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PARENT ATTITUDES ABOUT YOUNG CHILDREN'S MATH LEARNING:
CONNECTIONS TO PARENT MATH SUPPORT AND CHILD MATH OUTCOMES

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To my parents, Carmen y Jose. Todos mis logros son de ustedes

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ABSTRACT

Parents are children's first teachers; the learning interactions they engage in at home equip children with the foundational knowledge they need to be successful learners. This is particularly relevant in the domain of math, where children's knowledge prior to the start of formal schooling is one of the most important predictors of future academic achievement (e.g., Claessens & Engel, 2013). Yet, many parents may not know that they play a foundational role in supporting their child's math learning, and even if they do know this, they may lack knowledge about children's early math development. Moreover, their own positive or negative attitudes about math may be related to their math engagement with their children. In three studies, I explore how parents' child-relevant math attitudes are related to attitudes about their own math skills and to their math interactions with their children as well as to children's math outcomes.

In Study 1, I find that parents' attitudes about their child's math learning during the early school years are more strongly related to their self-relevant math attitudes than to their child's actual math achievement. In Study 2, I explore how parents' expectations and values for their child's current and future math learning change with children's schooling experience. Finally, in Study 3, I examine how parents' expectations and value for their child's current and future math success relates to the quality of their self-reported math input. Taken together, the results of these studies highlight potential mechanisms through which parents' math attitudes may influence their engagement with their children around math, which in turn, are likely to relate to children's math outcomes.

1. CHAPTER ONE: Introduction

The time children spend at home with their parents prior to the start of formal schooling equips them with the foundational tools they need to be successful learners. Parents are key socializers whose attitudes and behaviors during the early years of life influence their children's academic outcomes. In fact, parents are arguably children's first teachers (Vartuli & Winter, 1989; White, 1981). Thus, an effective approach to boost students' outcomes starts in the home.

The effect of parents' influence on children's academic achievement has been widely documented. Parental involvement in this domain has been broadly defined as parents' participation in the educational processes and experiences of their children (Jeynes, 2007). This includes different parent characteristics and behaviors, such as their attitudes about their child's learning or the quality and quantity of educational activities they engage in with their child.

One academic domain where parent involvement is crucial is early math. Parents' interactions with their young children around math during the preschool years are predictive of their math outcomes. This includes both their child's math achievement (e.g., Elliott et al., 2017) and their attitudes about math (e.g., Parsons et al., 1982). Yet, many parents do not understand their foundational role in supporting their child's math development. Research shows parents of preschoolers believe math education requires more direct instruction and is the responsibility of teachers once children enter elementary school (Cannon & Ginsburg, 2008). This assumption is concerning because early math knowledge prior to the start of formal schooling is one of the most important predictors of future academic achievement (Watts et al., 2014). Children's early math skills are related to both their math and reading outcomes in elementary school as well as high school (Claessens & Engel, 2013; Duncan et al., 2007; Watts et al., 2014). Furthermore, robust math skills are necessary for a 21st century STEM workforce, which has historically underrepresented minority groups and women (Landivar, 2013; U.S. Department of Education, Office of Innovation and Improvement, 2016).

Gaps in children's math knowledge emerge early. As early as preschool, children from lower-socioeconomic (SES) backgrounds are already performing below their middle- and higher-SES peers on math assessments (e.g., Jordan & Levine, 2009; Klibanoff et al., 2006; Lee & Burkam, 2002; Purpura & Reid, 2016). These disparities are not only present in children's math achievement, but also in the early interactions they have with their parents and teachers that support math learning (Ehrlich, 2007; Klibanoff et al., 2006; Levine et al., 2010). Moreover, this SES-related math achievement gap tends to persist as children advance through schooling (Claessens et al., 2009; Claessens & Engel, 2013; Duncan et al., 2007).

Since gaps in math achievement are established prior to the start of formal schooling, it is important to explore the factors that are related to math development in the home before children enter the classroom. A recent meta-analysis explored which form of parental involvement most strongly related to children's academic achievement (Wilder, 2014). Potential candidates included parents' homework help, communications with the child's school, parenting style, or their attitudes and beliefs about their child's school performance. The strongest relationship between parents' involvement and their child's achievement existed when it was defined as their expectations for the academic achievement of their children. This relation between parents' attitudes and child achievement may be particularly relevant in the domain of math since negative feelings about math are pervasive (e.g., Ashcraft, 2002; Foley et al., 2017).

This dissertation focuses on how parents form their attitudes about their young children's math learning, and how these attitudes influence their math engagement with their child and their child's math outcomes. While the relation between parents' attitudes and their child's math knowledge has been established in later school years (e.g., Berkowitz et al., 2015; Maloney et al., 2015), it is important to see how these connections play out as children enter formal schooling. Chapter 1 reviews the existing literature on parents' beliefs and attitudes about math and their link to achievement. Chapter 2 examines the relationship between parents' expectations and value about their child's math learning and child outcomes in the early school years. Chapter 3 explores whether there are changes in parents' expectations and value about their children's math learning as children progress through formal schooling. Chapter 4 shifts to parents' math input and explores if the quantity and quality of this input is related to their math attitudes. Taken together, the goal of these studies is to understand how parents form their attitudes and beliefs about their child's math learning and how this influences their engagement with their child around math.

1.1. Math Attitudes

Parents' math attitudes, as examined in this dissertation, refer to a set of beliefs and feelings about math. This cluster of attitudes includes feelings about math as a subject more generally, about one's own math achievement, and one's expectations for success or failure in math (Gunderson et al., 2012). Math attitudes are important because they guide an individual's choice to engage in math-related circumstances, such as course selection and future career (e.g., Hembree, 1990; Simpkins et al., 2012). Furthermore, math attitudes are linked to math achievement as early as 1st grade and this relationship is reciprocal (Gunderson, Park, et al., 2018).

Parents' math attitudes are of particular importance because they guide their behaviors when engaging in math learning opportunities with their child (e.g., Berkowitz et al., under revision; Elliott et al., 2020; Maloney et al., 2015). In addition, parents' math attitudes are linked to their children's math achievement and math attitudes. For example, the math achievement of 1st graders whose parent or teacher is math anxious is lower than that of 1st graders whose parent or teacher is not math anxious (Beilock et al., 2010; Berkowitz et al., 2015). Further, a study of 5th graders found that children's math attitudes are more strongly related to their parents' math attitudes than to their own math ability (Parsons et al., 1982).

The current review focuses on three types of parent math attitudes that relate to their own math outcomes that in turn may influence their child's math achievement. I use math outcomes as an umbrella term to refer to both attitudes and achievement. The first group of parent attitudes are self-relevant math attitudes (math anxiety, math self-concept, math self-efficacy); these reflect how parents think and feel about their own math ability and relation to math. The second type refers to general attitudes that reflect parents' broader belief about intelligence and ability (theories of intelligence). The third type are child-focused math attitudes, which is the focus of the studies in this dissertation. These attitudes tap parents' beliefs about their child's math learning and success (expectations and value). The final section discusses how these different kinds of attitudes relate to each other and how they may influence parents' math engagement and their child's math achievement.

1.1.1 Self-Relevant Attitudes

1.1.1.1 Math Anxiety

Math anxiety is the fear or nervousness an individual feels about doing or anticipating math (Hembree, 1990). It is estimated that 20% of the U.S. population suffers from high math anxiety (Eden et al., 2013). Math anxiety can be triggered by both academic settings and everyday interactions that involve math, such as calculating a tip (Ashcraft, 2002). There are two components associated with math anxiety - a cognitive component that involves worrying about performance and an affective component that involves the feelings of nervousness (Wigfield & Meece, 1988).

Math anxiety is evident as early as 1st grade (Ramirez et al., 2013) and increases across schooling, peaking in high school, and is associated with lower levels of math performance in children and adults alike (Ashcraft, 2002; Foley et al., 2017; Ramirez et al., 2013). The relationship between math anxiety and math performance is bidirectional, however, with lower math performance also predicting future math anxiety (Beilock et al., 2017; Gunderson, Park, et al., 2018). Math anxiety does not just negatively impact performance on complex tasks; studies with adults show it also relates to performance on more basic number processing tasks (Maloney et al., 2010, 2011). Math anxiety is also associated with tendencies to avoid math when possible (Choe et al., 2019; Maloney & Beilock, 2012).

Beyond affecting individual math performance, math anxiety can also have intergenerational effects. A study with 1st graders found that children of high math anxious parents had lower math performance at the end of school the year compared to children of low math anxious parents (Berkowitz et al., 2015). A separate study conducted with 5th to 10th graders in India found that parents' math anxiety promotes their children's math anxiety, which in turn negatively affected children's math performance (Soni & Kumari, 2015). A study with 6th to 8th graders in the United States found a more nuanced relationship: the negative association between parent math anxiety and child achievement was only evident when the child was also math anxious themselves (Casad et al., 2015). Taken together, these studies suggest parent math anxiety can be detrimental to child math outcomes by the elementary school.

Parent math anxiety is believed to influence child achievement because it affects the quality of parent-child interactions around math (e.g., Berkowtiz et al., under review; Elliott et al., 2020; Maloney et al., 2015). A study with parents of 1- to 2-year-olds found that higher math anxious parents engaged in less talk about cardinal number, a foundational math concept, than lower math anxious parents (Berkowitz et al., under revision). A separate study found that parents of preschoolers who were math anxious reported engaging in fewer math activities with their children (Elliott et al., 2020). Further, a study with 1st and 2nd graders found that children of high math anxious parents learned significantly less math and reported higher levels of math anxiety by the end of the school year (Maloney et al., 2015). This effect was mediated by the frequency of homework help. When high math anxious parents frequently helped their child with homework, their math performance suffered. Interestingly, when high math anxious parents reported infrequent homework help the child's math outcomes did not suffer. These findings suggest that parent math anxiety may make homework interactions less effective and more stressful for the child, which in turn may hurt children's math learning and increase children's math anxiety. In fact, high math anxious parents of 1st to 6th grade students reported that math homework help was a negative experience for them (DiStefano et al., 2020).

Math anxiety is also transmitted in the classroom. A study with 1st and 2nd graders showed that teachers' math anxiety at the beginning of the year negatively predicted female students' math achievement at the end of the year (Beilock et al., 2010). A follow up study with a larger, more diverse sample found that teacher's math anxiety negatively predicted math achievement for both girls and boys at the end of the year, even after controlling for the teacher's math ability and children's math knowledge at the beginning of the year (Schaeffer et al., 2020). A study with preschool teachers in Germany, however, found no relationship between teacher's math anxiety and their students' math performance (Jenßen et al., 2020). This finding suggests that teachers' math anxiety may not start to affect their students' math learning until the formal school years. The mechanism through which this relation operates has not been identified but given that math anxiety is correlated with math achievement, it may be that the math instruction of math anxious teachers is less effective. In addition, math anxious teachers could be conveying negative math attitudes to students and/or could be spending less time teaching math since math anxious individuals tend to avoid math.

Fortunately, the negative relationship between adult math anxiety and child math achievement seems to be sensitive to interventions. In an intervention study, parents and their 1st graders were provided with either a math app that included short stories with embedded math problems or a reading control app (Berkowitz et al., 2015). The math app intervention broke the detrimental link between parent math anxiety and child achievement which was seen in the control group; specifically, children of high math anxious parents in the intervention group had similar math achievement to children of low math anxious parents by the end of the school year. This finding suggests that math anxious parents can benefit from interventions that target and scaffold their math interactions.

1.1.1.2. Math Self-Concept

Math self-concept broadly refers to an individual's perception of their ability, interest, and enjoyment of math (Reyes, 1984; Shavelson et al., 1976). This can also refer to the degree to which an individual identifies with math (Nosek et al., 2002). This construct has been measured in a variety of ways, including asking individuals to report "how good they are at math" (Eccles & Wigfield, 2002), to rate their math ability in comparison to others (Marsh, 1990), or through an implicit association test measuring the strength of the association between self and math (Cvencek et al., 2021; Nosek et al., 2002).

Math self-concept is related to students' math achievement as early as 1st grade (Herbert & Stipek, 2005; Valeski & Stipek, 2001). Evidence suggests that young children's math self-concept is shaped by their math achievement (Arens et al., 2011; Ganley & Lubienski, 2016) but as they grow older the relationship becomes reciprocal (Chen et al., 2013). Children's math self-concept decreases from 1st to 5th grade when measured explicitly, but their implicit association of self = math is stable during this time (Cvencek et al., 2021).

There has been limited work exploring how an individual's math self-concept influences their math interaction with others. Yet, it is reasonable to expect a parent's math self-concept to influence their child's math outcomes via the quality of their math interactions with children. Mothers of 5th graders who reported having high math self-concept provided higher quality homework help during a taped math interaction (Hyde et al., 2006). In fact, their math self-concept was a stronger predictor of the quality of their homework help than the number of math courses they had taken. In turn, parent math attitudes also predict their child's math self-concept. Specifically, parents' child-focused math attitudes, their expectations and values of math for their child, influence their children's math-self-concept (Fredricks & Eccles, 2002). The connection between different types of math attitudes will be discussed in more detail in a later section.

1.1.1.3. Self-Efficacy for Teaching Math

Math self-efficacy refers to an individual's confidence in their ability to perform specific math tasks. Self-efficacy is theorized to be distinct from their more global rating of math ability (Betz & Hackett, 1983). This section discusses parents' self-efficacy related to one particular math task - teaching and supporting their child’s math learning (Self-Efficacy for Teaching Math; SETM). Parents’ SETM is important because it captures how they view their role in their child’s math education. A parent with high SETM believes that through their involvement in their child’s math learning they can positively influence their math achievement (Hoover-Dempsey & Sandler, 1997).

Most of the work examining teaching math-efficacy has been done with teachers. As expected, teachers' SETM is positively related to their own math achievement (Bates et al., 2011). This construct has also been shown to be related but separate from their more general math self-efficacy (e.g., Tschannen-Moran & Hoy, 2001; Zuya et al., 2016). Teachers’ SETM is also positively related to their students’ math learning and the quality of their classroom interactions (Perera & John, 2020).

Yet, there has been limited work exploring parents’ SETM. Since parents expose children to math through their interactions in the home, it is reasonable to expect their SETM to also influence their children’s math outcomes. Findings related to parents’ general self-efficacy suggests this is the case. Parents’ self-efficacy for helping their child succeed in school is one of the most important predictors of their involvement in their child’s education (Hoover-Dempsey et al., 2001, 2005; Hoover-Dempsey & Sandler, 1997). One study with parents of preschoolers and kindergartners found that parents’ beliefs about the best way to teach basic skills to children predicted not only their report of the frequency of learning activities they engaged in at home but also their school selection (Stipek et al., 1992). Based on these findings, SETM may affect the quantity and quality of parent-child math learning interactions as well as children’s math outcomes.

1.1.2. Attitudes about General Ability

1.1.2.1 Theories of Intelligence

Theory of intelligence refers to an individual's belief about whether intelligence is fixed or malleable (Dweck, 1986, 2008; Dweck & Yeager, 2019). A fixed mindset, or entity theory, is the belief that ability is inherent and cannot be changed. A growth mindset, or incremental theory, is the belief that human ability is malleable and can change over time depending on factors such as effort. Mindset is particularly important because it shapes how an individual approaches a challenging task. An entity theorist approaches a task with a performance goal; their focus is to avoid negative evaluations of their ability and so they opt for easy tasks that ensure their success. An incremental theorist approaches a task with a learning goal; their focus is to increase their ability and so they are likely to prefer challenging tasks that foster their learning. The consequence of these different learning goals accumulates over time and are associated with different levels of achievement, including in math (Blackwell et al., 2007; Dweck & Elliott, 1983).

While theory of intelligence is a general construct and does not specifically focus on math ability, an individual's mindset is associated with their math achievement. Mindset is believed to be particularly relevant for math because it is typically viewed as a challenging subject (Blackwell et al., 2007; Gunderson, Park, et al., 2018). Seventh graders with an incremental theory of intelligence showed greater gains in math by the end of 8th grade compared to those with an entity theory (Blackwell et al., 2007). In another study, 6th graders with an incremental theory of intelligence were more likely to take advanced math courses in 8th grade (Romero et al., 2014). In elementary school, the degree to which a child endorses a growth mindset is associated with their math achievement (Gunderson, Sorhagen, et al., 2018). A study by Gunderson et al. (2018) indicates that the relationship between mindset and math achievement is bidirectional in 1st and 2nd graders, yet the relation is stronger in the direction of achievement predicting later mindset.

Evidence suggests that a parents' mindset may affect the learning interactions they have with their child, which in turn relates to both the child's mindset and their achievement (Dweck, 2008; Gunderson et al., 2013; Pomerantz & Kempner, 2013). One particular behavior that may trigger this connection is the type of praise children hear. Praise may signal to a child how their abilities are perceived; feedback that highlights the process of learning (e.g., "You worked hard!") promotes a growth mindset while feedback that focuses on the individuals' abilities (e.g., "You are so smart!") fosters a fixed mindset. In fact, the proportion of process praise to total praise children heard from their parents between 1- to 3-years-old predicted their mindset when they were 7-years-old such that those who heard proportionally more process praise were more likely to hold a growth mindset (Gunderson et al., 2013). Consistent with this finding, 8- to 10-year-olds with parents who reported using more person-praise were more likely to have a fixed mindset (Pomerantz & Kempner, 2013). Moreover, a longitudinal study found a link between the type of praise parent provided to their children as toddlers and their math achievement in 4th grade that was mediated by children's mindset in 2nd grade (Gunderson, Sorhagen, et al., 2018).

Interestingly, parents' mindset can be experimentally induced. Mothers were introduced to a puzzle task through a description that either reinforced a fixed or growth mindset and were then observed working through the problems with their 6- to 9-year-old child (Moorman & Pomerantz, 2010). Compared to mothers induced with a growth mindset, mothers who were induced to hold a fixed mindset were involved in the task in a way that was unconstructive to their child's performance; they dominated the interaction, showed more negative affect, and were reinforcing performance-oriented learning goals. This study suggests that a parents' mindset is sensitive to interventions and can affect the ways in which they interact with their young children.

1.1.3. Child-Focused Attitudes

1.1.3.1. Expectations and Value

Parents' expectations and value of math for their children (EV) refers to their expectations about how well their child will do in math and how valuable they think math is for them (Hill & Tyson, 2009). Parents' EV has been found to be a strong predictor or their child's math outcomes, from kindergarten (Aunola et al., 2003; Fredricks & Eccles, 2002; Kleemans et al., 2012) to high school (Rozek et al., 2015, 2017). In fact, a recent metanalysis found that parent EV was the strongest moderator of the relationship between parental involvement in their child's schooling and their child's academic achievement (Fan & Chen, 2001). Parents' report of their EV for their kindergartner's math success is linked to their child's math growth during the school year (Aunola et al., 2003) and the frequency of math activities they engage in at home (Kleemans et al., 2012). EV might be particularly important for the transition to formal schooling as parents of preschoolers with high EV believed it was more important for children to learn math skills before entering kindergarten than parents of preschoolers with low EV (Silver et al., 2021).

Beyond the relation of parent EV to children's math performance, parent EV is also related to children's math attitudes. A study with parents of 2nd graders found that their EV not only predicted their child's math achievement but also their children's math anxiety (Vukovic et al., 2013). A longitudinal study found that parents' EV measured when their child was in elementary school also explained the variation in children's math beliefs from 1^{st} through 12^{th} grade (Fredricks & Eccles, 2002). Furthermore, parent EV has also been found to predict 1^{st} grader's math self-concept (Fredricks & Eccles, 2002).

The mechanism explaining how parent EV supports their child's math outcomes is not clear, however. According to expectancy-value theory (Wigfield & Eccles, 2000), the more value an individual places on a task the more likely they are to engage in that task. This would suggest that parents with higher math EV will spend more time supporting their child's math learning and engaging in math activities. In addition, they might also provide higher quality math learning experiences. One study with parents of 5-year-olds found that parents with high EV are more aware of what math skills are developmentally appropriate for their young child (DeFlorio & Beliakoff, 2015). Thus, it seems that parent EV might influence their child's math achievement through the quantity and quality of their learning interactions.

