriate kindergarten-readiness practices. Accordingly, one next step for researchers is to consider cultural and historical differences in school–family connections, such as caregiver expectations of who should be providing educational experiences (teachers, caregivers, others; [Sonnenschein et al., 2005](#)).

Moreover, the null association between numeracy practices and children's math problem-solving skills may in part be due to several factors. One possibility is that the specific type of activities included in the parent report measure do not align with the problem-solving skills assessed. It is well documented that HME scales assess different types of activities (Daucourt et al., 2021; Elliott & Bachman, 2018; Hornburg et al., 2021). Indeed, findings from previous studies indicate differences in the association between home math practices and children's math abilities based on whether the activities directly or indirectly taught math skills (i.e., formal versus informal), as well as the specific math domain of the activity (e.g., operational vs. mapping; Daucourt et al., 2021; Dunst et al., 2017; LeFevre et al., 2009, 2010; Mutaf-Yildiz et al., 2020; Niklas & Schneider, 2014; Susperreguy et al., 2020). A more nuanced approach to parent activity choices may further clarify the null findings reported here. For example, many items included in the scale may not be relevant to addition problem solving abilities (e.g., talking about time, classifying items by different categories, collecting, comparing quantities) and thus account for the non-significant results. Likewise, the numeracy practice measure focused only on the frequency of activities. Elliott and Bachman (2018) argue that other dimensions of these interactions, such as the quality, formality, and complexity of these activities may also play a role in how effectively they support math learning.

An alternative explanation is that the null findings may be related to the specific age group in the current sample (kindergarteners and first graders). One meta-analysis focused on examining moderators of the positive association between the home mathematics environment (HME) and math achievement revealed that from their analysis of 68 samples, the correlation between HME and mathematics outcomes was significantly higher for children in preschool and kindergarten than children in primary and secondary school (Daucourt et al., 2021). Existing studies within the HME literature have traditionally separated effects by preschooler and kindergarteners vs. first graders and onward. In this study, we aimed to address conflicting findings across these two developmental groups by examining children's individual growth trajectories across kindergarten and first grade. However, an even more recent meta-analysis by James-Brabham and colleagues (2025) of 334 effect sizes from 72 different samples revealed only a small correlation between home math *activities* and children's math achievement ($r = .13$) – and that this association was not moderated by age, geographic location, measurement of mathematical skills, activity type (i.e., formal, informal, direct, indirect), study design (i.e., longitudinal vs. cross-sectional), or risk of bias due to methodological limitations (e.g., missing data, floor/ceiling effects). Taken together, it is clear that (a) additional research is necessary to unpack components of the HME that transcend traditional conceptualizations of numeracy practices/activities and (b) these other components of the HME (e.g., attitudes, beliefs, expectations) need to be explored more thoroughly.

Beyond Numeracy Practices: Parents' Math Attitudes

A notable finding from this study was the effect of parents' math attitudes – over and above numeracy practices or expectations – on children's accuracy and strategy use on arithmetic problems. Given that parents' math attitudes were unrelated to numeracy practices (and therefore it is unlikely that more positive math attitudes improve numeracy practices), these findings suggest that there may be other pathways by which positive attitudes towards math held by parents may support children's mathematical skill development, especially within the context of problem-solving. One possibility is that parents who hold more positive attitudes towards math (e.g., “When I was in school, I enjoyed math”, “I find math activities enjoyable”), foster similar positive mindsets towards math learning in their children. Specifically when it comes to strategy use, the current study found that children with parents who had more positive attitudes towards math entered kindergarten exhibiting more instances of *using a strategy to solve a problem* than their peers. When applying Fredrickson's (1998) broaden-and-build theory in the context of strategy use, positive emotions experienced during mathematical problem-solving can facilitate a state of “free activation” that encourages exploratory cognition, creativity, and persistence (Fisher et al., 2012; Grigg et al., 2018; Irhamna et al., 2020) – meaning that carrying positive views towards math may be crucial for children to develop, maintain, and navigate their repertoire of strategies for solving problems.

