MATH ANXIETY AND ACHIEVEMENT: INVESTIGATING PARENT-CHILD RELATIONSHIPS IN THE MATH HOMEWORK-HELPING CONTEXT

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Preface

This dissertation emerges from extensive research and experience accumulated over several years in the areas of parent-child relationships and mathematical well-being. My interest in parent-child dynamics began when I started working at a children's summer camp after completing my first undergraduate Child Development course. Observing the interactions between children and their caregivers, I recognized the influence parents have on children's development. This prompted me to pursue further research in attachment theory during my undergraduate studies. During this time, I was introduced to Dr. Erin Maloney's research on math anxiety. My curiosity was piqued as I realized there was a term for an experience that had been a significant part of my life. As Dr. Maloney would say, this research turned into "me-search." I am grateful to Dr. Maloney for trusting me with the idea to merge my interests in parent-child relationships and math anxiety, and for encouraging me to explore this intersection.

At the inception of this dissertation project, the Ontario mathematics curriculum (Government of Ontario, 2005) organized math into five strands: Number Sense and Numeration, Measurement, Geometry and Spatial Sense, Patterning and Algebra, and Data Management and Probability. In 2020, the new curriculum was introduced (Government of Ontario, 2020), and places a stronger emphasis on fundamental math skills, ensuring students have a solid foundation in basic arithmetic, fractions, and decimals. It introduces coding and computational thinking, financial literacy, and social-emotional learning to prepare students for modern challenges and careers. Although the new curriculum maintains the strand structure of the 2005 curriculum, it integrates these new topics and provides clearer connections between different mathematical concepts.

I had the opportunity to use previously collected data from Dr. Gerardo Ramirez, which I replicated in 2019 with the assistance of Dr. Maloney, forming the basis of Study 1 in my dissertation. Elements of this research were published in the International Journal of Educational Research (2020) and presented at the Association for Psychological Research (2019). This study on the self-reported emotional experiences of parents during math homework-helping interactions informed the development of Studies 2 and 3, which were part of a larger-scale study I was involved with from its inception.

The onset of the COVID-19 pandemic disrupted in-person data collection and altered children's access to education. As a result, the data presented in Studies 2 and 3 were collected from late 2019 to early 2020, resulting in a smaller sample size than intended. The impacts of the COVID-19 pandemic on my research analyses are further discussed in Chapter 4 (Study 3). Despite these challenges, Studies 2 and 3 emphasize the importance of directly observing parent-child interactions to better understand the relations among math anxiety, math achievement, and dynamics during math homework-helping interactions, revealing emotional and relational contexts often overlooked in self-reported data. Elements from this research have been presented at the Association for Psychological Science (2021) and the Math Cognition and Learning Society (2023) and published in Education Sciences (2023).

Looking ahead, I hope that this research encourages future investigations to move beyond reliance on self-reported data and individual assessments by employing a multi-method approach, aiming for a more nuanced understanding of children's mathematical development and well-being. Furthermore, I aspire for this work to inspire future research to explore these topics through alternative theoretical frameworks, such as attachment theory, providing fresh perspectives on the dynamics of parents' involvement in children's education.

Abstract

This dissertation investigated the multifaceted dynamics of parent-child interactions during math homework help and their influence on children's achievement and anxiety towards math. Across three studies—using Social Learning Theory, Social Referencing Theory, and Attachment Theory as theoretical frameworks—the way in which both child and parent math anxiety relate to interactions during math homework-help, emotional experiences, math achievement, and the quality of parent-child attachment was explored. **Study 1** was conducted over two separate studies to explore the connection between parents' math anxiety and their perceptions of math homework-helping interactions. Surveys conducted with parents of children in grades 1 to 6 across North America (Study 1a [n = 192]: controlling for math knowledge; Study 1b [n = 214]: controlling for math knowledge and general anxiety) revealed that higher math anxiety was associated with an altogether more negative homework-helping experience from the parent's perspective (i.e., diminished confidence, increased conflict, stress, frustration, and emotional distance during math homework interactions). Building upon these results, **Study 2** used a multi-method approach to assess the quality of math homework-helping interactions, including observational coding methods. The study involved 40 Canadian parents and their children (ages 10-12 years; grades 5 to 7) engaging in a simulated math homework task. Results indicated that higher quality interactions correlate with task accuracy, and the variability in the quality of the interaction is linked to parents' and children's math achievement, as well as children's math anxiety. The linguistic analysis revealed a positive correlation between parents' and children's use of negative words during the interaction. Additionally, the variability in the frequency of positive words used by parents was associated with parents' math achievement and accuracy on the math task. Using the same sample as Study 2, **Study 3** extended beyond the