Another important open question is understanding what factors contribute to the development of parent EV about their child's math achievement. The connection between parent EV and other parent math attitudes is discussed in a later section. Future work is also needed to explore if children's math achievement might in turn reciprocally affect future parent EV.

1.2. Relations between Math Attitudes

While these various math attitudes have been studied separately to understand their unique influence on math outcomes, they do not exist in isolation. An analysis of data from the Program for International Student Assessment (PISA) suggests that the three self-relevant math attitudes (math self-concept, math self-efficacy, and math anxiety) represent distinct factors (Lee, 2009). Yet, there is reason to believe that these separate constructs are connected and collectively influence an individual's math behavior. The following sections discuss connections between the three self-relevant math attitudes and how these attitudes relate to parents' child-specific attitudes. Taken together, results suggest that not only are different parent attitudes connected, but it is important to understand how parents' self-relevant and child-focused math attitudes collectively influence their child's math outcomes. By considering the attitudes in concert we can begin to understand some of the mechanisms behind how these beliefs and emotions relate to parent math behaviors and children's math outcomes.

1.2.1. Connections Among Self-Relevant Attitudes in Adults and Children

Self-relevant math attitudes are connected in the expected direction. Math anxious individuals tend to have lower math self-efficacy (Cooper & Robinson, 1991; Meece et al., 1990) and a lower math self-concept (Ahmed et al., 2012). Teachers with high math anxiety are also less confident in their ability to teach math (Bursal & Paznokas, 2006; Gresham, 2008; Richland et al., 2020; Swars et al., 2006). These findings suggest that math anxiety may undermine parents' and teachers' confidence in their ability to support children's math learning.

Math anxiety has also been linked to an individual's mindset. A study with elementary school students found that a fixed mindset at the beginning of the year predicted higher levels of math anxiety at the end of the school year (Gunderson, Park, et al., 2018). However, the reciprocal relationship did not hold; early math anxiety did not predict future mindset. Both attitudes, however, were also predicted by students' math achievement at the beginning of the year.

Taken together, these findings suggest that math attitudes might work together to influence student's achievement and that these reciprocal relationships are evident by 1st grade.

While more longitudinal work is needed to establish the directionality of these relations, and their relation to math achievement, the correlational studies discussed suggest earlier math achievement predicts later math attitudes more strongly than the reverse.

1.2.2. Connections between Parent Attitudes and Child Math Outcomes

Parents' attitudes about their children's math learning are shaped by their self-relevant math attitudes. Higher math anxious parents are more likely to hold lower expectations and value for their elementary school-aged children, which in turn negatively predict their children's math achievement (Schaeffer et al., 2018). Parent math anxiety not only negatively predicts children's math achievement, but also their math attitudes; notably children of high math anxious parents are more likely to have a lower math self-concept (del Río et al., 2020).

Considering parents' math attitudes beyond their math anxiety is important because not all math anxious parents have similar beliefs about the role of math in their child's life. A recent study with parents of preschoolers found that the relationship between parent math anxiety and their child's math performance depended on parents' belief about the importance of math for their child (Silver et al., 2021). When parents had high EV, parent math anxiety was not negatively related to their children's math outcomes. In fact, for these math anxious parents, higher EV was related to their children's higher math achievement. On the other hand, math anxious parents with lower EV had children with lower math achievement. There was no relationship between parents' EV and their child's achievement for low math anxious parents. These findings are important because they suggest that not all math anxious parents have the same beliefs about the importance of math for their young children. Consistent with this finding, a qualitative study with parents found that math anxious parents reported intentionally engaging in more frequent math activities with their young children in order to disrupt the transmission of negative math attitudes (Elliott et al., 2020). Thus, it is important to explore differences in parent attitudes beyond just math anxiety to better understand how parents influence their children's math outcomes.

Taken together, these findings suggest the importance of intervening on parents' EV about their child's math learning. The math app intervention study discussed in the Math Anxiety section provides some causal evidence of how scaffolding parent-child math interactions can lead to changes in parent EV. In particular, a mediation analysis showed that the math app boosted math outcomes for children of high math anxious parents because it increased parent EV (Schaeffer et al., 2018). This finding suggests that providing high math anxious parents with interventions that promote positive math interactions with their children influence their EV for their child's math achievement, which in turn boost children's math performance.

1.3. Research Questions

The literature on math attitudes makes predictions about how parents will behave when engaging in math activities with their children. However, two very important questions about this relationship remain unanswered.

First, what factors shape parent attitudes about their child's math learning? Previous evidence suggests that parents' math attitudes are related. Yet, it is unclear how parents form their beliefs about their child's math learning, or their expectations and value of math for their child. Given that not all math anxious parents have lower math EV for their children, it is important to explore what information guides parents' beliefs about their child's math learning. This may be particularly important to understand during the transition to formal schooling since this is the time when parents begin to receive feedback about their child's math ability from their teachers.

Second, how do parent attitudes about their child's math learning translate to their math behaviors with their children? The literature assumes that parent attitudes influence the quantity and quality of their math interactions with their children, which in turn impact their child's math ability and math attitudes. Yet, it is important to systematically explore how parents with certain attitude profiles engage in math with their young child. Looking at this during the early school years is particularly important because it is the time when children transition from learning in the home to the classroom, and because we know that children's early math achievement predicts their long-term math outcomes.

This dissertation addresses these questions through three studies. In Study 1, I explore what factors influences parent attitudes about their young children's math achievement, in particular their math EV for their child. In Study 2, I focus on parent attitudes and look at how their EV for their child's math learning may vary as children have more schooling experience. Finally, in Study 3, I examine how parents' EV relates to the quantity and quality of their self-reported math input.

2. CHAPTER TWO Study 1: Relation between Parent Math Attitudes and Child Outcomes in the Early School Years

2.1 Background

As discussed in Chapter 1, parent attitudes about their child's math learning are related to their child's math achievement. This relationship has mostly been explored in elementary school and beyond, with results suggesting that it emerges as early as 1st grade (e.g., del Río et al., 2020; Berkowitz et al., 2015; Maloney et al., 2015). However, less is known about the intergenerational transmission of math attitudes during the preschool and kindergarten years and how parents form their attitudes and beliefs about their child's math learning. This is the time when many children are influenced by interactions with their parents in the home as well as by their interactions with teacher and peers in the classrooms. Although it is assumed that the link between parent attitudes and children's math outcomes emerges early, it is important to explore how this relation plays out as children transition from learning in the home to the classroom environment.

Given that the relationship between children's math attitudes and math ability is bidirectional (e.g., Gunderson, Park, et al., 2018), it could also be the case the relations between parents' math attitudes and their child's math outcomes establish a virtuous or vicious cycle. Parent attitudes may affect their child's outcomes which in turn may influence parents' attitudes about their child's math success. Exploring this link in the preschool and early school years is an important piece of the puzzle because it examines these relationships before and as children start to get evaluated at school, which could influence parents' beliefs.

It could be the case that parent attitudes and their child's math outcomes are linked even before formal schooling and evaluations. This connection may form in the home environment through early math learning interactions; parent attitudes may affect how they engage in math with their child which in turn influences the child's own math attitudes and learning. On the other hand, parent attitudes may not be related to children's math outcomes until parents (and children) receive feedback about their math performance in school. Here I examine the hypothesis that the relationship between math parent attitudes and child math outcomes is not strongly established during the early school years. Furthermore, I also hypothesize that parents' attitudes about their child's math learning during this may be based on their own characteristics, such as their own math ability, and shift as they have more experience with their child's performance.

2.1.1 The Present Study

The present study explores the relationship between parent expectations and values about their child's math learning and child math outcomes in a sample of parents and their children in preschool, kindergarten, and 1st grader. I focus on children in this age group in order to capture differences in this relationship as children transition to formal schooling.

Study 1 addresses two main questions. First, I ask if child math ability and math attitudes are related to their parents' math attitudes during preschool and in early elementary school. This relationship has been documented as early as 1st grade, and I expect to replicate this finding for children of this age. However, I also predict that the link between math parent attitudes and child math outcomes will be weaker. Specifically, I hypothesize that parent math attitudes may influence their child's math achievement but not their math attitudes. Parent attitudes may influence how parents engage in math activities with their child at home prior to the start of formal schooling, which in turn relates to children's math knowledge. However, I expect children's math attitudes to be formed as they begin to receive more formal feedback about their ability.

Second, I examine what factors predict parents' attitudes about their child's math learning. I hypothesize that parents' expectations and value about their child's math success may be more highly related to their own math attitudes than to their child's actual math performance at this age. Parents may draw from their own experiences to shape their attitudes since they do not know how to evaluate their child's math knowledge. In other words, many parents may lack knowledge of what math skills children should have prior to starting school. The relationship between children's math skills and parents' expectations and value of math for their children may emerge during early elementary school based on the feedback they receive from their child's teacher about their math achievement levels.

2.2 Method

Participants

98 children (56 girls) and 65 primary caregivers (51 mothers) participated in the study. The sample consisted of 48 preschoolers, 28 kindergartners, and 22 1st graders (M_{age} = 5.58, SD = 1.05, range 4 to 8.67 years). Families were recruited from community partners in the Chicago and Seattle area. Data collection for this study was interrupted due to the Covid-19 pandemic; the target planned sample was 150 children and their caregivers, with 50 families in each grade group.

Measures

Parent Measures.

Socioeconomic Status. A composite measure of socioeconomic status (SES) was created based on annual household income and the parents' educational attainment. Parents were asked about these variables in a demographic questionnaire; household income was measured on a 6-point scale and highest level of education completed on a 9-point scale. The average household income was $33,600, ranging from less than $15,000 to greater than $100,000. The mean highest level of education completed was an Associate's/2-year college degree, ranging from completing elementary school to a graduate degree. Household income and parents' education level were highly correlated ($r = .86$, $p < .001$) and were combined into a single SES measure using a Principal Component Analysis based on their loading on one factor. This composite measure has an average of 0, (*SD* = 1, range -1.52 – 1.47). Parents with a high SES composite measure have a high household income and high level of education attainment.

Math Ability. Parent math ability was assessed using the Math Fluency subtest from the Woodcock-Johnson IV (Schrank & Wendling, 2018). This subtest requires the participant to solve as many simple addition, subtraction and multiplication facts as they can during a 3-minute period. All reported scores for WJ subtests are w scores, which are transformed Rasch ability scales. Parents' Math WJ score ranged from 442 to 567, with an average of 538.01 (*SD* = 25.13).

Verbal Ability. Parent verbal ability was assessed using the Reading Fluency subtest from the Woodcock-Johnson IV (Schrank & Wendling, 2018). The subtest measures vocabulary knowledge and semantic fluency; it requires the participant to read four words and select the two that are related. Parents' Verbal WJ score ranged from 399 to 593, with an average of 531.85 (*SD* = 41.15).

Math Anxiety. Parent math anxiety was measured using two scales. The first is the Abbreviated Mathematics Anxiety Scale (AMAS; Hopko et al., 2003). This requires parents to respond to 9 items about how anxious different situations would make them feel (e.g. "listening to a lecture in math class") on a scale from 1 ("low anxiety") to 5 ("high anxiety;" Cronbach's alpha = .93). Parents' AMAS score was the average of the 9 items, ranging from 1 to 5 with an average score of 2.38 (*SD* = 0.98).

The second math anxiety measure is the Parent Math Anxiety Scale for Families (PMAF), which we adapted from a scale used to measure math anxiety in teachers (Ganley et al., 2019; see Appendix A for full scale). This scale consists of 16 items and describes scenarios which are meant to reflect both general situations involving math (e.g., "I feel self-conscious if I don't know how to solve a math problem right away") and situations that specifically ask about parents' interactions with their children around math (e.g., "I would feel uncomfortable if my child asked me to explain why a math strategy works;" Cronbach's alpha = .96). Parents rated each item on scale from 1 ("not true of me at all') to 5 ("generally true of me"). Parents' PMAF score was the average of the 16 items, ranging to 1 to 5 with an average score of 2.23 (*SD* = 0.94).

Reading Anxiety. Parent reading anxiety was measured using the 9-item Abbreviated Reading Anxiety Scale (ARAS). Items were adapted to be the reading equivalent of math items from the AMAS (e.g., "listening to a lecture in literature class"). Parents responded to each item on the same 5-point scale and their score was the average of their nine ratings (Cronbach's alpha = .90). ARAS scores ranged from 1 to 5, with an average was 1.87 (*SD* = 0.80).

Self-efficacy for teaching and supporting their child's math/reading. Parents' self-efficacy for teaching math (SETM) was measured with a 4-item questionnaire capturing how capable and efficacious they feel in supporting their child's math learning. These items were adapted from a scale used to measure teacher's self-efficacy (Midgley et al., 2013; Tschannen-Moran & Hoy, 2001; see Appendix A for full scale). Parents rated each item on scale from 1 (“not true of me”) to 5 (“very true”). The Cronbach's alpha for this scale increased from .49 to .72 when the third item was removed so parents’ score was the average of the other three items. Parents’ SETM score ranged from 1.67 to 5, with an average of 4.03 (*SD* = 0.93).

Parents also completed a parallel 4-item scale to measure their teaching self-efficacy for reading (SETR). Similar to SETM, the Cronbach’s alpha increased from 0.45 to 0.67 when the third item was removed so their score was the average of the other three items. Parents’ SETR score ranged from 2.67 to 5, with an average of 4.43 (*SD* = 0.63).

Math Self-concept. Parents’ math self-concept (MSC) was measured with a 3-item scale tapping the degree to which they identify with math compared to reading (Nosek et al., 2002). Items either asked about their identification with math (“I consider myself to be a math person”) or whether they identified more with math or reading (“Do you consider yourself more mathematical or more literary?”). Parents responded on a 5-point Likert scale and their score was the average of the 3 items (Cronbach’s alpha = .63). Positive scores indicate a stronger identification with math while negative scores indicate a stronger identification with reading. Parents’ MSC score ranged from -2 to 1.67, with an average of 0.51 (*SD* = 0.93).

Theory of Intelligence. Parents’ mindset/theory of intelligence was measured with an 8-item scale capturing the degree to which they believe certain abilities are fixed (Dweck, 2008). The scale was adapted to include items about general ability (e.g., “People have a certain amount of intelligence, and they can't really do much to change it”) as well as their ability in specific domains (e.g., “Someone’s math ability is something about them that they can’t change very much”). Parents rated their agreement with each item on scale from 1 (“strongly disagree”) to 6 (“strongly agree”), with higher scores meaning they hold a more fixed mindset. Both domain general and domain specific items were highly related (Cronbach’s alpha = .93), so we treated them as a single scale. Parents' TOI score was the average of the 8 items, ranging from 1 to 5.38, with an average of 2.36 (*SD* = 0.94).

Expectations and value about their child's math/reading achievement. Parents' expectations and value for their child's math success (MEV) was measured with a 5-item questionnaire (Cronbach's alpha = .71). These items were adapted to capture parents' perception of their child's math abilities and how important it is for their success, as well as their future expectations (Schaeffer et al., 2018; Wigfield & Cambria, 2010; see Appendix A for full scale). Parents responded to each item on a 5-point scale and their score was the average of the 5 items. Parents' MEV score ranged from 2.60 to 5, with an average of 4.09 (*SD* = 0.55).

Parents also completed a parallel 5-item scale to measure their expectations and value for reading (REV; Cronbach's alpha = .73). Parents' REV score ranged from 2.60 to 5, with an average of 4.27 (*SD* = 0.50).

Child Measures.

Child Grade. Children's grade was considered a continuous variable to indicate years of formal schooling. Values were centered around kindergarten (0) since this is considered the start of formal education.

Math Achievement. Children's math achievement was assessed using the Applied Problems subtest (AP) from the Woodcock-Johnson IV (Schrank & Wendling, 2018), which measures children's ability to apply math procedures and concepts to real world problems. Children's AP score ranged from 324 to 474, with an average of 425.60 (*SD* = 23.72).

Verbal Achievement. Children's verbal achievement was assessed using the Picture Vocabulary subtest (PV) from the Woodcock-Johnson IV (Schrank & Wendling, 2018), which measures children's expressive vocabulary for single-word items. Children's PV score ranged from 418 to 499, with an average of 464.70 (*SD* = 12.87).

Both WJ subtests are administered orally, with items increasing in difficulty. The assessment is administered until the child reaches basal (six consecutive items correct) and ceiling (six consecutive items incorrect). The child's raw score is then converted to a w score, which is a Rash ability scale. A w score of 500 is the approximate average performance of a 10-year-old. These scores are not age-normed so all analysis considering children's w-scores across grade levels will control for their age.

Child math anxiety. Children's math anxiety (CMA) was assessed using an adapted version of the Mathematics Anxiety Rating Scale for Elementary School Children (Gunderson, Park, et al., 2018; Ramirez et al., 2013; Suinn et al., 1988). There are two versions of this questionnaire to tailor the questions to the child's age. Four- and 5-year-olds answered 7 items on a 3-point scale while 6- and 7-year-olds answered 16 items on a 5-point scale. The Cronbach's alpha was .63 for the scale used with younger children and .87 for the scale used with older children. The way the measure was administered did not account for the child's grade; this meant some 6-year-olds who were in kindergarten received the more extensive math anxiety scale while their 5-year-old classmates received the shorter version. To equate for the different response scales for the two age groups, children's average responses were z-scored within each measure. Children also completed a parallel reading version to measure their reading anxiety (CRA).

Preliminary analyses suggested that within each scale, younger children showed high math and reading anxiety than older children. We reasoned that this could be because the specific items (e.g., "How do you feel when you have to solve 27 + 15?") tapped skills that the older children were more confident about due to the instruction they experienced. The analyses reported here removed these items and assessed the anxieties based on general items (e.g., "How do you feel when you are in math class and your teacher is about to teach something new?"; 2 items for the younger anxiety scales and 4 items for the older anxiety scales). Children's average responses to the general items were z-scored within each of the four scales. Children's MA score ranged from -1.13 to 2.79, with an average of 0 (*SD* = 0.99). Children's RA score ranged from -1.39 to 1.71, with an average of 0 (*SD* = 0.99).

Procedure

Children were assessed across two testing days, completing the attitude measures on day 1 and the achievement measures on day 2. Parents completed all measures during one testing session, answering all attitudes measures first before completing the achievement battery. Parents were instructed to think about their youngest child between the ages of 4- to 7-years-old when answering the questions.

2.3 Results

Parent Measures

The correlations between all parent measures are reported in Table 1.

Table 1. Correlations of all Parent Measures

	1	2	3	4	5	6	7	8	9	10	11
1. SES	--										
2. MF	.57**	--									
3. VF	.56**	.70**	--								
4. AMAS	-.44**	-.52**	-.37**	--							
5. PMAF	-.26[a]	-.39**	-.29*	.75**	--						
6. ARAS	-.31*	-.46**	-.56**	.60**	.59**	--					
7. SETM	.05	-.01	-.02	-.12	-.36**	-.06	--				
8. SETR	-.17	-.13	-.04	.12	-.04	-.01	.54**	--			
9. MSC	.19	.18	-.04	-.33*	-.51**	-.12	.20	-.16	--		
10. MEV	.41**	.26[a]	.08	-.41**	-.45**	-.15	.43**	.12	.20	--	
11. REV	.30*	.20	.052	-.16	-.14	-.07	.32*	.25*	-.04	.56**	--
12. TOI	.32*	-.04	.16	-.17	-.11	-.06	-.06	-.20	-.004	.10	-.004

[a]p < .10; *p < .05; **p < .01

The two math anxiety scales were significantly related (*r* = .75, *p* < .01). The rest of the reported analyses will consider parents' score on the PMAF because the items are a more representative measure of their math experiences. However, I will use the AMAS when comparing math and reading anxiety since the comparable items allow for a more direct comparison. Unless specified, all results hold regardless of which measure is used.