Similarly, positive attitudes towards math have the potential to counteract *negative* feelings towards math, such as math anxiety – which affects approximately 25% of elementary-school-aged children and can lead to math avoidance behaviors, deter engagement in STEM careers, and if untreated, can impede math learning and achievement (Ganley et

al., 2019). The relation between math anxiety and performance is complex during this developmental period, as traits such as perfectionism, test anxiety, and general anxiety can contribute to the emotional profile of young math learners – even among high-achievers (Hill et al., 2016). Accordingly, when parents model confidence, enjoyment, and creativity within the context of math, children may adopt similar mindsets that (a) facilitate greater math learning and (b) serve as a protective factor against the potential onset of math anxiety during the transition to elementary school.

Limitations and Future Directions

Despite the longitudinal design of this study, following children across multiple years of elementary school, there are several limitations. Data collection for the Classroom Memory Study was compromised due to the presence of Hurricane Florence in the Southeastern region of the United States and the COVID-19 global pandemic. Accordingly, school closures as a result of these events led to a reduction in the expected samples of both children and families, thus limiting generalization. Further, although parent education was not a significant predictor in the models, the sample came from a highly education area. Thus, the findings should be interpreted within the contextual characteristics of the sample. As a result, future work should be directed at understanding the interaction between parents' math attitudes, numerical expectations, and home numeracy practices on children's mathematical outcomes with a larger, more diverse sample. In doing so the results could be generalized more widely and allow for more complex analyses – as our findings could not explicitly test if differences in parents' attitudes could account for differences in children's outcomes *due to differences in numeracy practices*. There remains a need to understand a greater breadth of mathematical activities in the home (Zippert & Rittle-Johnson, 2020) as well as the ways in which individual-level characteristics of caregivers and children might explain variations in the home mathematical environment (Cosso et al., 2023; Huntsinger et al., 1997). In addition to attitudes, beliefs, and expectations, parents' and children's gendered stereotypes towards mathematics achievement and ability have been identified as a potential predictor of quality of mathematics engagement in the home – and the effects of that engagement on early mathematics development (del Río et al., 2021). Importantly, an additional limitation of the current study is the use of a home numeracy scale that has been traditionally administered to caregivers of preschool- and kindergarten-aged children. Other parent-child math-related interactions that occur in the home, such as homework help interactions, are important to consider during this developmental period (Oh et al., 2022).

Developmental Implications

Although children with parents who reported more negative views towards math entered kindergarten with lower accuracy scores and utilized fewer strategies, there were no differences in children's (a) rate of change over time or (b) their skills at the end of first grade that could be attributed to differences in components of the HME. These findings stand in contrast to those from previous studies, in which children who started formal school with lower initial numeracy knowledge and skills did not catch up to their peers, even after being exposed to formal instruction (Jordan et al., 2009). Rather, the current findings suggest that children who enter school having been exposed to negative parental attitudes towards math may benefit differentially from the formal school experience. Notably, these findings are consistent with those of Hudson and colleagues (2018), in which parent-level predictors of children's strategy effectiveness were only significant at the beginning of kindergarten, and as children progressed across the school year, the amount of growth that students demonstrated across the year in strategy effectiveness was predicted by teachers' instructional language. Therefore, future work should be directed at understanding the interplay between parent- and teacher-level predictors of children's strategy use within the context of mathematics during the transition to formal school. Implications of the current findings are applicable to parents' and educators' efforts to support children's math problem-solving skills during the transition to elementary school, skills that are thought to serve children's long-term mathematics engagement and academic success.

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Data Availability: The data, code, and materials that support the findings of this study are available from the corresponding author, upon reasonable request.

Supplementary Materials

The Supplementary Material associated with this publication consists of one document (see [Cook et al., 2025S](#)). In this document, we provide four tables:

- *Table S1:* The actual addition problems (stimuli) administered during the math problem-solving task.
- *Tables S2, S3, and S4:* The original wording for all items used in our survey instruments and their corresponding descriptive statistics.

Index of Supplementary Materials

Cook, O. K., Westover, A. E., & Coffman, J. L. (2025S). *Supplementary materials to "Children's early math problem-solving: The role of parent numeracy practices, numeracy expectations, and math attitudes"* [Stimuli, items, and corresponding descriptive statistics]. PsychOpen GOLD. <https://doi.org/10.23668/psycharchives.21453>

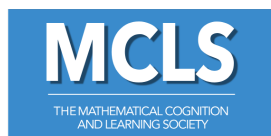
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