homework-helping context by investigating the relation between parent-child attachment, math homework-helping interactions, math achievement, and math anxiety. Attachment security and the quality of the simulated math task interaction were found to be marginally correlated, while attachment insecurity was found to be associated with lower quality interactions during the simulated math task, as well as increased math anxiety in children. Taken together, these studies provide valuable insights into the influence of parent-child interactions on children's mathematical well-being, substantiated by both self-reported data and observational methods. The findings from this dissertation underscore the importance of adopting a more holistic approach that integrates the quality of parent-child relationships with individual cognitive and emotional factors. This approach is essential for gaining a deeper understanding of children's experiences with mathematics.

Keywords: math anxiety, math achievement, homework, parental involvement, parent-child interactions, parent-child attachment, mathematical well-being

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CHAPTER 1: General Introduction

Introduction

It is important for future economic success that significant steps be taken to improve mathematical well-being within North America. Mathematics is integral to every aspect of daily life, including social, economic, cultural, and environmental, and it is an important entryway to fields relating to science, technology, engineering, and mathematics (STEM) (Roman, 2004). While mathematics is rooted in the study of number, quantity, and space, it also possesses a creative aspect that connects abstract ideas and fosters new ways of thinking (Government of Ontario, 2020). Students trained in STEM domains benefit society in many ways (e.g., generating medical breakthroughs and creating innovative technology). It has been argued that "investments in STEM literacy are crucial for developing a skilled society that is prepared to respond to an uncertain future" (Council of Canadian Academics, 2015, p. xiii). To achieve this, it is imperative to facilitate math learning and achievement effectively. Throughout the years, studies have identified several factors associated with low math achievement, including cognitive factors such as working memory (see Passolunghi et al., 2016; Peng et al., 2016; Raghubar et al., 2010), language (see Peng et al., 2020), and socio-emotional factors, including math anxiety (Maloney & Beilock, 2012), stereotype threat (Good et al., 2008), and math self-efficacy (Parker et al., 2014). Yet, Clarkson et al. (2010) argued that mathematical well-being includes more than cognitive functioning (i.e., the knowledge and skills required to do mathematics), but also incorporates affective (i.e., incorporating values in mathematics education) and emotional (i.e., feelings, responses, and reactions toward mathematics) domains. In addition to the factors inherent to the individual, researchers have begun to investigate various factors relating to parental involvement in children's education (for reviews, see Hill & Tyson, 2009; Hoover-

Dempsey et al., 2001; Patall et al., 2008; Walker et al., 2004), which may contribute to children's mathematical well-being.

Maloney and colleagues published a study in 2015 exploring the relation between parental math anxiety and its influence on their children's attitudes and performance in mathematics, particularly when parents are involved in their children's math homework. The researchers sought to understand the causes behind variations in math performance among students by investigating how parental math anxiety could potentially influence their children's experiences with the subject. While there is already established literature indicating a negative correlation between a person's math anxiety and math performance (for a review of the literature, see Dowker et al., 2016), what is less known is how one person's negative emotional reactions to mathematics may relate to the mathematics attitudes and performance of others. In their study, Maloney et al. (2015) found a significant association between parents experiencing math anxiety and their children exhibiting lower math proficiency and heightened anxiety towards mathematics, particularly when parental assistance in math homework was frequent. Poisall et al. (2023) attempted to replicate these findings using a larger and more diverse sample size and demonstrated that homework help was negatively associated to children's math outcomes regardless of the parents' math anxiety, prompting further inquiry into the underlying mechanisms driving these outcomes. Both the research by Maloney et al. (2015) and Poisall et al. (2023) rely solely on self-reported data, and it remains unclear how homework-helping behaviours play a role in children's mathematical development. These findings lay the groundwork for the present dissertation, which aims to investigate how parent-child interactions during math homework serve as an avenue for understanding children's mathematical well-being.

Specifically, the current dissertation seeks to address two significant gaps in current literature regarding parent-child interactions during math homework. First, it underscores the necessity of examining dyadic interactions within these contexts, rather than solely relying on individual reports. Second, it underscores the limitations of self-reported data in gauging the quality of parental involvement in math homework and its impact on children's learning and attitudes. Across three studies—using Social Learning Theory, Social Referencing Theory, and Attachment Theory as theoretical frameworks—I investigate how both child and parent math anxiety influence interactions during math homework-help, emotional experiences, math achievement, and the quality of parent-child attachment. To achieve this, a combination of survey data, standardized assessments, and observational methods was used. The remainder of this general introduction will explore the issue of mathematics and math anxiety, particularly in relation to achievement and social influences. It will then discuss homework and parental involvement during middle childhood, before examining parent-child relationship frameworks and outlining the specific studies conducted for the dissertation.