As expected, there was a significant negative relationship between parents' math ability and their math anxiety; math anxious parents had a lower math fluency score (*r* = -.39, *p* < .01). There was also a negative relation between parents' math anxiety the other self-relevant attitude measures. Math anxious parents feel less confident in their ability to support their child's math learning, though this relationship was only significant for the math anxiety measure designed for parents (PMAF: *r* = -.36, *p* < .01) but not the traditional measure of math anxiety that asks about math in academic contexts (AMAS: *r* = -.12, *p* = 0.93). Math anxious parents also identified less with math (*r* = -.51, *p* < .01). There was no relationship between parent math anxiety and the degree to which they believe ability is fixed (*r* = -.11, *p* = .41). Importantly, math anxious parents had lower expectations and placed less value on their child's math success (r = -.45, p < .01).

Interestingly, parents' math ability was not related to any of their self-relevant math attitudes or child-specific math beliefs. Neither parents' self-efficacy in supporting their child's math learning (r = .18, p = .19) nor their math self-concept (r = -.01, p = .93) were significantly related to their math ability. Parents' mindset also was not related to their math ability (r = -.04, p = .77). The relationship between parents' math expectations and value for their child and their math ability was marginal in the expected direction, with higher math ability related to higher MEV (r = .26, p = .06).

Beyond math anxiety, only parent attitudes that involved their child's math learning were related. Parents' math EV was significantly related to their self-efficacy for teaching math (r = .43, p < .01); parents who feel more confident in their ability to support their child's math learning also have higher expectations for their success. Yet, their EV or SETM was not related to any of the other math attitude measures.

Table 2 summarizes parents' attitudes about math compared to reading. Overall, parents feel more positively about reading than math. Parents reported feeling more anxious about math compared to reading (t(59) = 4.79, p < .001). Parents also believe they are less able to support their child's math learning compared to reading (t(64) = -4.06, p <0.001). Parents' rating of their self- efficacy did not differ by their child's grade for either math (F(2,51) = 1.02, p = .37) or reading (F(2,51) = 0.60, p = .55). Finally, parents reported significantly lower expectations and values of their children's math compared to reading success (t(63) = -2.99, p = .004). Parents' EV ratings also did not differ by their child's grade for math (F(2,50) = 0.28, p = .76) or reading (F(2,50) = .27, p = .77).

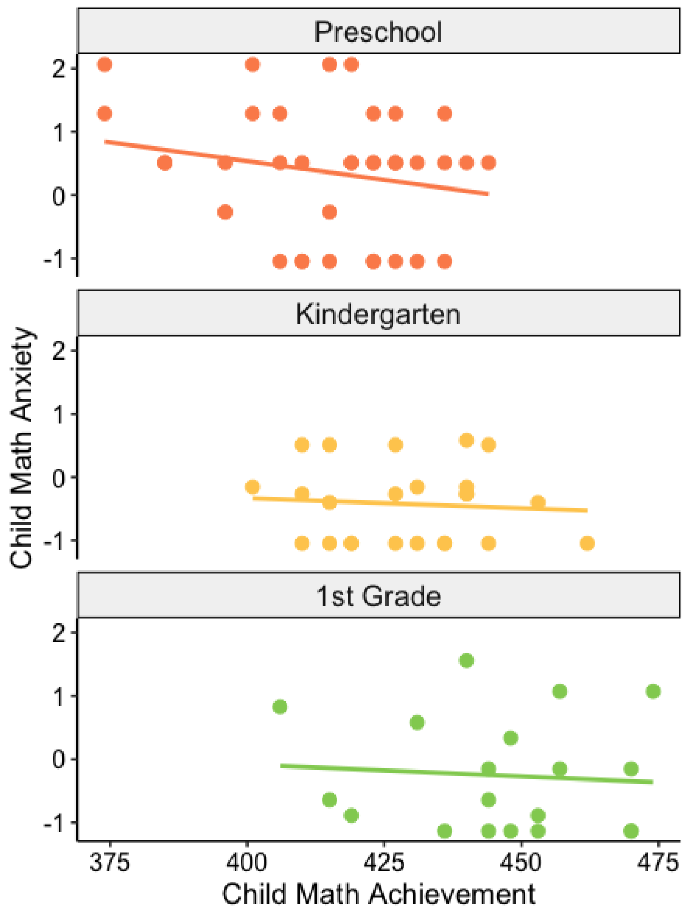
Table 2. Comparison of Parent Math and Reading Attitude Measures

	Mean	SD	Min	Max	t-test
Math Anxiety (AMAS)	2.38	0.98	1	5	*t*(59) = 4.79
Reading Anxiety	1.87	0.80	1	5	*p* < .001
Self-Efficacy for Teaching Math	4.02	0.93	1.67	5	*t*(64) = -4.06
Self-Efficacy for Teaching Reading	4.43	0.63	2.67	5	*p* < .001
Math Expectations and Value	4.09	0.55	2.60	5	*t*(63) = -2.99
Reading Expectations and Value	4.27	0.50	2.60	5	*p* = .004

Child Measures

Unlike for parents, and unlike prior studies with students in 1st grade and beyond, there was no relationship between children's math ability and their math anxiety, controlling for their age ($r = -.16$, $p = .12$). Anxiety and ability were not related at any of the grade levels tested: preschoolers ($r = -.02$, $p = .89$), kindergarteners ($r = -.11$, $p = .60$), and 1st graders ($r = -.08$, $p = .75$). It is important to note that the sample size for each group is small and the analysis may be underpowered. However, there seems to be no trending pattern in the current data (Figure 1). Also unlike their parents, children also did not report feeling more anxious about math compared to reading ($t(97) = 0.002$, $p = .99$).

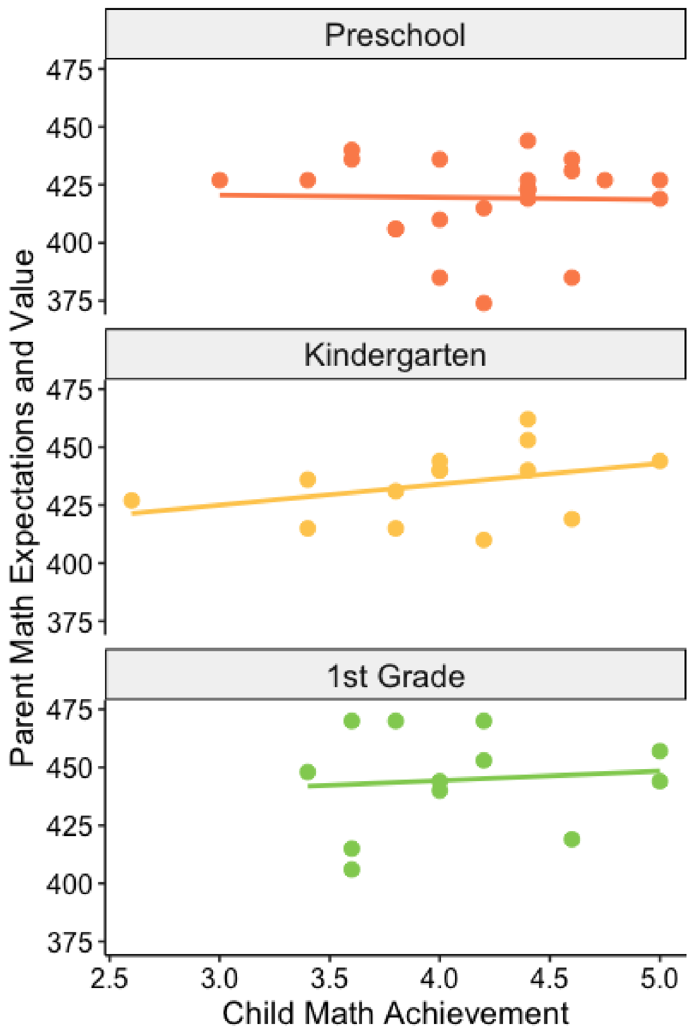
Figure 1. Relationship between Child Math Anxiety and Math Achievement by Grade



Relating Parent and Child Measures

As expected, parents' math ability was significantly correlated with their child's achievement, controlling for the child's age ($r = .44$, $p < .01$). Contrary to expectations, children's math achievement was not related to any of the parent math attitudes, controlling for child age. There was no relationship between child math performance and parents' self-relevant math attitudes: math anxiety ($r = -.05$, $p = .72$), self-efficacy for teaching math ($r = 0.00$, $p = .98$), and math self-concept ($r = .06$, $p = .66$). There was also no relationship between parents' TOI and their child's math achievement TOI ($r = -.12$, $p = .38$). Surprisingly, parents' child-focused math attitude, EV, was also not related to their child's math achievement (*r* = .17, *p* = .22), although this relation was directionally consistent with expectations and may have been significant with greater power. There was no evidence of this relationship for all grade levels tested (Figure 2): preschoolers (*r* = .10, *p* = .63), kindergarteners (*r* = .36, *p* = .17), and 1st graders (*r* = -.10, *p* = .76). Children's math anxiety was also not related to parent math anxiety (*r* = -.12, *p* = .36) or parent ability (*r* = -.01, *p* = .93).

Figure 2. Relationship between Parent Math EV and Child Math Achievement by Grade



Predicting Child Outcomes. Since children's math ability was not related to their own math attitudes in this sample, I ran a multiple regression analysis to examine if any parent factors predicted children's WJ Applied Problems score. Predictors included: the child's grade level, SES, parent math fluency, parent math anxiety, self-efficacy for teaching math, math self-concept, math EV, and theory of intelligence. The child's grade level (b = 0.61, p < .01) and the parents' math fluency (b = 0.33, p = .05) significantly predicted children's math achievement but none of the other predictors were significant (Table 3). This model accounted for 44% of the variance in children's math ability. This result suggest that child outcomes may not be related to parents' attitudes about math at this age.

Table 3. Model Output Predicting Children's Math Achievement

	B	SE B	β	t	Sig. (p)
Child Grade Level	19.95	4.63	0.61	4.31	.00
SES	6.22	4.84	0.22	1.29	.21
Parent Math Fluency	0.50	0.25	0.33	2.03	.05
Parent Math Anxiety	7.38	6.38	0.24	1.16	.24
Parent Self-Efficacy for Teaching Math	0.48	4.33	0.02	0.11	.91
Parent Math Self-Concept	3.93	4.54	0.15	0.87	.39
Parent Theory of Intelligence	-5.11	4.02	-0.17	-1.27	.21
Parent Math Expectations and Value	1.81	8.28	0.04	0.22	.83

Since the child's grade level is a strong predictor of their ability, I wanted to make sure the effect of this variable was not masking the influence of parent math attitudes on their child's math achievement. To address this, I ran a regression to explore if any of the parent factors predicted the residuals of the child math achievement and age relationship (Table 4). Similar to the previous analysis, parents' math fluency was still the only significant predictor (b = 0.47, p = .03). This model explained 26% of the variances of the discrepancy between age and math achievement.

Table 4. Model Output Predicting Math Achievement by Age Residuals

	B	SE B	β	t	Sig. (p)
SES	2.42	4.13	0.10	0.59	.56
Parent Math Fluency	0.59	0.23	0.47	2.59	.03
Parent Math Anxiety	6.02	6.03	0.23	1.00	.32
Parent Self-Efficacy for Teaching Math	-.00	4.09	0.00	-.00	.99
Parent Math Self-Concept	2.26	4.31	0.10	0.52	.60
Parent Theory of Intelligence	-4.24	3.87	-0.16	-1.10	.28
Parent Math Expectations and Value	2.84	7.88	0.06	0.36	.72

Factors Related to Parents' EV of Math for their Children. To address the second research question, I shift my analyses to explore what factors predicted parents' attitudes about their child's math learning. Potential predictors in the regression analysis included the child's grade level, the child's math achievement, SES, parent math fluency, parent math anxiety, self-efficacy for teaching math, math self-concept, and theory of intelligence. Parents' self-efficacy for supporting their child's math learning significantly predicted parent EV ($b = 0.36$, $p = 0.02$) but none of the other predictors were significant (Table 5). Notably, children's math ability did not predict parent EV. This model accounted for 43% of the variance in parent math EV. This analysis suggests parents' attitudes about their young children's math learning are more strongly related to their own math attitudes than to their children's actual math achievement.

Table 5. Model Output Predicting Parent Math Expectations and Value

	B	SE B	β	t	Sig. (p)
Child Grade Level	0.05	0.11	0.07	0.40	.69
Child Math Achievement	0.00	0.00	0.04	0.22	.83
SES	0.07	0.10	0.12	0.70	.49
Parent Math Fluency	0.00	0.00	0.23	1.38	.18
Parent Math Anxiety	-0.19	0.13	-0.31	-1.49	.15
Parent Self-Efficacy for Teaching Math	0.20	0.08	0.36	2.51	.02
Parent Math Self-Concept	-0.10	0.09	-0.20	-1.16	.25
Parent Theory of Intelligence	0.08	0.08	0.13	0.95	.35

In order to test the domain specificity of the relationship between parent math EV and their self-efficacy, I ran a parallel analysis that also included parents' attitudes about reading – self-efficacy for teaching reading and reading anxiety – as predictors of parent math EV. The results of this analysis show that self-efficacy for teaching math (*b* = 0.39, *p*= .03) is still a significant predictor but parent self-efficacy for teaching reading is not (Table 6). Adding the additional measures did not account for any additional variance, since this model also accounted for 43% of the variance in parent math EV.

Table 6. Model Output Predicting Domain Specificity of Parent Math EV

	B	SE B	β	t	Sig. (p)
Child Grade Level	0.00	0.00	0.08	0.42	.68
Child Math Achievement	-0.00	0.13	-0.00	-0.03	.98
SES	0.03	0.11	0.02	0.12	.91
Parent Math Fluency	0.00	0.01	0.21	1.17	.25
Parent Math Anxiety	-0.18	0.12	-0.31	-1.48	.15
Parent Self-Efficacy for Teaching Math	0.21	0.09	0.39	2.35	.03
Parent Math Self-Concept	-0.07	0.08	-0.14	-0.86	.40
Parent Theory of Intelligence	0.09	0.08	0.15	1.04	.31
Parent Reading Anxiety	-0.04	0.12	-0.05	-0.31	.76
Parent Self-Efficacy for Teaching Reading	0.08	0.14	0.10	0.56	.58

To see if this relationship between expectations and values and teaching self-efficacy was also evident in the reading domain, I ran an analysis predicting parent reading EV. Predictors included: the child's grade level, the child's reading achievement, SES, parent reading fluency, parent math and reading anxiety, self-efficacy for teaching math and reading, and theory of intelligence. Similar to the math analysis, self-efficacy for teaching reading significantly predicted parent reading EV ($b = 0.42$, $p = 0.02$) but none of the other predictors were significant (Table 7). This model accounted for 33% of the variance in parent reading EV.

Table 7. Model Output Predicting Parent Reading Expectations and Value

	B	SE B	β	t	Sig. (p)
Child Grade Level	-0.09	0.10	-0.16	-0.87	.39
Child Verbal Achievement	0.01	0.01	0.18	1.07	.29
SES	0.00	0.11	0.00	0.02	.99
Parent Reading Fluency	-0.00	0.00	-0.05	-0.26	.80
Parent Math Anxiety	-0.10	0.09	-0.20	-1.04	.31
Parent Self-Efficacy for Teaching Math	0.11	0.09	0.23	1.29	.21
Parent Math Self-Concept	-0.04	0.08	-0.09	-0.49	.63
Parent Theory of Intelligence	0.11	0.08	0.21	1.33	.19
Parent Reading Anxiety	0.10	0.12	0.14	0.83	.41
Parent Self-Efficacy for Teaching Reading	0.28	0.13	0.39	2.21	.03

2.4 Discussion

The goal of Study 1 was to explore the relation between parent EV and their child's math outcomes in the early school years. The Study focused on preschoolers, kindergarteners, and 1st graders since previous work suggests this connection emerges by elementary school.

Contrary to my expectations, child math outcomes were not related to their parent's math attitudes in this sample. There was also no evidence that children's own attitudes are related to their math ability at this age. In fact, the strongest predictor of children's math ability was parent ability. It could be the case that the link between parent and child achievement is a genetic one. However, given the previous work establishing the connection between parent attitudes and their child's math outcomes, it is also likely that parents with higher math ability may be providing more fruitful learning opportunities for their children.

Results also suggest that parents' attitudes about their young children's math learning are more strongly related to their own math attitudes than their child's actual math achievement. In particular, parents' self-efficacy for teaching and supporting their child's math learning was the strongest predictor of their expectations and values for their child's math success and how valuable they think math is for them. Furthermore, this self-efficacy seems to be domain specific, since this effect holds even when controlling for their self-efficacy in supporting their child's reading. Similarly, parent self-efficacy for supporting their child's reading predicted their EV of reading for their child.

Teaching self-efficacy is an attitude that has been considered almost exclusively in teachers. However, these findings suggest that this attitude is also important to consider with parents when examining the role they play in supporting their child's learning experiences. An important open question is how parents are operationalizing this construct and how it manifests when they engage in math with their child.

Given previous findings, we expected to find a relationship between child outcomes and parent attitudes in our sample of 1st graders. It is possible that our sample was underpowered in this age group and failed to detect this relationship. However, it is important to note that our measures were collected at the beginning of the school year whereas previous work considered child's math achievement at the end of the school year. It could be the case that this is a critical year where parents' attitudes begin to influence their child's performance. In fact, this supports the hypothesis that parent attitudes about their child's math learning are guided by the feedback they receive from their child's teachers. Study 2 will explore variations in parents' child-focused math attitudes as children have more schooling experience.

It could also be the case that the link between parent attitudes and child outcomes may already exist at this age, but our current measures are not capturing this variability. The pathway of parent attitudes to child achievement may already be in play by affecting parents' math engagement. Teachers' mindset affects their 1st and 2nd graders math achievement through a similar mechanism; teacher's report of their instructional practices mediates the relationship between their mindset and their students' mindset and achievement (Park et al., 2016). Similarly, parent attitudes may already be influencing their child, but it is not yet evident in their achievement. The relationship between parent attitudes and their math engagement will be explored in Study 3.

Limitations

The proposed plan for this study included a balanced sample of children from each grade level. Data collection was interrupted due to the Covid-19 pandemic and our analytical sample consisted of mostly preschoolers. The unbalanced age distribution does not allow us to systematically explore the strength of this relationship as children get older and consider the interaction of parent attitudes with their child's age. In fact, previous work has shown a relationship between 1st graders math ability and their math attitudes, as well as their parent's attitudes. However, our current sample of 22 1st graders may be underpowered.

Furthermore, this study explores the relationship between parent and child math outcomes at a single timepoint at the beginning of the school year. This design does not allow us to explore the directionality of these relationships or how these relationships may change throughout the school year. In fact, most of the previous literature has explored this relationship by measuring children's outcomes at the end of the year. A follow-up study should assess children's math ability and attitudes at multiple time points to examine predictive relations and changes over time.

Conclusion

Taken together, findings from Study 1 show that the relationship between parent attitudes and their child's math outcomes may not yet have emerged during the preschool years. While parent attitudes did not predict child outcomes in this sample, they eventually do. Parent attitudes may be influencing their math interactions with their child, which in turn, are likely to relate to children's math outcomes. Given that parent EV for their child's math is more related to their math attitudes than to their child's math abilities, in subsequent chapters I will shift my focus to only parents and explore their math attitudes and the math supports they provide to their children. I will assess these relations in a wider age group that spans from preschool to 2nd grade.

3. CHAPTER THREE Study 2: Variations in Parents' Attitudes about their Children's Current and Future Math Learning

3.1 Background

While early math knowledge is critical for future success, many parents of young children do not know they play a foundational role in supporting their child's math learning. A study by Cannon and Ginsburg (2008) asked how an economically diverse sample of mothers approached their preschooler's math learning. Their results suggest that parents are less likely to engage in math learning opportunities in the home compared to reading. Parents also lack knowledge about children's early math development and how they can support this learning. Furthermore, the majority of parents had no expectations or goals for their children's math learning. In fact, they believe math education will be the responsibility of their teachers once children enter formal schooling.

Results from Study 1 suggest parent attitudes about their child's math learning are constructed from their own math attitudes, specifically their self-efficacy for teaching math, rather than the child's actual math ability. One important open question to consider, then, is how in tune are parents with their young child's math skills?

Previous work suggests parents have an understanding of their child's math ability, but this understanding is broad. Parents' ratings of their child's math ability predict their actual performance, even when controlling for demographic variables (Lin et al., 2021). Yet, parents are not aware of how children will perform on specific math skills (Fluck et al., 2005; Lin et al., 2021; Zippert & Ramani, 2017). Mothers of preschoolers were unaware of the discrepancy between children's ability to count and their understanding of cardinality, the concept that the last number counted refers to the amount of items in a set (Fluck et al., 2005). Parents of preschoolers also report uncertainty about their understanding of children's advanced number skills, such as comparing magnitudes or solving simple sums (Zippert & Ramani, 2017). In addition, parents also had an overall tendency to overestimate their child's math ability (Fluck et al., 2005; Zippert & Ramani, 2017).

The literature so far has considered parents' ratings of their young children's current math skills. However, parents' lack of knowledge about young children's early math development or lack of expectations for their math learning does not necessarily mean they will not value their future math success. Measures of parents' child-focused math beliefs have considered their expectations and value for their future and current math ability as a single construct (e.g., Wigfield & Eccles, 2000). Yet, it is reasonable to expect their beliefs to vary depending on whether they are thinking about their child's current or future success, especially when their children are young. This is particularly important to consider given my hypothesis that schooling experience impacts parents' child-focused attitudes based on the feedback they receive from teachers, which ranges from positive to negative.

Thus, another unexplored question concerns differences in parents' attitudes about their children's math learning, depending on whether they are thinking about their current or future performance. The cognitive psychology literature can shed light on how parents may value their child's math learning differently depending on whether they are considering their current or future outcomes. On the one hand, parents may be overly focused on the present and discount the future. Consistent with findings indicating that people often are subject to present-bias, parents may underemphasize their child's future math success and focus mostly on how they are doing in the moment (Mayer et al., 2015; Thaler, 2015). On the other hand, parents may be overly optimistic about their child's future ability as future events have a tendency to be viewed more positively than present ones (Atance & O'Neill, 2001; Berntsen & Jacobsen, 2008; Newby-Clark & Ross, 2003; Rasmussen & Berntsen, 2013; Schacter et al., 2017). It could be the case that parents are more realistic or unaware about their child's current math ability but have more idealistic expectations and value of their future math success. Both present bias and unrealistic future optimism are concerning. If both are operative early in development, this may delay parents' involvement in their child's math learning during this foundational time; parents may they believe that their child's math skill is fine in the present and be overly optimistic about their future math skills. Moreover, parents may not know that their child's current understanding of foundational math skills predict their future math achievement.

3.1.1 The Present Study

The present study explores variation in parents' attitudes about their child's current and future math success, and how this may change with increasing schooling experience. I consider this question in a broader age sample than Study 1, examining the math attitudes of parents of children ranging from preschoolers to 2nd graders. I also include parents of 3-year-olds who are and are not attending preschool.

This study considers two additional measures of parents' math beliefs and engagements in addition to those examined in Study 1. The first is parents' reported frequency of how often they engage in different math learning activities with their child. Parents' reported frequency of math activities in the home is related to their observed math behavior (Skwarchuk, 2009; Thippana et al., 2020) and predictive of children's math outcomes (LeFevre et al., 2009; Napoli & Purpura, 2018; Ramani et al., 2015; Skwarchuk et al., 2014). Furthermore, their frequency of math activities has been shown to relate to their math attitudes, such that parents who engage in math activities more frequently report more positive attitudes about math (Susperreguy et al., 2020) and lower math anxiety (del Río et al., 2020). The second measure is parents' ranking of the importance of math relative to other subjects. Parents may be likely to say that all academic subjects are important for their child; this ranking provides a more discrete measure of how important they think it is compared to other important academic domains and may relate to their other math attitudes as well as to their math engagement with their child.

Study 2 particularly focuses on whether parents' expectations and values about their child's math learning differ depending on whether they are thinking about their current or future ability. I hypothesize that this may depend on the child's schooling experience. Parents of younger children who have not yet received feedback about their child's math performance from their teachers may be overconfident about their child's future math performance. In other words, they may report higher expectations and value for their future performance compared to their present ability. On the other hand, parents of children in formal schooling may be more attuned to their child's math ability and have more consistent beliefs about their current and future math success. In other words, I predict parents of older children will report similar expectations and value for their child's present and future ability.

3.2 Method

Participants

139 parents (75 mothers, 64 fathers) participated in the study through Mechanical Turk. In order to be eligible, participants had to live in the United States and have at least one child between the ages of 3 to 7-years-old. Parents also had to pass a series of attention checks in order

to be included in the final sample. Participants were recruited until there were at least 25 parents with a target child in each age group.

The final sample consisted of parents of 30 3-year-olds, 24 4-year-olds, 25 5-year-olds, 31 6-year-olds, and 28 7-year-olds. The sample also varied in terms of the target child's schooling experience; 35 were not attending school yet, 31 were in preschool, 35 were in kindergarten, 25 were in 1st grade, and 13 were in 2nd grade. Table 8 describes the distribution of these groups.

Table 8. Distribution of Child Age per Grade

		Age Group					
		3	4	5	6	7	Total
Grade	Not attending school	24	10	1	0	0	35
	Preschool	6	14	10	1	0	31
	Kindergarten	0	1	14	19	1	35
	1st Grade	0	0	0	10	15	25
	2nd Grade	0	0	0	1	12	13
	Total	30	25	25	31	28	139

Measures

Child Grade. Children's grade was considered a continuous variable to indicate years of formal schooling. Values were centered around kindergarten (0) since this is considered the start of formal education.

Socioeconomic Status. Parents reported their annual household income and educational attainment through the same demographic questionnaire used in Study 1. The average household income was $47,600, ranging from less than $15,000 to greater than $100,000. The average highest level of education completed was an Associate's/2-year college degree, ranging from completing High School to a graduate degree. Household income and parents' education level were correlated (r = .23, p < .01) and were combined into a single SES measure using a Principal

Component Analysis. This composite standardized score measure has an average of 0 (*SD* = 1, range -2.82 – 2.24).

Math Ability. As a proxy for a standardized math performance measure, parents completed the Subjective Numeracy Scale (SNS; Fagerlin et al., 2007). This measure has been validated with different objective math assessments (Zikmund-Fisher et al., 2007). The SNS consists of 8 items rated on a 7-point scale (Cronbach's alpha = .83); 4 items measure individuals' perceived ability to perform specific math tasks and 4 items measure their preference for presenting information in numerical vs. prose form. Parents' score was the average of the 8 items, ranging from 1 to 7 with an average score of 5.28 (*SD* = 1.03).

Math Anxiety. Parent math anxiety was measured using the Abbreviated Math Anxiety Scale (AMAS) and the Parent Math Anxiety Scale for Families (PMAF). Parents' score on the AMAS was the average of the 9 items (Cronbach's alpha = .93), ranging from 1 to 4.44 with an average score of 2.60 (*SD* = 1.02). Parents' score on the PMAF was the average of the 16 items (Cronbach's alpha = .96), ranging from 1 to 4.38 with an average score of 2.68 (*SD* = 1.05).

Reading Anxiety. Parent reading anxiety was measured using the Abbreviated Reading Anxiety Scale (ARAS). Parents' score on the ARAS was the average of the 9 items (Cronbach's alpha = .92), ranging from 1 to 4.44 with an average score of 2.40 (*SD* = 0.99).

Self-efficacy in teaching and supporting their child's math/reading. Parents' self-efficacy for teaching math (SETM) and reading (SETR) was measured with the 4-item scale from Study 1. Similarly, the Cronbach's alpha for this scale increased from .43 to .64 for SETM and .47 to .67 for SETR when the third item was removed so parents' score was the average of the other three items. SETM ranged from 1.33 to 5, with an average score of 3.88 (*SD* = 0.73). SETR ranged from 2.67 to 5, with an average score of 4.12 (*SD* = 0.70).

Math Self-concept. Parents' math self-concept (MSC) was measured with the same scale as Study 1. Their score was the average of the 3 items (Cronbach's alpha = .46); positive scores indicate a stronger identification with math while negative scores indicate a stronger identification with reading. MSC ranged from -2 to 1, with an average score of -0.53 (*SD* = 0.71).

Theory of Intelligence. Parents' mindset/theory of intelligence was measured with the same scale from Study 1. Their score was the average of the 8 items (Cronbach's alpha = .96); high scores mean parents hold a more fixed mindset. TOI ranged from 1 to 5.88, with an average score of 3.25 (*SD* = 1.41) 1.40).

Expectations and value about their child's math/reading achievement. Parents' expectations and values for their child's math (MEV) and reading (REV) success was measured with the same scale as Study 1. This scale includes 3 items measuring parents' current perception of their child's math ability and how much value they place on this success and 2 items measuring their future expectations (see Appendix A; Cronbach's alpha was .70 for MEV and .72 for REV). Parents' overall score was the average of the 5 items. MEV ranged from 1.8 to 5, with an average score of 3.86 (*SD* = 0.63) while REV ranged from 2 to 5, with an average score of 4.03 (*SD* = 0.64)

Home Learning Environment Questionnaire. Parents were asked to report the frequency with which they engaged in different learning activities with their child. They responded to comparable math and reading scales, with items adapted from Hart and colleagues (2016) and LeFevre and colleagues (2009), and asked to rate each item on a scale from 1 ("never") to 7 ("multiple times a day;" see Appendix B for full math scale). The Home Math Environment (HME) scale included 12 items, (Cronbach's alpha = .85). Parents' HME score was the average of the 12 items, ranging from 1 to 6.5, with an average score of 4.32 (*SD* = 1.02). The Home Reading Environment (HRE) scale included 8 items (Cronbach's alpha = .74). Parents' HRE score was the average of the 8 items, ranging from 2 to 7, with an average score of 4.83 (*SD* = 0.92).

Learning Goals. Parents were asked to rank five academic subjects in order of how important they are as learning goals for their child, from 1 (most important) to 5 (least important). The order of the subjects was randomized for each participant. As a measure of how important parents believe math is for their child relative to other subjects, I consider their math ranking, with lower numbers indicating higher importance.

Procedure

All measures were administered through a Qualtrics survey. After passing the eligibility screener, parents were instructed to think about their youngest child between the ages of 3- to 7-years-old when answering the questions. Parents were randomized to either complete the Attitudes or Home Activities questionnaire first. Similar to Study 1, parents completed the math ability measure last.

3.3 Results

Children's age and grade level were highly correlated ($r = .90$, $p < .001$); I focus the analyses on differences in parent attitudes by the child's grade since the main research question is concerned with changes in parent attitudes as a result of the child's schooling experience, rather than their general developmental timeline.

The correlations between all measures are reported in Table 9.

Table 9. Correlations for all Math Measures

	1	2	3	4	5	6	7	8	9
1. Child Grade	--								
2. SES	.01	--							
3. SNS	.07	.16	--						
4. PMAF	.17 [a]	-.03	-.40**	--					
5. SETM	.01	-.02	.34**	-.30**	--				
6. MSC	.01	.15 [a]	.31**	-.08	.20*	--			
7. TOI	.15 [a]	.09	-.13	.56**	-.11	.23**	--		
8. MEV	.18*	.03	.33**	.04	.37**	.17 [a]	.12	--	
9. HME	.15[a]	.12	.15	.26**	.19*	.06	.25**	.29**	--
10. Math Ranking	.03	.04	-.11	.11	-.10	-.19*	.04	-.28**	-.08

[a]p < .10; *p < .05; **p < .01

Results from new measures –Math Ranking and Home Math Environment

The two additional measures mostly related to other attitudes in the expected direction. Table 10 summarizes parents' learning goal rankings for all subjects. On average, parents were ranking math as the second most important learning goal for their child. However, there was variability – some parents ranked math as being most important (1) while others ranked it as least important (5) relative to the other subjects.

Table 10. Parents Ranking of Learning Goals

	Mean	SD	Min	Max
Reading	1.59	0.95	1	5
Math	2.63	1.09	1	5
Writing	2.85	1.19	1	5
Science	3.45	1.09	1	5
History, Geography, & Social Studies	4.49	0.90	1	5

Parents' ranking of math as a learning goal was related to their EV (r = -.28, p < .001) and math self-concept (r = -.19, p = .03). Parents with higher EV ranked math higher than those with a lower EV. Parents who reported a stronger association with math also ranked math higher than those who reported a stronger association with reading.

Parents report engaging in significantly less math activities with their child compared to reading ($t(130) = -7.79$, $p < .001$). Parents' report of the frequency of math learning activities was significantly related to their SETM ($r = .19$, $p < .001$) and their EV ($r = .29$, $p < .001$); parents with higher EV and higher self-efficacy in supporting their child's math learning reported engaging in math activities more often. Yet, their HME report related to their math anxiety and TOI in an unexpected direction (PMAF and HME: $r = .26$, $p < .01$; TOI and HME: $r = .25$, $p < .01$); parents who were math anxious and parents who held a fixed mindset reported engaging in math activities with the target child more often. These factors were highly correlated ($r = .56$, $p < .001$), however, and when controlling for parents' math anxiety their mindset is no longer related to their frequency of math activities ($r =.11$, $p = .20$). It could be the case that parents who are math anxious and hold a more fixed mindset are overestimating the amount of math they do with their children relative to those who are less math anxious and have more of a growth mindset, so this is not a valid report. These findings suggest the importance of examining reported versus actual math activities in parents who hold different math attitudes.

Replicating Study 1 Findings

Most Study 2 attitude measures related in the expected direction. Parents' self-reported math ability showed a similar relationship to their attitudes as the objective math fluency measure from Study 1. Parents who reported higher math ability were less math anxious ($r = -.39$, $p < .01$) and had higher expectations and values for their child's success ($r = .33$, $p < .01$). Parents' expectations and values for their child's math success was positively related to their self-efficacy for teaching math (r = .37, p<.001). Parents' socioeconomic status was not related to math attitude or engagement measure.

While these relations are mainly consistent with those found in Study 1, there a two notable differences. First, parents' self-efficacy for teaching math is related to their math ability (r = .34, p < .001). This difference might be due to the fact that the current study uses a self-report measure asking their perceived math ability and preference for numerical information while Study 1 uses a standardized math fluency measure. Yet, this relationship holds when only the four ability items are considered (r = .36, p < .001). It could be the case that this self-reported measure is more closely tied to their sense of self-efficacy compared to a standardized math fluency measure. This result is consistent with previous work that finds a relationship between teachers' self-efficacy and their math ability (Bates et al., 2011).

Second, parents' expectations and values were not significantly related to their math anxiety (r = .04, p = .68), while Study 1 showed a negative association. The findings in the parent literature have been mixed, however, with some studies suggesting either a negative association (Schaeffer et al., 2018) or no relation (Elliott et al., 2020; Silver et al., 2021) between math anxiety and EV. Thus, it is possible that the inconsistencies in findings between the two studies reflect the fact that this relation varies depending on the particular sample being examined, which differed in terms of parent demographics and children's age.

Relation of Self-Relevant Math Attitudes to Parent EV

As in Study 1, I examined what parent self-relevant attitudes predicted their expectations and value about their child's math learning. Potential predictors included the parent self-reported math ability, math anxiety, self-efficacy for teaching math, math self-concept, theory of intelligence, child grade level, SES, and reported frequency of math activities, and their ranking of math as a learning goal. Parent self-reported math ability (*b* = .26, *p* = .02), their self-efficacy for teaching math (*b* = 0.32, *p* < .01), and ranking of math as a learning goal for math (*b* = -.25, *p* < .01) significantly predicted their EV, but none of the other predictors were significant (Table 11). This model explained 32% of the variance in parent EV. Overall, these analyses were consistent with those found in Study 1 in that parent self-efficacy is the attitude that most strongly predicts parents' beliefs about their child's math learning.

Table 11. Replication of Study 1 Analysis Predicting Parent EV

	B	SE B	β	t	Sig. (p)
Child Grade Level	0.07	0.04	0.14	1.66	.10
SES	0.02	0.05	0.03	0.32	.75
Parent Math Ability (SNS)	0.16	0.07	0.26	2.44	.02
Parent Math Anxiety	0.12	0.07	0.19	1.62	.11
Parent Self-Efficacy for Teaching Math	0.27	0.08	0.32	3.48	.00
Parent Math Self-Concept	-0.04	0.08	-0.04	-0.43	.67
Parent Theory of Intelligence	0.01	0.05	0.02	0.18	.86
Home Math Environment	0.08	0.06	0.12	1.26	.21
Learning Goal Math	-0.15	0.05	-0.25	-3.00	.00

Future vs. Current Expectations and Value of Children's Math Achievement

Parent MEV is calculated from parents' responses to 5 items capturing their perception of their child's math achievement and how important it is for their success, as well as their future expectations (Appendix A). In order to distinguish how this may vary depending on whether they are considering their children's present or future ability, two separate scores were calculated. Parents' current EV was the average of the 3 items asking about their children's current math ability (*M* = 3.73, *SD* = 0.74, range 1.67 – 5). Parents' future EV was the average of their responses to the 2 items asking about their child's future math performance (*M* = 4.07, *SD* = 0.67, range 2 – 5). Current and future EV were significantly related ($r = .55$, $p < .01$; Figure 3). However, parents' future EV was significantly higher than their current EV ($t(139) = -6.21$, $p < .001$). This relationship held when considering the expectations and value items separately but was strongest for parents' expectations (Figure 4). Furthermore, parents' current EV for their child's math achievement was significantly correlated with their child's grade ($r = .22$, $p < .01$) but their future EV was not ($r = .07$, $p = .43$).

Figure 3. Relation between Current and Future EV

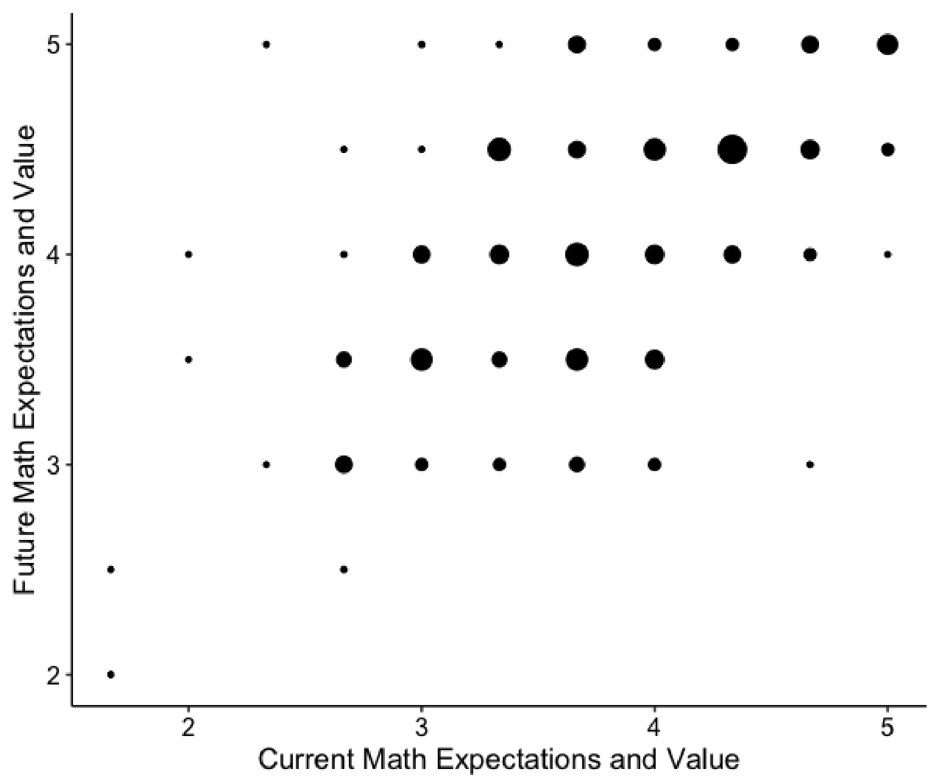


Figure 4. Comparing Current and Future Parent Expectations and Parent Values

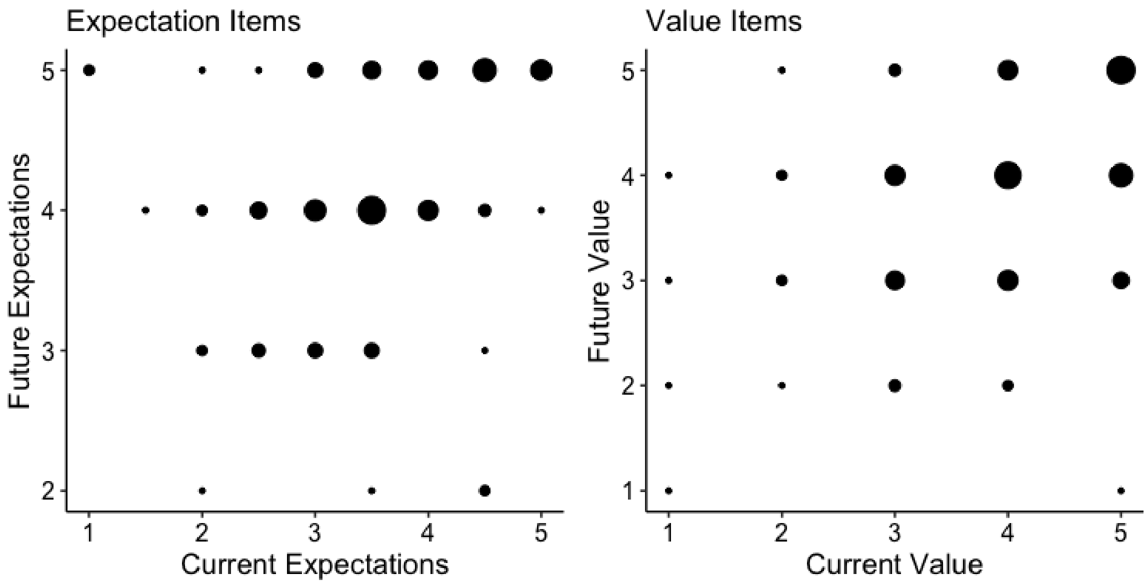
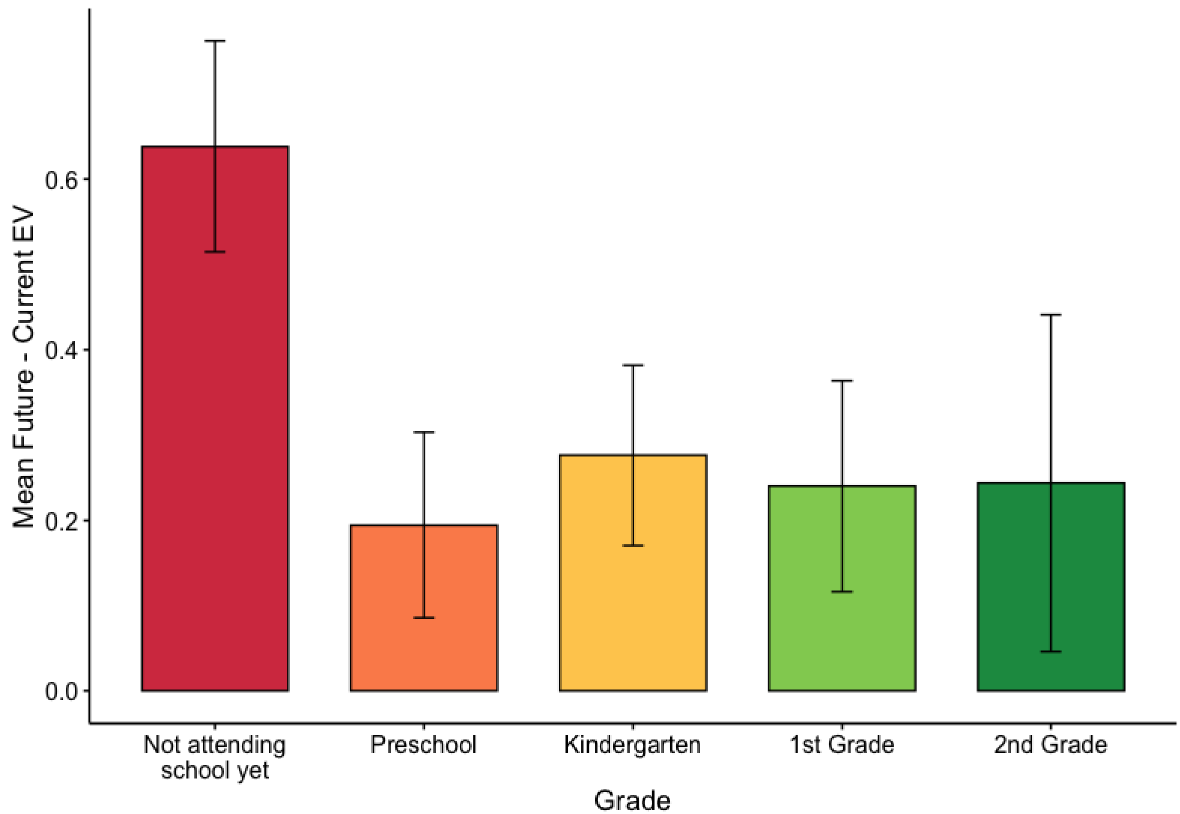


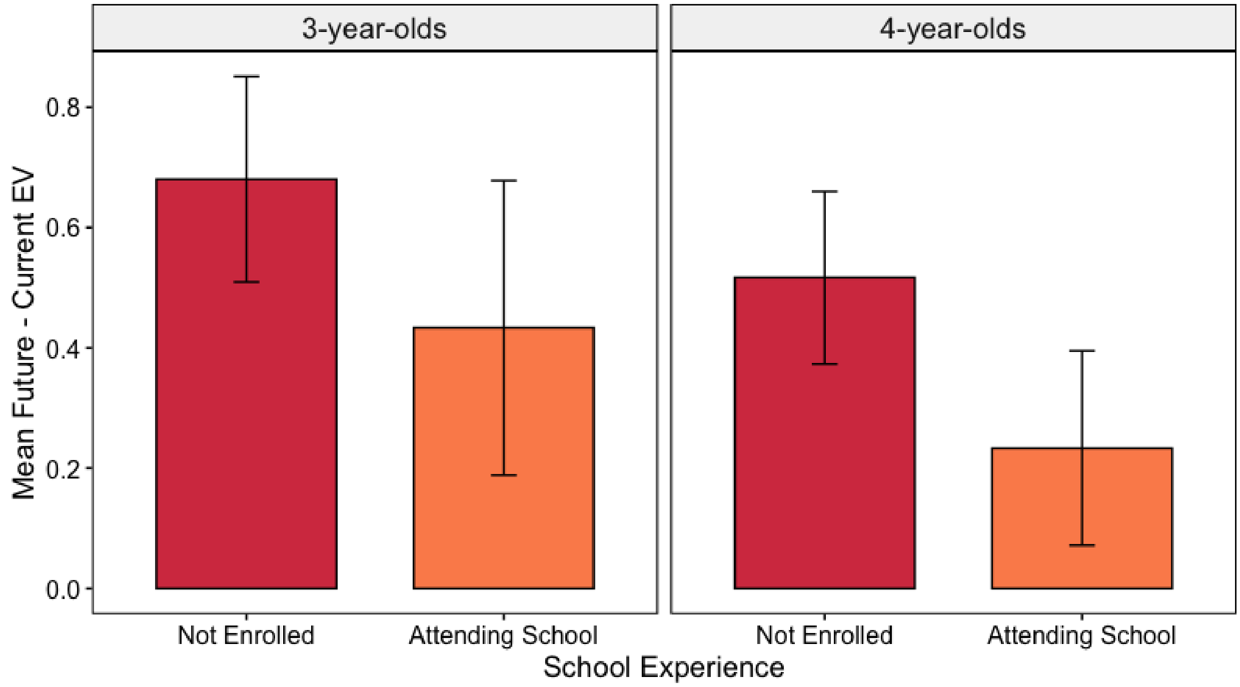
Figure 5 shows the difference between parents' current and future EV by their child's grade. A positive difference score indicates that parents have higher expectations for their child's future math success and place more value in math in the future compared to the present. There was a negative relationship between the child's grade level and the difference between parents' current and future EV (r = -.187, p = .03), with parents of younger children having higher expectations and value for their child's future success compared to their present success. The difference between parents' current and future EV significantly varied by their child's grade level (F(4,133) = 2.48, p = .04). This relationship is mostly driven by parents of children who are not yet attending school.

Figure 5. Difference between Parents' Current and Future EV by Child Grade Level



The current analysis confounds the role of children's age and schooling experience. In order to disentangle this, I ran an exploratory analysis comparing the difference in parents' future and current EV for 3- and 4-year-olds who either not attending in school or in preschool (Figure 6). Parents of both age groups showed the same trend; parents of children who are not enrolled in school report a larger difference between the future and current expectations for their children's math success compared to the present than parents of children who are attending preschool. Even for this underpowered sample, the difference is marginal ($t(51) = 1.80$, $p = .06$). This exploratory analysis suggests the difference in parents' future and current EV may be associated with children's schooling experience rather than their age.

Figure 6. Difference between Parents' Current and Future EV based on School Enrollment



Relating Current and Future EV to other Attitudes. The difference between parents' current and future EV was not significantly related to any of their other math attitudes. Yet, these two components of EV were differentially predicted by different parent attitudes. Utilizing all of the variables measured as predictors, parents' current EV is significantly predicted by the child's grade level (b = .19, p = .03), their self-reported math ability (b = .27, p = .02), their self-efficacy in supporting their child's math learning (b = .25, p < .01) and their ranking of math as a learning goal (b = -.18, p = .03) whereas parents' future EV was only significantly predicted by their math teaching self-efficacy (b = .33, p < .001) and math ranking (b = -.31, p < .01; Table 12).

Table 12. Predictors of Parent Current and Future Expectations and Value

	Current EV	Future EV
	Unstandardized Parameter Estimates	
Child Grade Level	0.11* (0.05)	0.01 (0.05)
SES	0.06 (0.07)	-0.04 (0.06)
Parent Math Ability (SNS)	0.20* (0.08)	0.11 (0.07)
Parent Math Anxiety	0.13 (0.09)	0.10 (0.08)
Parent Self-Efficacy for Teaching Math	0.25** (0.09)	0.31** (0.08)
Parent Math Self-Concept	-0.05 (0.08)	-0.02 (0.09)
Parent Theory of Intelligence	0.01 (0.06)	0.01 (0.05)
Home Math Environment	0.07 (0.07)	0.10 (0.07)
Math Ranking	-0.12* (0.06)	-0.20** (0.05)

Number in parentheses are SEs of B
[a]p < .10; *p < .05; **p < .01

Classifying Parent Attitudes

Chapter 1 discussed parent attitudes in terms of 3 groups: self-relevant, child-focused, and general. I was curious if parents' actual scores on these attitude categories corresponded with this theoretical classification. To address this question, I conducted a Principal Component Analysis to identify how these attitudes were empirically grouped. This analysis identified three independent math attitude components (Table 13). Component 1 indexes parents' self-efficacy for teaching math and their current and future expectations and values, which accounts for 33% of the variance in parent attitudes. A high score in this factor indicates high expectations and value of children's current and future math achievement and high self-efficacy in supporting their child's math learning. Component 2 indexes parents' math anxiety and theory of intelligence, which accounts for 28% of the variance in parent attitudes. A high score in this factor corresponds to high anxiety and a fixed mindset. Component 3 indexes parents' math self-concept, which accounts for 17% of the variance in parent attitudes. A high score on this factor indicates a stronger identification with math. This analysis suggests that parent math teaching self-efficacy may actually be a more child-focused measure, a finding I consider in the discussion.

Table 13. Principal Component Analysis of Parent Math Attitudes

Measure	Component		
	1	2	3
Math Anxiety	-.27	**.83**	-.25
Math Self-Concept	.40	.23	**.84**
Self-Efficacy for Teaching Math	**.74**	-.24	.11
Math EV – Current	**.74**	.29	-.31
Math EV – Future	**.79**	.18	-.30
Theory of Intelligence	-.05	**.87**	.22

3.4 Discussion

The goal of Study 2 was to explore variation in parents' attitudes about their child's current and future math success with schooling experience. I hypothesized that parents' expectations and values may shift depending on whether they are considering their child's current or future ability and that this difference would depend on the child's grade level. Indeed, parents of younger children report having higher expectations for their child's future success compared to their present math knowledge. On the other hand, this difference in future and current EV is not as pronounced for parents of older children. The follow-up analysis looking at parents of 3- and 4-year-olds suggests that this effect is associated with children's schooling experience rather than their age. However, the directionally of this relationship remains an open question for future work. It could be that parents learn about their young children's math development and adjust their current expectations accordingly once their children are enrolled in school. On the other hand, parents who choose to send their children to preschool may be more focused on early math or academics more broadly.

In Chapter 2, I hypothesized that parent attitudes may relate to their math engagement. However, parents' self-reported frequency of math activities did not relate to their math attitudes. Notably, parents' self-reported math engagement was not significantly related to their current or future EV when controlling for their other attitudes. Study 3 explores differences in the quality of their math engagement in relation to their EV, a potentially more sensitive measure.

Findings from this study also continue to highlight the important influence of parents' self-efficacy for teaching math on how parents are conceptualizing their child's math success. Previous work with teachers suggests this attitude is self-relevant and closely tied to their math abilities. Yet, results from the factor analysis suggests that for parents this may be a child-focused attitude. While the literature does not account for this discrepancy, it is not entirely unexpected given that parents and teachers have different experiences supporting children's math learning. In particular, teachers have to instruct many students with varying levels of math ability in their classroom while parents only have to support their own child's math learning. Future work is needed to examine how this attitude forms in parents and how it affects their math engagement.

Results also suggest that different factors contribute to parents' current and future expectations and value for their child's math success. Future EV is predicted by parents' self-efficacy in supporting their child's math learning and their ranking of math as a learning goal Current EV is predicted by these variables as well as parents' own math ability and their child's grade level. This difference suggests that parents are drawing more on their own math abilities when considering their beliefs about their child's current math learning. It could be that parents lack awareness about math development at this age and do not have an objective measure of their child's knowledge, and thus base their attitudes on their own abilities.

An important open question is why current and future EV differs for parents of young children. One possibility is that parents may not fully understand the connection between their child's current math skills and their future math success and therefore do not value it in the same way. On the other hand, parents may not know what math is age-appropriate for their young child, particularly when their young child does not attend preschool. Parents may know that math is important for their young child, but they lack an understanding of what their expectations for their current math performance should be. When thinking about the future, however, they are aware of the skills that guide their math success and are more confident in their child's ability then. A third possibility is that parents are evaluating children of all ages by the same math standards. They may believe that math is a fixed set of skills that children become more proficient in with age. It could be the case that parents see that their young children are not able to solve more advanced math problems and thus underestimate their current math ability.

Limitations

This study was collected online, and the data consisted of parents' self-report of their math ability, attitudes, and engagement. While these reports related to each other in the expected direction, it is important to replicate these results with more direct measures of their actual math engagement. Furthermore, this study did not consider measures of their child's actual math outcomes. It is unclear how these attitude profiles relate to children's math attitudes and ability. An important future direction is to replicate these findings with an in-person study of parent and child math outcomes.

Conclusions

Taken together, findings from Study 2 suggest parents' attitudes about their child's math learning change with their child's schooling experience. In particular, parents tend to have higher expectations and values for their child's future math success and this difference is strongest for parents of young children who are not yet attending school. The following chapter will focus on how these parent math attitudes relate to the quantity and quality of parents' math engagement.

4. CHAPTER FOUR Study 3: Parent math attitudes relate to quality of their math input

4.1 Introduction

Children's math learning is not limited to formal academic contexts. Math engagement in the home is related to children's math skills. These experiences include exposure to math-related activities (e.g. LeFevre et al., 2009; Napoli & Purpura, 2018; Ramani et al., 2015; Skwarchuk et al., 2014) as well as the amount and of math related language input children hear from their parents (e.g., Levine et al., 2010; Gunderson & Levine, 2011). The way parents talk about math with their children during everyday interactions supports their math learning.

Naturalistic observations of parent-child interactions suggest that the amount of math related language input children hear from their parents is predictive of their math knowledge and lays the foundation for the development of later math achievement. One longitudinal study explored how differences in the amount of number talk children heard from their parents related to their subsequent math knowledge (Levine et al., 2010). This study found substantial variation in the amount of number related language children heard from their parents between 14 and 30 months of age. Furthermore, this variation predicted children's understanding of cardinality at 46 months, even when controlling for socioeconomic status and other measures of parent and child talk. The foundational relationship between number talk and child achievement has also been found in older children. A study with kindergarteners found that the amount of informal number information children were exposed to at home was a significant predictor of their math knowledge (Benavides-Varela et al., 2016).

Certain contexts have been found to elicit more math input than others. A study with 4- and 5-year-olds and their parents randomly assigned families to three different activity contexts and found that formal learning contexts prompted more math talk than guided or unguided play

(Eason & Ramani, 2020). Another study observed parents' interactions with their preschoolers during three different activities and found that parents' math talk corresponded to the specific numerical content embedded in the activity (Daubert et al., 2018). In particular, parents engaged in more talk about counting and cardinality during shared book reading and more numeral identification while completing a puzzle and playing a board game with their child. Furthermore, parents' math talk is malleable and sensitive to prompts and scripting. A study with 2- to 5-year-olds and their parents found that families who shopped in a grocery store displaying signs that prompted math-related conversations engaged in higher levels of math talk compared to a control group with prompts for more general topics (Hanner et al., 2019). An intervention study with 2- to 4-year-olds and their parents found that families who read storybooks with embedded math language increased children's number knowledge after a four-week period compared to a control group (Gibson et al., 2020).

There is also evidence that different types of early parent math talk may be more or less supportive of children's math knowledge. A follow-up analysis on the longitudinal sample from Levine et al. (2010) found that parents' talk that involved counting or labeling visible and/or larger sets (i.e. 4-10) was more predictive of their later understanding of cardinality than talk involving rote counting and/or smaller number words (i.e. 1-3) (Gunderson & Levine 2011). A separate study also found that mother's labeling of sets during an observed interaction with their 3-year-old predicted children's preschool and 1st grade math knowledge, even when controlling for other potential confounds such as parents' education level (Casey et al., 2018). However, parent talk involving numeral identification or rote counting were not related to their child's future math achievement. The importance of large number words was also replicated in an older sample; parents' use of number words larger than 10 was predictive of their 5- to 6-year-old's math understanding (Elliott et al., 2017).

Recent studies have highlighted the importance of parents' math talk related to advanced number concepts during these naturalistic interactions. Advanced number concepts refer to specific skills that are support children's ability to solve number problems, such as magnitude comparison and operations (Geary, 2000). These concepts build on more foundational number concepts, such as counting, cardinality, and numeral identification (e.g., Geary et al., 2018). A study with parents of preschoolers classified parent math talk during an observed interaction as either foundational (e.g., counting and numeral identification) or advanced (e.g., cardinality, magnitude comparison; Ramani et al., 2015). Parents' use of advanced math talk predicted their children's advanced number skills, while their foundational talk did not. Another study suggests that the level of math input that is effective in promoting children's skills depends on the child's level of understanding (Gibson, Gunderson & Levine, 2020). That is, what is advanced and beneficial for one child may be basic for another.

4.1.1 Relation between Parent Math Attitudes and Parent Math Input

Recent work has considered how parents' math input may vary as a result of their math attitudes. On the one hand, parents' math anxiety is related to the frequency of their math talk; high math anxious parents engaged in less number talk with their 1- to 2-year-old than lower math anxious parents (Berkowitz et al., under revision). Yet, findings examining the relation of other parent math attitudes to their support of children's math learning is mixed. Parents' self-efficacy and the value they place on math related to their reported math activities with their preschooler (Missall et al., 2015). A separate study found that parents' beliefs about their own math ability, but not their belief about the importance of math, predicted their math talk (Elliott et al., 2017). Furthermore, another study found that neither parents' self-relevant nor their child-focused math attitudes related to their advanced number talk to 4-year-olds (Douglas et al., 2019). Overall, it seems the link between parent math attitudes and their math input may be nuanced and should be explored in future research.

4.1.2 The Present Study

The present study explores the relation between parents' expectations and values about their child's current and future math learning and the quality and quantity of their self-reported math input. This study revisits a sub-sample of parents with a child between 3- and 7-years of age who completed the Mechanical Turk survey in Study 2.

Each of the participating parents was asked to respond to a number of prompts that invite but do not demand talk about math by answering a number of questions probing how they would discuss these stimuli with their child. I hypothesize that parents with higher EV will be more likely to discuss math with their child during these hypothetical learning interactions.
I also hypothesize that parents with higher EV will me more likely to discuss advanced math concepts since this is the type of math input previous research has identified as supporting children's math knowledge. Thus, I expect that higher parent EV will relate to higher quantity and quality of the math they report they would share with their child, a proxy for their math input.

Finally, I hypothesize that there will be a stronger relation between the quantity and quality of parent math input with their current EV than their future EV since it is a more proximal indicator of how they are conceptualizing and supporting their young child's math learning. Future EV operationalizes how parents feel about their child's math potential, so it might not be as strongly related to the math input they report they would share during interactions with their child.

4.2 Method

Participants

50 parents (28 mothers, 22 fathers) participated in the study through Mechanical Turk. In order to be eligible for this study, parents needed to have participated in Study 2. I recruited the same participants because these parents already completed all math attitude measures. The final sample consisted of parents of 13 children who were not attending school yet, 10 preschoolers, 13 kindergarteners, 10 1^{st} graders, and 3 2^{nd} graders. Analysis will combine parents of 1^{st} and 2^{nd} graders when considering the child's grade level.

Procedure

Parents from Study 2 were invited to complete a follow up survey looking at how parents and children work through everyday activities together. On average, parents' responses were collected 4 months after completing Study 2.

Parents were shown a series of scenarios one at a time through a Qualtrics survey. Parents first saw the picture for 20 seconds before answering a series of questions (Table 14). The first four scenarios were meant to represent everyday activities, and included a produce stand, recipes, a weather report, and a train station scene a schedule (Figure 7). While the scenarios and prompts do not require the parents to focus on math, they afford the opportunity for rich math input. The math content in the scenarios is also adaptable to be appropriate for children in this broad age range. The order of the scenarios was counterbalanced across participants.

Table 14. Question Prompts of each Activity Scenario

1. What are some things you would talk about with your child?
2. What might your child notice when looking at this picture?
3. What are some questions you might ask your child?
4. What are some things your child could learn from this discussion?

Figure 7. Activity Scenarios

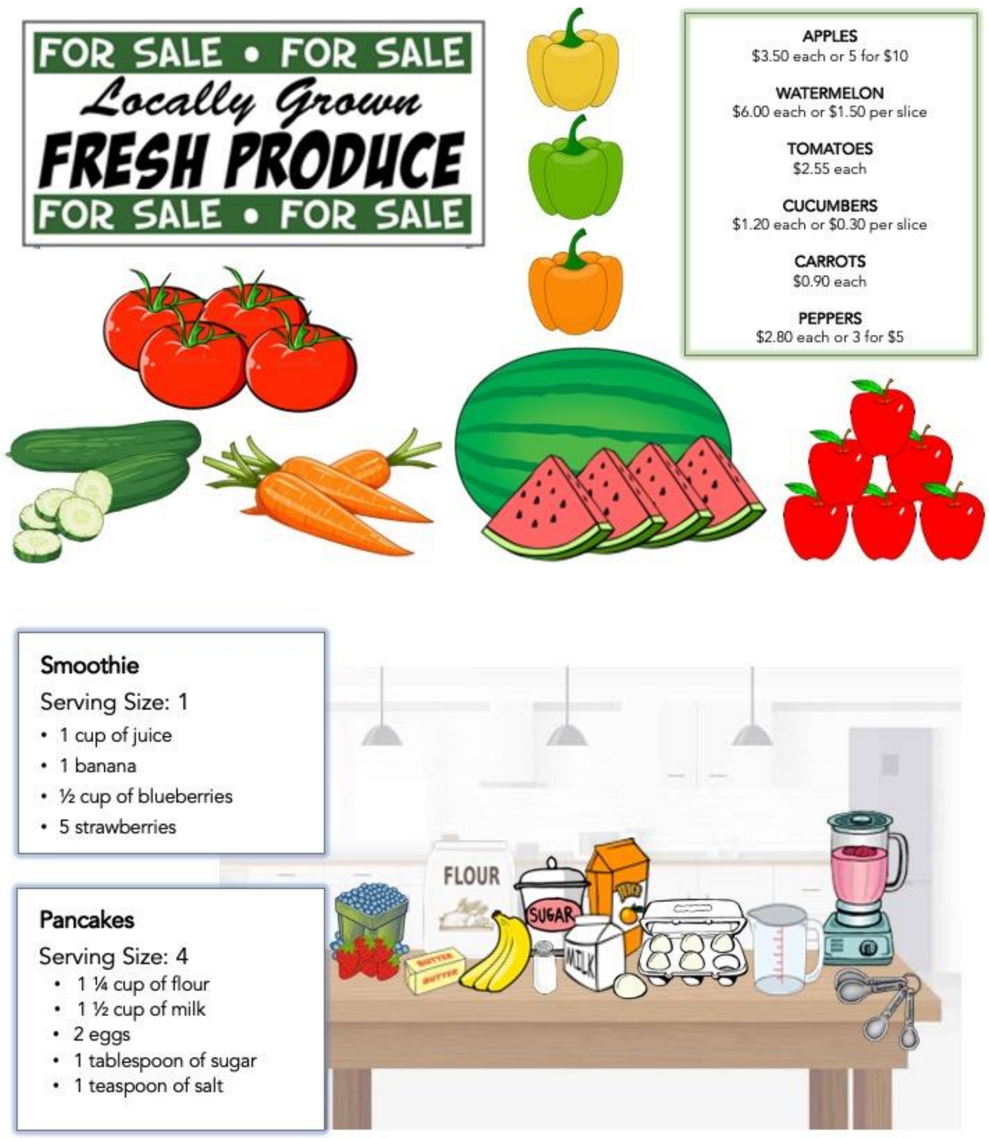
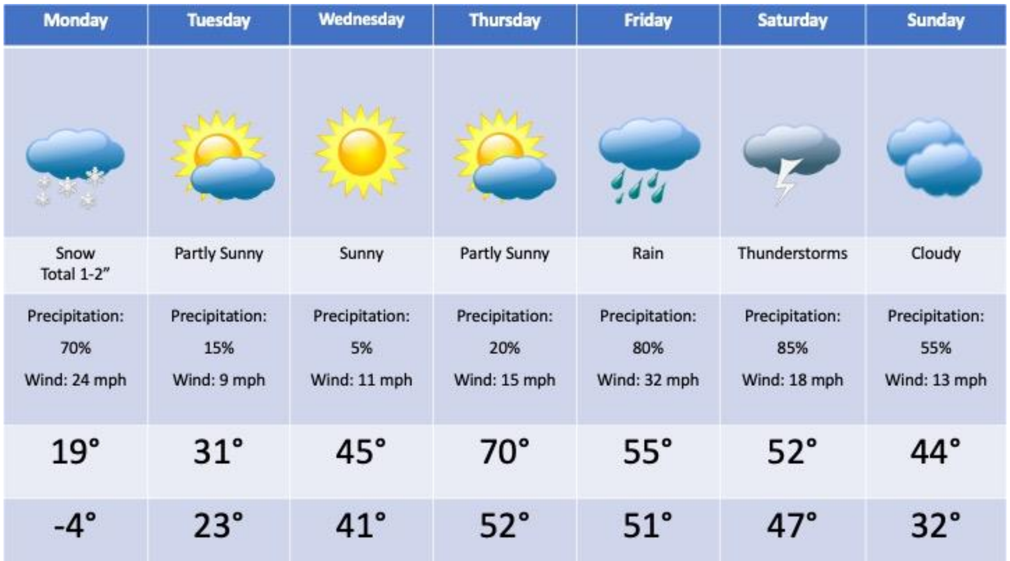


Figure 7. Activity Scenarios, continued



Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Snow Total 1-2"	Partly Sunny	Sunny	Partly Sunny	Rain	Thunderstorms	Cloudy
Precipitation: 70% Wind: 24 mph	Precipitation: 15% Wind: 9 mph	Precipitation: 5% Wind: 11 mph	Precipitation: 20% Wind: 15 mph	Precipitation: 80% Wind: 32 mph	Precipitation: 85% Wind: 18 mph	Precipitation: 55% Wind: 13 mph
19°	31°	45°	70°	55°	52°	44°
-4°	23°	41°	52°	51°	47°	32°

The last scenario parents responded to was a page from the Bedtime Math book (Figure 8). The page featured a fun passage about towns that are named after foods and included four math problems that parents could solve with their child. The problems were labeled for three general age groups (wee ones, little kids, big kids) plus a more difficult bonus question (Table 15). Unlike the other scenarios, which do not demand a math focus, the Bedtime Math prompt was included to probe how parents would talk with their child through an explicitly mathoriented task. After completing the same four questions used for the other scenarios, parents were then asked which of the math problems they would pick to work through with their child and why.

Figure 8. Bedtime Math Prompt[1]

[1] Page from Overdeck, L. (2015). *Bedtime Math: The Truth Comes Out*. Feiwel & Friends.

Table 15. Bedtime Math Problems

Wee ones: For breakfast you can choose to visit Bacon, Indiana; Buttermilk, Kansas; Hot Coffee, Mississippi; Ham Lake, Minnesota or Oatmeal, Texas – they're all real towns! How many towns is that, and which one would you visit?
Little kids: It's only 10:00 a.m. in Sandwich, Massachusetts and they always eat their sandwiches at noon, how much longer do they have to wait to eat?
Big kids: For dessert you can drive 1,100 miles from Chocolate Bayou, Texas to Pie Town, New Mexico, then another 800 miles to Sugar City, Idaho. How far do you drive in total?
Bonus: If half the 300 people in Two Egg, Florida eat 2 eggs each while half eat 4 apiece, how many do they eat in total?

Coding and Reliability

Parents' responses were coded for each question by two independent coders who were blind to the hypotheses of the study and the age of the child. The goal was to identify what type of concepts or skills the parent said they would highlight or teach their child during the hypothetical learning interaction. Parents' responses could receive multiple content codes if they introduced different topics. For example, a parent who wrote they would discuss "What time some of the trains are leaving, the numbers of the train tracks, and what is generally happening in the picture" would get credit for discussing numerals (math) and the setting (literacy). Coders scored the content of all 1000 responses (50 parents, 5 prompts, 4 questions) and agreed on 93% of the responses. All disagreements were resolved with a third coder.

Coding Scheme

Math. Table 15 summarizes the coding scheme for math content codes and provides example responses for each one. Parents' responses were coded for common categories identified in previous research (e.g., Ramani et al., 2015).

Table 16. Math Content Coding Scheme

Counting	Counting sets, cardinality, asking how many *"She would count the people in each family and talk about what they look like"* *"We'd count things like the number of apples or carrots we see"* *"How many eggs do you see?"*
Written Numerals	Identifying numerals. *"We would talk about the numbers of the train track".* *"My child would notice the numbers next to the ingredients and talk to me about them"*
Spatial & Relational Language	Relating to labeling or describing the attributes to shapes. Relational Language *"We would compare the shapes and sizes of the objects, like the eggs"*
Advanced Math	Operations, transforming numbers in some way (combining, separating), comparing quantities (more, or less) *"They can learn about adding and subtracting numbers. They will also learn how to add and subtract units of time"* *"Which day will have the highest temperature? which day will have the lowest temperature?"* *"I would ask if they would prefer to buy "single" items or "bulk" at a cheaper price"*
General Math	Any mention of math that is too vague to fit into the above categories. *"He would learn some math information"* *"We would talk about math"*

Literacy and General Domains. Parents also talked about a variety of topics that did not involve math. To capture this, the coding scheme also considers talk beyond the math domain including a variety of literacy topics, and talk about important domains including life skills, colors, and science (Table 17).

Table 17. Coding Scheme for Literacy and General Content

Literacy Domains Codes:

Vocabulary	Defining or elaborating on the meaning of a word. *"We would go over what the word produce means"*
Plot & setting	Discussing what is happening in the picture or where the scenario takes place *"I would ask him what he thinks is going on in the picture"* *"We would talk about the train coming to the station and the families who are waiting to get on the train so they could travel somewhere"*
Physical traits	Discussing physical traits of the items or characters in the picture *"They would look at all of the people waiting for the train. They would notice the skateboard for sure. They would also notice how happy the little girl is"*
Relating the prompt to the child's life	Prompting the child to think about how the scenario relates to their own life *"How would weather impact when he can go out to play or not"*

Table 17. Coding Scheme for Literacy and General Content, continued

General Domains:

Life Skills	General non-academic life skills, how we interact with others, societal constructs. *"I would ask him if he remembers how to crack the eggs against the counter and not the bowl rim"* *"Mainly how unsafe everyone is being who is standing past the yellow line in the photo and how we will not be doing that until the train is ready to board"* *"I'll talk about the diversity of the people in this image and how their backgrounds are different"*
Colors	Labeling or asking the child to recognize colors *"I would also ask my child the colors of the ingredients as well"* *"Do you know what color the sun is? Do you think you can identify the blue clouds?"*
Science	Discuss science-related topics *"Why the earth has different kinds of weather"*

Bedtime Math Problems. Parents' response to why they chose certain Bedtime Math problems to work on with their child was coded for whether they showed awareness of how the problem related to their child's current math ability. Table 18 summarizes and provides examples for the kinds of responses parents gave. Parents' responses sometimes touched on various reasons for sharing a problem with their child, but we coded their most advanced explanation because I was interested in whether they showed sensitivity to their child's math learning or not, which is captured by the two codes that fall in the Child Math Ability category (Table 18).

Table 18. Coding Scheme for Bedtime Math Prompt

General Child Characteristics	**Interest, enjoyment, engagement**	*"It's a fun question that doesn't sound like work, but it will allow her to use her imagination."* *"Because he would have fun with it."*
	Attention	*"She would be more attentive and engaged with this problem"*
	Child's age	*"This is the most age-appropriate question"* *"These questions are very challenging and quite the brain teaser for a 5-year-old"*
Child Math Ability	**Child's skillset, knowledge**	*"She will not be able to answer this independently yet so we can work through it"* *"I think she and I could figure this one out together if she couldn't with a pencil and paper. I also think she would feel a great sense of self reward if she did this one on her own too."*
	Presently learning	Parent shows awareness of what the child is currently learning in school and how the problem can help *"Because addition and subtraction are what they've been working on so he's ready for this problem."* *"It helps him with telling time, which he is working on in school."*

4.3 Results

Figure 9 shows the distribution of each parents' total mentions score, collapsed across all five scenarios and four question prompts. A parent who identified only one concept or skill they would talk about with their child for each question asked (5 prompts and 4 questions per prompt) would get a score of 20. Parents' total mention score ranged from 20 to 48, with an average of

31.94 (*SD* = 5.86). Thus, because parents were asked 20 questions, on average they mentioned 1.5 total topics per prompt (31.94/20).

Figure 9. Histogram of Parents' Total Mentions

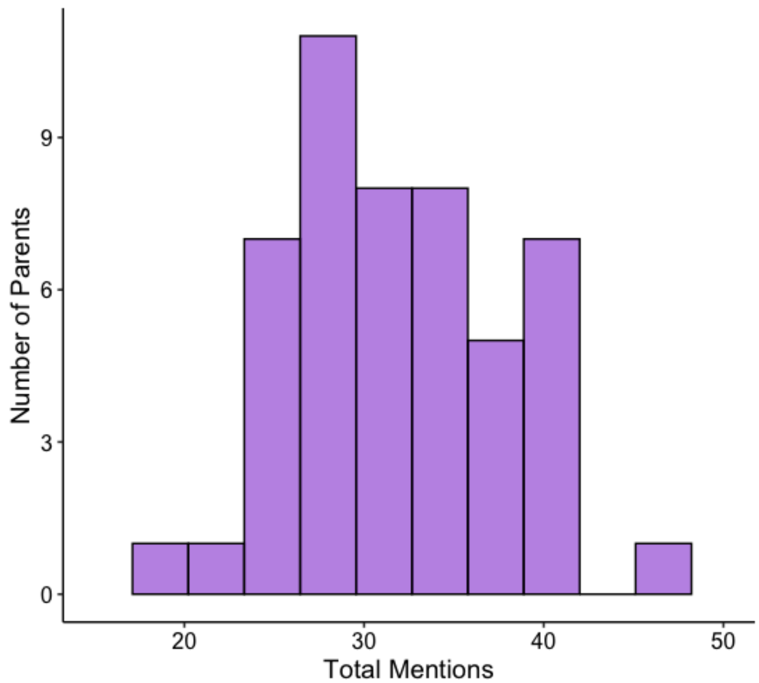


Figure 10 shows the distribution of parents' math mentions. Parents' math mentions ranged from 0 to 26, with an average of 7.47 (*SD* = 5.49). Thus, on average, parents mentioned .37 math topics per prompt (7.47/20).

Figure 10. Histogram of Parents' Total Math Mentions

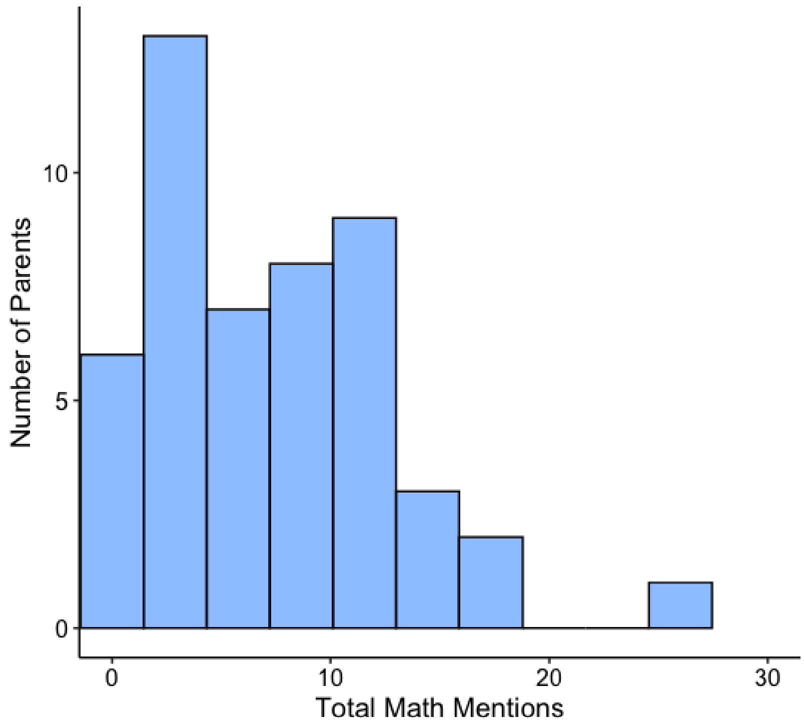


Table 19 summarizes parents' math mentions for each of the five scenarios. Parents were most likely to discuss math on the produce stand questions and least likely to discuss math on the recipe questions. However, parents self-reported math talk did not significantly differ based on the scenario they were responding to. Interestingly, I expected parents to engage in more math talk during the Bedtime Math prompt since it had an explicit math focus, but this was not the case.

Table 19. Descriptive Statistics of Parents' Math Mentions by Scenario

	Min	Max	Mean	SD
Train Station	0	7	1.84	1.87
Weather Report	0	4	1.43	1.31
Produce Stand	0	8	2.08	1.86
Recipe	0	4	0.86	1.19
Bedtime Math	0	4	1.27	1.30

Table 20 summarizes parents' math mentions based on the question they were responding to. Parents were more likely to bring up math learning moments when thinking about the questions they would ask their child and what their child could learn from the discussion. Yet, parents' responses to these questions did not statistically differ. Subsequent analyses will consider parents' total math mentions, collapsed across all questions and scenarios.

Table 20. Descriptive Statistics of Parents' Math Mentions by Prompt

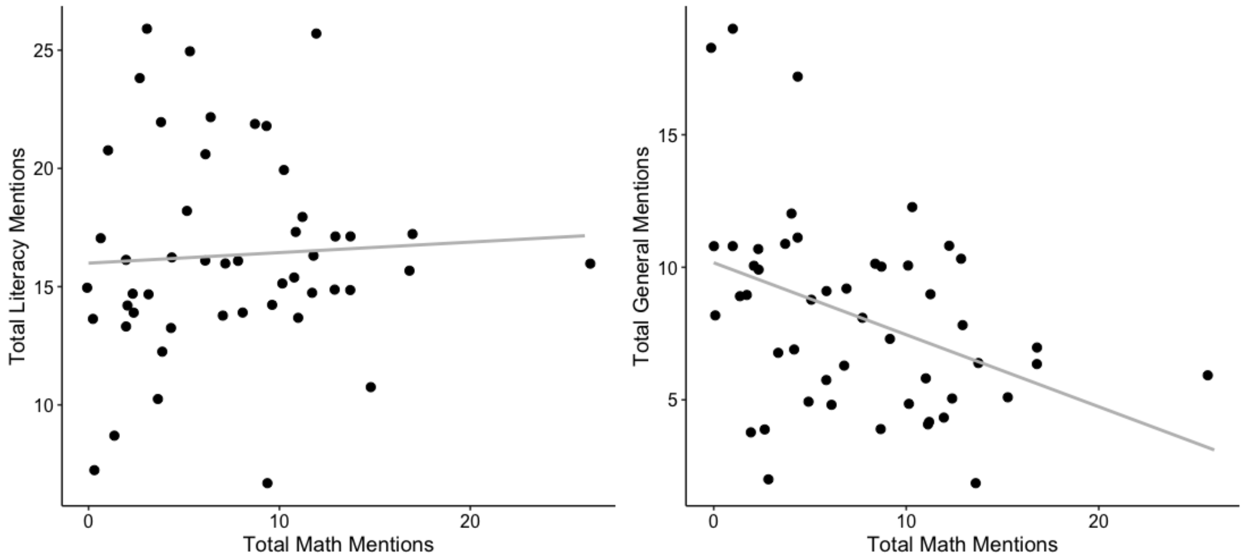
	Min	Max	Mean	SD
Talk	0	4	0.98	1.13
Notice	0	6	1.71	1.58
Questions	0	9	2.63	2.26
Learn	0	7	2.14	1.89

Comparing Parents' Math Mentions to Other Domains

Parents' literacy mentions ranged from 7 to 26, with an average of 16.33 (*SD* = 4.34). Parents general domain mentions ranged from 2 to 19, with an average of 8.14 (*SD* = 3.70). Notably, all parents mentioned at least one of these two domains once, which was not the case with math. In fact, parents discussed math related topics significantly less than literacy ($t(49) = -9.11$, $p < .001$). The difference between math and general domain mentions was not statistically significant ($t(49) = -0.61$, $p = .55$). Furthermore, parents had significantly more literacy mentions than general domain mentions ($t(49) = 8.10$, $p < .001$).

The number of parents' math mentions was not significantly related to the number of their literacy mentions ($r = .06$, $p = .70$; Figure 11). This suggests that parents' mention of math related topics did not take away from their literacy engagement. However, parents' math talk was negatively related to their general domain mentions ($r = -.40$, $p < .01$). The more parents talked about math the less likely they were to discuss general topics. There was a similar negative relation between literacy responses and this general domain responses ($r = -.46$, $p < .001$).

Figure 11. Relation between Math Mentions to Other Domains



Relation of Quantity of Parent Math Mentions to Parent Attitudes

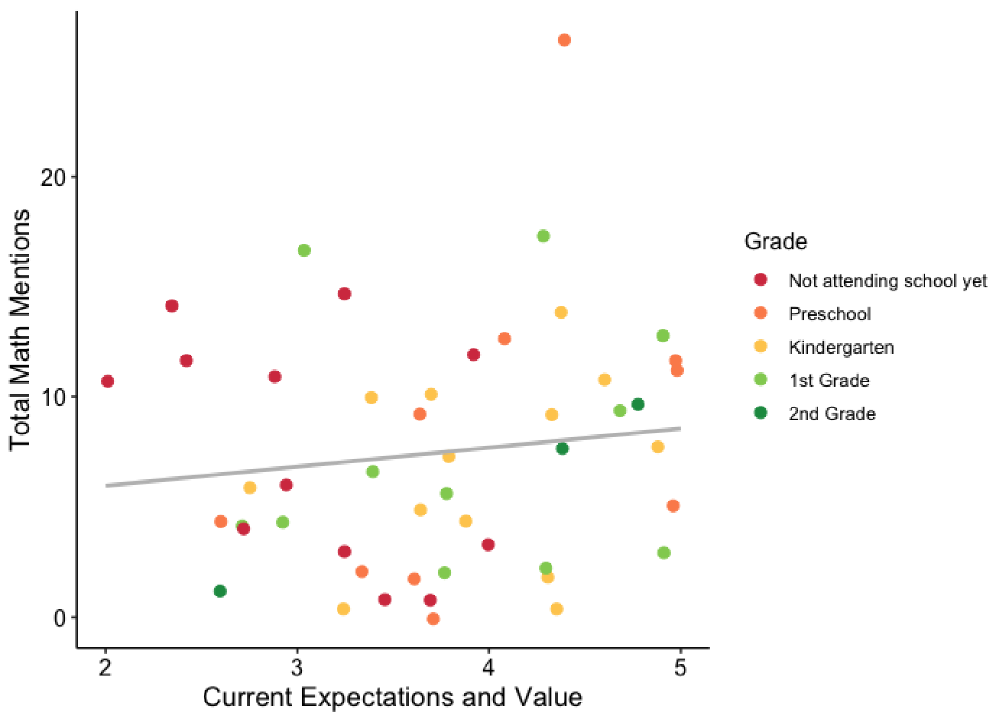
Table 21 reports the correlation between parents' number of math mentions number of and their math attitudes. Contrary to my expectations, the quantity of parents' self-reported math input was not significantly related to any of their math attitudes. In particular, there was no relation between parents' current or future EV and their total amount of math talk (Figure 12). There was a marginally significant relation between parents' ranking of the importance of math and their amount of math talk.

Table 21. Correlations between Quantity of Self-Reported Math Talk and Parent Attitudes

	Overall Math Talk
Child Grade Level	-.06
Math Ability	.08
Math Anxiety	-.2
Theory of Intelligence	-.12
Current EV	.13
Future EV	.10
Self-Efficacy for Teaching Math	-.05
Math Self-Concept	.16
Math Ranking	-.24[a]
Home Math Environment	.02

[a]p < .10; *p < .05; **p < .01

Figure 12. Relation between Math Input Quantity and Parent Current EV



Relation of Quality of Input to Parent Attitudes

Table 22 summarizes descriptive statistics for the different types of math input. Interestingly, the most pervasive kind of parent math response received a general math code; this is the type of talk that referred to math vaguely without identifying specific skills or concepts.

Table 22. Descriptive Statistics of Math Input Content

	Min	Max	Mean	SD
Counting	0	6	1.12	1.63
Numeral	0	6	1.33	1.56
Spatial	0	1	0.04	0.2
Advanced Math	0	9	1.18	1.82
General Math	0	11	3.79	2.69

Table 23 reports the correlations between the different types of parents' planned math input and their math attitudes.

Table 23. Correlation between Math Input Content and Parent Attitudes

	Grade	SNS	PMAF	TOI	Current EV	Future EV	SETM	MSC	LG	HME
Counting	-.21	.03	.01	-.09	-.04	-.04	.01	.12	-.08	-.30[a]
Numeral	-.06	-.04	-.34*	-.21	.11	.21	.18	.20	-.21	.02
Spatial	.07	.16	-.18	-.16	-.06	-.07	-.04	-.03	.19	.17
Advanced Math	.07	.21	-.13	-.13	.35*	.10	.07	.20	-.09	.20
General Math	-.05	.06	-.25[a]	-.17	.09	.12	-.03	.19	-.25[a]	-.08

[a]p < .10; *p < .05; **p < .01

In line with my hypothesis, parents' current EV was significantly related to their advanced math talk. Parents with higher expectations and values for their child's current math success were more likely to report that they would discuss advanced number topics with their child (Figure 13). This is the type of input that has been shown to support their math learning. Parents' current EV, however, was not related to the other types of math input. (Figure 14). Furthermore, this relationship did not hold when considering parents' expectations and values for their child's future math learning (Figure 15).

Figure 13. Relation between Advanced Math Input and Parent Current EV

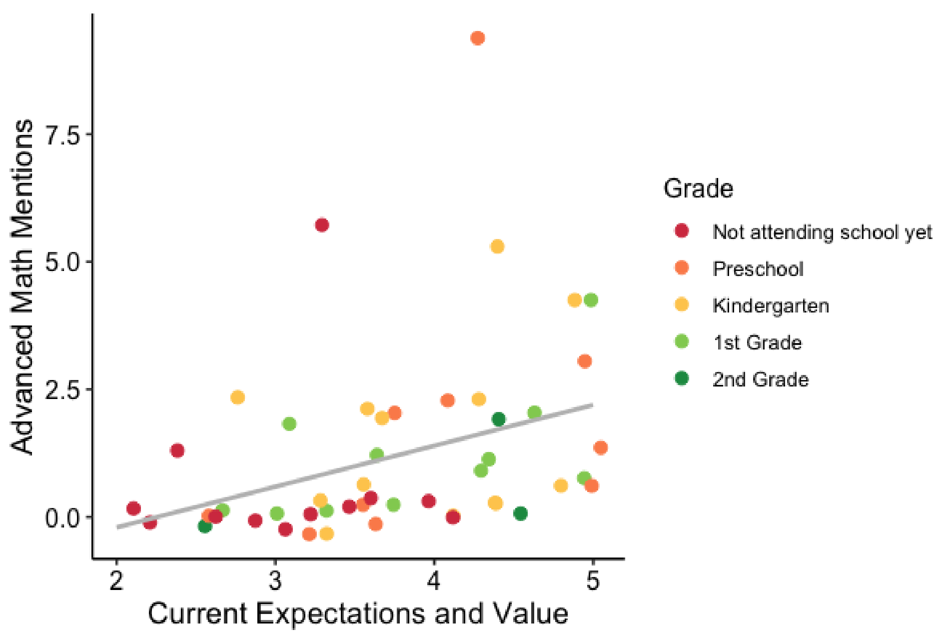


Figure 14. No Relation between Foundational and General Math Input and Parent Current EV

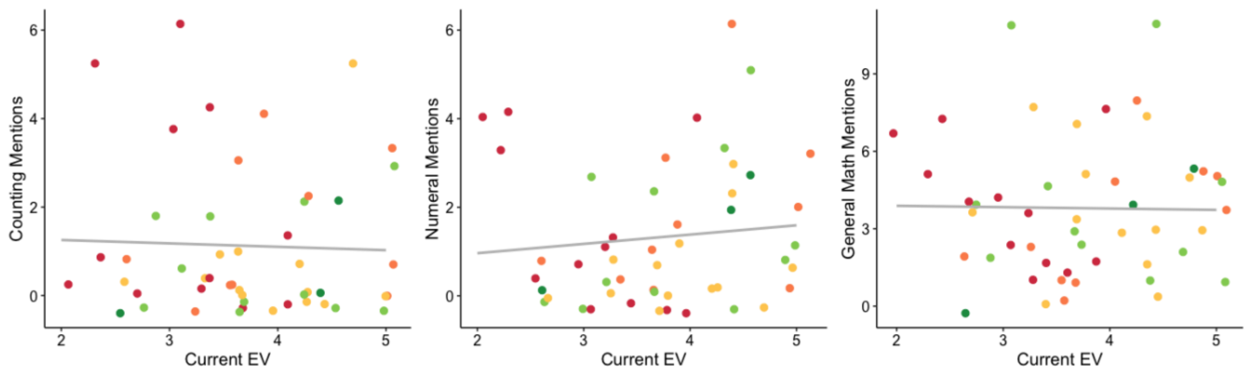
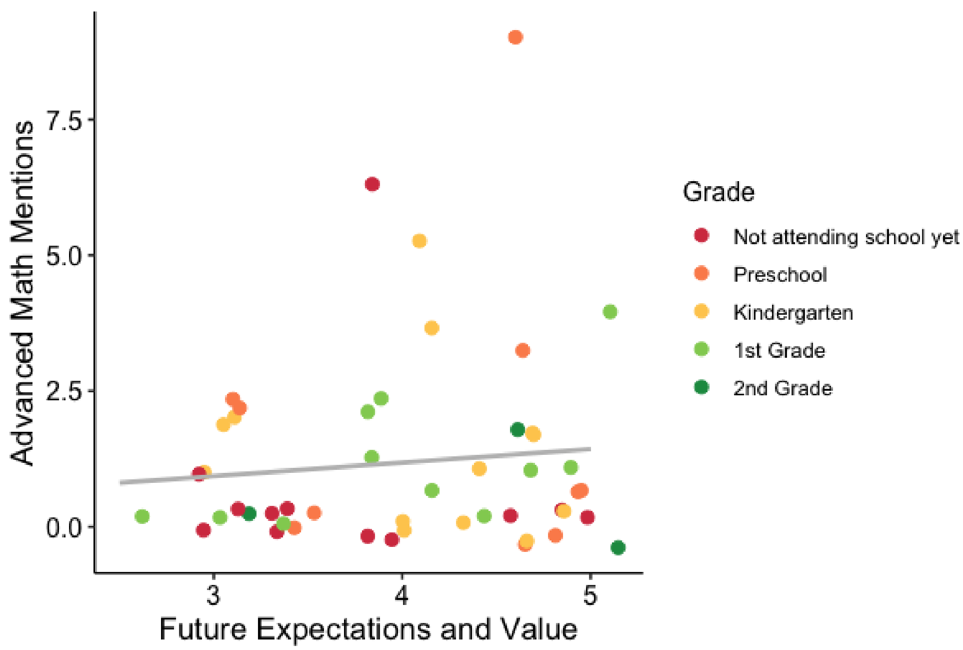


Figure 15. No Relation between Advanced Math Input and Parent Future EV



Parents' Bedtime Math Responses

Parents were categorized into two groups based on their explanation for why they would work through their choice of Bedtime Math Problem with their child; those who referenced their child’s math ability or learning (*N* = 33) and those who only referenced general child characteristics not specific to math (*N* = 17).

Parents in these two groups varied by one important math attitude – their current EV. Parents who referenced their child’s math skill in their response had significantly higher expectations and value for their child’s current math learning than parents who did not ($t(48) = -2.03$, $p = .05$; Figure 16). Parents in the two groups did not vary in terms of any of their other math attitudes, including future EV ($t(47) = -1.72$, $p = .10$). Furthermore, parents’ responses to the Bed time Math prompt was related to the quality of their input; parents who referenced their child’s current math skill were more likely to discuss advanced number concepts than parents who only mentioned general child characteristics ($t(48) = -1.8$, $p = .05$; Figure 17)

Figure 16. Parents’ Current EV by Bedtime Math Problem Response

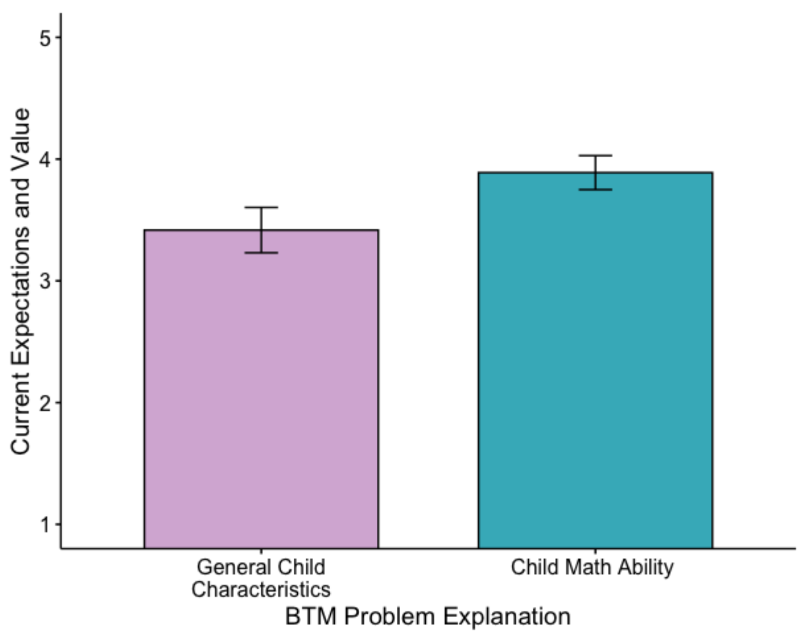
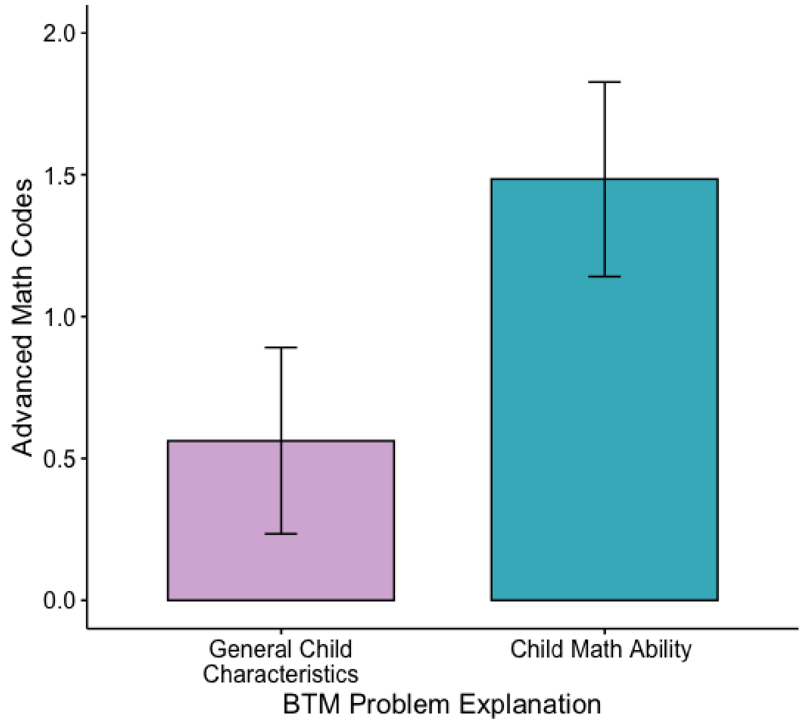


Figure 17. Parents' Advanced Math Input by Bedtime Math Problem Response



4.4 Discussion

The goal of Study 3 was to explore how parents' child-focused math attitudes related to the quantity and quality of their math input. In particular, I was interested in how parent math input related to parents' expectations and values for their current child's math learning. I hypothesized that parent current EV would have a stronger relation to the quality and quantity of their math input compared to their other math attitudes.

Contrary to my expectations, the quantity of parents' self-reported math input did not relate to any of their math attitudes. However, the quality of their self-reported math input was positively related to their current EV but not any of the other math attitudes. Parents with higher expectations and value for their child's current math success were more likely to introduce advanced number concepts during these hypothetical learning interactions and to discuss the child’s skill when choosing which math problems to work through with them. Moreover, mentions of advanced topics on the open-ended probes was related to mentions of child’s skill level on the Bedtime Math Problem question about why particular problems were chosen.

It is important to note that this study is not measuring parents’ actual math talk bur rather their reports of what they would discuss with their child. While this measure might not be as valid as their talk from an actual parent-child interaction, it gives us valuable insight into what parents value and think is important to discuss with their child. If a parent does not bring up math talk during a conversation it could be due to two reasons. On the one hand, the parent might not value math or would rather not discuss it with their child. On the other hand, the parent could value math but be directed away from math by their child’s involvement in the conversation. Given that these responses relate to parent current EV for math in the expected directions, these prompts may be a new tool to measure what types of input parent value while controlling for the child-directed factors of an interaction.

An open question from Study 2 was whether the difference in current and future EV was due to the fact that parents lack knowledge about children’s early math development and are not aware of the math content that is age-appropriate to their child. While this study did not address this question directly, parents’ responses provide information about how they are conceptualizing what math is for their young child (Table 24).

Table 24. Sample Parent Math Responses

1. *“It's too early in his education for math, so I would focus on other things like counting. Which group has the most, least, etc.”* (Preschooler)
2. *“I would ask her how many of each item there are. I wouldn't bother asking about the math, as that would frustrate her too much”*. (1st Grader)
3. *“I'm not the best at math, but we would talk about it together.”* (Kindergartener)

Interestingly, the first two parents explicitly mention not wanting to engage in math but discussed examples of math content anyways. In particular, they mention that math may be too hard or advanced for their young child. This highlights the fact that parents may not be aware that counting is an important math skill they should focus on and reinforce with their child during these everyday learning interactions. One important future direction is to design interventions that help parents understand what age-appropriate math is for a young child and how they can support their math learning. These responses suggest parents are already engaging in math talk, yet it is important for them to realize the foundational role they play in their child's math learning and how they can best support them.

On a positive note, the last parent mentions how they have negative feelings about their own math ability but want to make sure they still provide fruitful learning moments for their child. This supports findings from a study by Elliott and colleagues (2020) that found that some high math anxious parents reported intentionally engaging in more frequent math activities with their young children in order to disrupt the transmission of negative math attitudes.

Limitations

This study collected parents' self-reported math input in an online study. The survey questions may not have been specific enough to prompt how they would actually interact with their child. Just because a parent says that they would like to highlight operations or magnitude comparison does not mean they would engage in a beneficial learning interaction that would promote their child's math learning. While the quality of parents' math responses to our probes were related to their attitudes in the expected direction, in particular showing significant relations to parents' EV for their child's current math learning, it is important to explore how these responses relate to their observed math behavior when interacting with their child. An important future direction is to replicate these findings with a larger in-person of parent and child interactions.

Conclusions

Taken together, findings from Study 3 suggest that parents' child-focused math attitudes relate to the quality, but not the quantity, of their math input. In other words, parents' expectations and values for their child's current math ability do not relate to whether they are engaging in general math talk, but rather to their discussion of more advanced math topics and to their sensitivity to children's learning levels. Importantly, these kinds of inputs and sensitivity to child level have been shown to be related to children's math outcomes.

5. CHAPTER FIVE: General Discussion

Parent-child interactions around math during the preschool and early elementary school years are a critical predictor of children's math attitudes and math achievement. Yet many parents do not know they play an important role in children's math development, and even if they do, struggle to understand how to support their children's enjoyment and learning of math. Moreover, their own positive or negative attitudes about math may be related to their math engagement with their children.

Previous work has found that parent math attitudes influence their child's math outcomes as early as 1st grade (e.g., Berkowitz et al., 2015; Schaeffer et al., 2018). However, the developmental trajectory of this relationship is an open question. Although it is assumed that this relationship between parent attitudes and children's math outcomes emerges early, it is important to understand how it plays out as children transition to formal school. From the child's perspective, this period is critical because it marks a shift from learning mainly through their interactions with parents in thee home to also being influenced by the classroom environment. This time is also formative for parents since they begin to receive objective evaluations of their child's math performance from their teachers.

The overarching goal of this dissertation was to explore how parents form their attitudes about their young children's math learning, and how these attitudes influence their math engagement and child's math outcomes. The studies addressed two research questions. First, what factors shape parent attitudes about their child's math learning? While previous work suggests that parents' self-relevant and child-focused math attitudes are related, it is unclear how parents form their expectations and value for their child's math learning. Second, how do parent attitudes about their child's math learning manifest when engaging in learning interactions with their child? Previous work assumes that parents' math attitudes affect their children's math outcomes because they affect the quantity and quality of their math input. Yet, previous findings on this relationship have been mixed, which suggest the link between parent math attitudes and input may be more nuanced.

The present set of studies found that parents' attitudes about their child's math learning during the early school years are more strongly related to their self-relevant math attitudes than to their child's actual math achievement. Parent attitudes about their child's math learning also change as their children have more schooling experience. Finally, their expectations and value for their child's math success relate to the type of math input they highlight during learning interactions. There was no relation between parent attitudes and their child's math outcomes in this sample. However, these results highlight potential mechanisms through which parents' math attitudes may influence their engagement with their children around math, which in turn, are likely to relate to children's math outcomes. In this chapter, I summarize the findings of Studies 1-3, outline questions for future research, and discuss the theoretical and practical implications of this work.

5.1. Summary of Results

Studies 1 and 2 addressed the first research question – what factors shape parents' expectations and value about their child's math success? Study 1 also asked if child outcomes are related to their parent's math attitudes during the preschool and kindergarten years. Findings from Study 1 indicate that parent EV is more closely related to their own math attitudes than their child's math achievement. In particular, parents' self-efficacy for teaching and supporting their child's math learning was the strongest predictor of their EV. The influence of parents' self-efficacy on their EV seems to be domain specific, since the relationship holds even when controlling for their self-efficacy in supporting their child's reading. Furthermore, children's math achievement was not related to either their own attitudes or their parents' attitudes about math, including parent EV, at these ages. Previous work has suggested that the relationship between parent EV and child outcomes is evident by the end of 1st grade (e.g., Schaeffer et al., 2018), yet our sample of 1st graders showed no evidence of this relationship at the beginning of the school year. While these results could be due to a lack of statistical power, it could also be the case that the relationship between parent attitudes and child outcomes is not as strong at this stage. Taken together, the findings from Study 1 suggest that early elementary school is an important time to support parent EV about their child's math learning, before low EV begins to predict low child math outcomes.

Study 2 asked whether parents' expectations and values about their child's math learning shift depending on whether they are thinking about children's current or future math achievement and whether this variation related to children's schooling experience. This study considered parents of children who were between the ages of 3 and 7, with their grade level ranging from not attending school yet to 2nd grade. Parents of younger children reported having higher expectations and value for their child's future success compared to their present success in math. This difference in future and current EV for math was not as pronounced for parents of preschool-aged children attending school and older children. Furthermore, analyses predicting parents' current and future EV again showed that parents' future EV was mostly predicted by their self-efficacy for teaching math while their current EV was influenced by their self-efficacy for teaching math as well as by parents' own math ability. This discrepancy suggests that parents are mainly drawing on their own math abilities when considering how well their child is currently doing in math and how valuable math is to them.

Study 3 asked if parents' expectations and values for their children's current and future math success related to the quality and quantity of their self-reported math input. This study considered a representative sample of the parents from Study 2. Results suggest that neither parents' current nor future EV for their child's math achievement related to the quantity of their math input. However, parents' current EV for children's math achievement, but not their future EV, related to the quality of the math input they discussed in these hypothetical learning interactions. Parents with higher current EV were more likely to discuss advanced math concepts, such as operations or magnitude comparison. This is the type of input that has been shown to particularly support children's math learning at this age (e.g., Ramani et al., 2015). In addition, parents with higher current EV take their child's skill level into account when choosing which math activities to engage in with their child.

5.2 Limitations and Questions for Future Research

This dissertation is a starting point in understanding the formation of parents' child-focused math attitudes and how these attitudes relate to their math-related interactions with their children, which in turn may influence children's math achievement. The data collected for this dissertation consisted mostly of parents' self-report of their math attitudes, ability, and input collected at a single time point. In this section, I discuss some open questions that should be considered in future work.

One important open question is how parent math attitudes are expressed during parent-child interactions. Our findings indicate that parents with higher EV about young children's current math skills are more likely to think about engaging their children in advanced math topics and are more likely to take the child's level of math understanding into account when selecting problems for them to solve. However, it is important to replicate these findings on the relationship between parent attitudes and their math engagement with more direct measures of parent behavior. In particular, a future study should consider how parents' expectations sand value affects parents' math engagement.

Another important direction for future work is to explore these relationships with multiple time points during the school year. One reason why Study 1 may have not found a relationship between parent attitudes and child outcomes is that measures were collected during a single time point at the beginning of the school year. Previous work with this age range considered parent attitudes during the fall and children's math ability at the beginning and end of the school year in 1st graders (e.g., Berkowitz et al., 2015; Maloney et al., 2015). Given the hypothesis that schooling experience shifts parents' math attitudes, a future study should measure children's math achievement at multiple time points to explore the directionality of the relationship between parent attitudes and child outcomes and see how connections emerge during the school year in younger children.

5.3 Theoretical Implications

Measurement Development - Applying Teacher Literature to Parents

This dissertation included the development of two new scales to capture parents' attitudes about math that should be considered and validated in future work – the parent math anxiety scale for families and parents' teaching/supporting math learning self-efficacy. Both of these scales were adapted from measures that have been previously used with teachers to have a more to have a more valid representation of parent math attitudes during everyday learning contexts.

The standard measure of math anxiety for parents has been the Abbreviated Math Anxiety Scale (AMAS). This scale asks parents how they feel about their academic math experiences. However, this measure may not be sensitive to parents' math experiences outside of a formal academic setting. The Parent Math Anxiety Scale for Families describes scenarios that tap general situations involving math (e.g., "I feel self-conscious if I don't know how to solve a math problem right away") and situations that specifically tap parents' interactions with their children around math (e.g., "I would feel uncomfortable if my child asked me to explain why a math strategy works"). While these measures were highly related, the PMAF may be a more valid measure of their math attitudes during everyday interactions. In fact, the PMAF was significantly related to parents' self-efficacy for teaching math in Studies 1 and 2 whereas the AMAS was not.

The second new measure was parents' teaching/supporting math learning self-efficacy. The literature on parent math attitudes has no consistent measure of their self-efficacy. Some studies consider efficacy about one's own math ability (e.g., Cooper & Robinson, 1991; Meece et al., 1990) while others use a subset items from longer scales to measure their sense of efficacy in helping their children learn (Hoover-Dempsey et al., 2001, 2005). The measure used in this dissertation was adapted from the standard measure that has been used previously with teachers (Midgley et al., 2013; Tschannen-Moran & Hoy, 2001) . Findings from Study 1 and 2 highlight the importance of this attitude when considering the role parents' play in their child's math learning and the value they place on this success.

Teaching self-efficacy has been considered a self-relevant attitude in previous work. However, the factor analysis from Study 2 suggests this may be a child-focused attitude for parents. This discrepancy makes sense because teachers self-efficacy is based on their interactions with many students and thus be more tied to their own math ability and attitudes. On the other hand, parents are mainly supporting their own child's math learning so this attitude may be more tied to other child-focused attitudes for them. However, it is unclear how teaching self-efficacy is operationalized in a parent sample. Specifically, what behaviors are characteristic of a parent with high self-efficacy for teaching math when they interact with their child around math? Results from Study 3 suggest it is not related to the quantity and quality of their self-reported math input. Future work is needed to examine how this attitude forms in parents and how it affects their math engagement.

Furthermore, Study 3 designed a new method to measure parents' math input. Previous work on parents' math engagement has considered their reported frequency of math activities (e.g., LeFevre et al., 2009; Napoli & Purpura, 2018) or their math talk during an observed interaction (e.g., Levine et al., 2010; Ramini et al., 2015). This new measure might be an important tool for the field to examine what content parents value and want to highlight during their learning interactions with their child. In particualr, this measure allows us to meaure parents' hypothetical input without the influence of their child. It could be the that parents who value math may not get the chance to introduce math concepts during an observed interaction because their child may direct their attention to other topics. Thus, this measure may in fact give us a more accurate repressentation of the kinds of topics parents value and want to highlight to their child. However, it is important for future work to consider if parents' self-reported input aligns with their observed behavior during an interaction with their child.

Attitudes about the Present vs. Future

Previous measures of parents' expectations and values have considered the items about their child's current and future math ability as a single construct. However, results from Study 2 and Study 3 revealed important differences on parents' attitudes depending on whether they were considering their child's current or potential math success. In fact, only parents' current EV related to the quality of their math input, while their future EV did not. Parents current EV may be a more proximal indicator of how they are currently conceptualizing and supporting their young child's math learning. Thus, this might be more closely related to their current math engagement than how they think about their child's math potential. While this relationship needs to be validated with an in-person sample, it highlights an important new way to measure how parents are thinking about their math experiences.

Previous work did not find a relation between parents' math input and their child-focused math attitudes (Douglas et al., 2019; Elliott et al., 2017). It could be that this relationship would be detected in these studies if they had considered parents' attitudes about their child's current math achievement, rather than their general expectations and values about their child's math achievement, which include both present and future math achievement. Findings from this dissertation highlight the importance of breaking apart parent attitudes about the future vs. present because this difference can shed light on some mechanisms behind parent math engagement that are masked when they are considered together.

This nuance is an important distinction that should be considered in future work even beyond the domain of math learning More experimental work is needed to understand how parents are conceptualizing children's development when thinking about the present and the future, and the mechanism behind how these different attitudes are formed.

5.4 Broader Impacts

Understanding the relations of parent math attitudes to their math interactions with their child may inform the design designing interventions that support children's math learning. The results of these studies highlight potential mechanisms through which parents' math attitudes may influence their engagement with their children around math, which in turn, are likely to relate to children's math outcomes. In particular, two parent attitudes that should be the target of future math interventions are parents' expectations and value for their child's current math ability and their teaching self-efficacy for supporting their child's math learning.

A previous intervention study with parents of 1st graders found that introducing informal math activities through a math app increased the expectations and value of high math anxious parents (Berkowitz et al., 2015; Schaeffer et al., 2018). This finding suggest that parent EV is sensitive to interventions that target their math engagement. While the current studies focused on what factors contribute to parent EV, there was no evidence that this attitude impacted children's outcomes at this age. This suggests that a similar intervention for families in this age range may be particularly important because it may impact parents' math attitudes, and potentially the quality of their math interactions with their children, before they have an effect on their children's outcomes.

One hypothesis that emerged from the findings of Study 2 and 3 is that parents may not know what math content is age-appropriate for their young child. While parents may know that math is important, they may not know how to approach their child's math learning or what math content their children should be learning. Furthermore, it is possible that even when parents do engage in math activities with their child, they may be unaware of the connection between fundamental math skills and their future math learning. Another potentially powerful way to boost parents' expectations and values of early math learning and their self-efficacy for teaching math is to design an intervention that highlights the math content they can highlight during their daily interactions.

To recap, this dissertation shows that parents' expectations and values 1) are related to their own self-efficacy for teaching math rather than to their child's actual math achievement, 2) shift as children have schooling experience, 3) relate to the quality of their intended math input. Taken together, these studies highlight the importance of understanding how parents are thinking about their children's current math learning. In particular, the results suggest that parents' EV about their child's current math competence influences their math engagement, which in turn, may to relate to their child's math outcomes. The fact that parents are not considering their young child's math ability when forming their expectations and values for their math success suggests they may not understand early math development. Future intervention work should examine whether increasing parents' awareness about early math would increase their understanding of the important role they play in supporting their child's math learning as well as their support of their child's math learning.

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Appendix A: Measures of Parent Math Anxiety, Self-Efficacy for Teaching Math and Math Expectations and Value

Math Anxiety Scale for Families

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

	Not true of me at all	Generally not true of me	Somewhat true of me	Generally true of me	Very true of me
1. My palms start to sweat if I have to do a difficult math problem.	1	2	3	4	5
2. I would start to panic if I had to solve challenging math problems.	1	2	3	4	5
3. I get a sinking feeling when I think of trying to solve math problems	1	2	3	4	5
4. Feelings of anxiety interfere with my ability to start a challenging math problem.	1	2	3	4	5
5. My mind goes blank when I am about to start a challenging math problem.	1	2	3	4	5
6. I start to worry when I am given difficult math problems to solve.	1	2	3	4	5
7. I feel self-conscious if I don't know how to solve a math problem right away.	1	2	3	4	5
8. I get nervous when I think my math ability is being evaluated.	1	2	3	4	5
9. I would feel nervous if I had to figure out a math problem in front of other adults.	1	2	3	4	5
10. I would worry about making mistakes while solving math problems in front of my child.	1	2	3	4	5
11. I would feel uncomfortable if another adult was watching me help my child with math	1	2	3	4	5
12. When I am helping my child with math, I avoid going into depth about math concepts I don't feel comfortable with.	1	2	3	4	5

13. I would feel uncomfortable if my child asked me to explain why a math strategy works.	1	2	3	4	5
14. It makes me nervous to solve a math problem in front of my child if I haven't already figured out the solution.	1	2	3	4	5
15. I feel nervous when I have to change a recipe to make food for fewer or more people.	1	2	3	4	5
16. I feel nervous when I go to check whether I got the right change back after I buy something.	1	2	3	4	5

Teaching/Supporting Math Learning Self Efficacy

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

	None at All	A Little	A Fair Amount	Much	Very Much
4. How much can you do to motivate your child if he/she shows low interest in math?	1	2	3	4	5

Math Expectations and Values

Instructions: The following questions ask you to provide your opinion about your child's ability in math and reading. For each question, circle the number that corresponds to your answer. There are no right or wrong answers. We are simply interested in your own opinion.

	Not well at all	Not well	Moderate	Well	Very well
1. How is your child doing in math?	1	2	3	4	5
	None at all	A little	A fair amount	Much	Very much
2. How much natural talent does your child have in math?	1	2	3	4	5
	Not at all important	Slightly important	Moderately important	Important	Very important
3. How important do you think math is for your child?	1	2	3	4	5
	Not well at all	Not well	Moderate	Well	Very well
4. How well do you think your child will-do in math in the future?	1	2	3	4	5
	Not at all important	Slightly important	Moderately important	Important	Very important
5. How important do you think math will be for your child's future career?	1	2	3	4	5

Appendix B: Home Math Environment Questionnaire

How often do you expose your child to math through…

	Never	Once a Month	Less than once a week	Once a week	2-3 times a week	Every day	Multiple times a day
Storybooks that involve math	1	2	3	4	5	6	7
Workbooks that involve math	1	2	3	4	5	6	7
Educational television shows, videos, that involve math	1	2	3	4	5	6	7
Educational computer, video games or apps that involve math	1	2	3	4	5	6	7
Educational websites	1	2	3	4	5	6	7
Playing games	1	2	3	4	5	6	7
Blocks (such as Legos, Lincoln Logs, or constructions sets like Duplo or Megablocks)	1	2	3	4	5	6	7
Puzzles (such as picture puzzles, tangrams, slide puzzles, 3D puzzles)	1	2	3	4	5	6	7
Cooking	1	2	3	4	5	6	7
Household activities (such as cleaning up)	1	2	3	4	5	6	7
Shopping and money	1	2	3	4	5	6	7
Everyday activities that involve math	1	2	3	4	5	6	7