Math Anxiety

Math anxiety is commonly understood as the fear and apprehension felt by individuals when faced with a math-related situations (Ashcraft, 2002; Richardson & Suinn, 1972). Such situations can occur in the context of schooling (e.g., opening a math textbook or taking a math test), but they can also take place in everyday life, such as calculating a tip at a restaurant or balancing a check book. Math anxiety has been reported to begin as early as age 6 (Ramirez et al., 2013; Wu et al., 2012). Up to 27.4% of school-aged children reportedly experience math anxiety (Sorvo et al., 2017), and results from the Programme for International Students Assessment (PISA) indicate that the proportion of 15-year-old students that feel tense when

confronted with mathematics homework is increasing. Indeed, 38% of Canadian adolescents report feeling math-anxious during homework (OECD, 2013). For post-secondary students, the prevalence of math anxiety alarmingly increases to approximately 80% (Ginet et al., 2019).

Although a moderate correlation ($r = 0.35$) has been found between math anxiety and general anxiety (Hembree, 1990), math anxiety is not solely attributable to a propensity to be anxious in general. Various assessments of math anxiety tend to exhibit stronger correlations with each other ($r = 0.5–0.8$) than with test anxiety or general anxiety (Dew et al., 1984; Hembree, 1990; review by Ashcraft & Ridley, 2005). Moreover, mathematics typically provokes increased emotional responses, particularly anxiety, compared to other subjects (Punaro & Reeve, 2012).

Math Anxiety and Math Achievement

Research findings consistently indicate a negative relation between math anxiety and academic performance in both primary and secondary education settings. For instance, a 1990 meta-analysis including students from grades 5–12 revealed correlations ranging from $r = -0.18$ to $r = -0.47$ (Hembree, 1990). Similarly, a study conducted in the same year focusing on students in grades 7–9 reported correlations of $r = -0.20$ (Meece et al., 1990). A broader 1999 meta-analysis covering 26 studies across all secondary education grades found correlations between $r = -0.12$ and $r = -0.47$ (Ma & Xu, 2004). A more recent meta-analysis conducted by Barroso and colleagues (2021), which examined 747 effect sizes, identified a small-to-moderate correlation between math anxiety and math achievement ($r = -0.28$). The correlation was found to be stronger in middle school and high school. Furthermore, findings from international studies such as PISA, involving 15- to 16-year-olds, support these correlations, demonstrating a consistent

negative relationship between math anxiety and PISA math task achievement across various countries over multiple assessment periods (Lee, 2009; OECD, 2013).

In primary education, research outcomes echo those of secondary education, with similar negative correlations observed between math anxiety and academic performance, often measured through diverse metrics. A meta-analysis focusing on upper elementary education indicated correlations between various facets of math anxiety and performance ranging from $r = -0.19$ to $r = -0.49$, signifying shared variance between 3.61% and 24.01% (Ma & Xu, 2004). Moreover, the influence of math anxiety extends beyond the immediate academic year, influencing performance not only within the same grade but also in subsequent grades. For instance, math anxiety experienced in early grades, such as Grade 2, has been shown to affect math performance in subsequent academic years (Skaalvik, 2018). These findings underscore the significance of addressing math anxiety early on in education to mitigate its adverse effects on academic achievement.

While it is true that higher levels of math anxiety are correlated with poorer academic outcomes, it is worth noting that math anxiety is not a proxy for poor achievement (Hembree, 1990; Maloney & Beilock, 2012; Park et al., 2014). Indeed, the performance deficit associated with math anxiety seems to be specific to mathematical achievement (Ashcraft & Krause, 2007). More importantly, this quantitative deficit may actually be caused by the anxiety itself, wherein this apprehension towards mathematics would cause individuals to perform more poorly on math tasks than their abilities should warrant (Ashcraft & Faust, 1994; Faust et al., 1996). As such, children's math anxiety is an important factor that affects performance in mathematics and researchers have illustrated this association time and time again (see Ashcraft et al., 2007; Bekdemir, 2010; Betz, 1978; Hembree, 1990; Ma, 1999; Ma & Kishor, 1997; Richardson &

Suinn, 1972; Schenkel, 2009; Schreiber, 2002; Sparks, 2011; Woodard, 2004; Zakaria & Nordin, 2008).

Math Anxiety and Social Influences

The literature documents various factors that precede math anxiety, categorized into personal and environmental influences. Personal factors pertain to individual traits (e.g., prior knowledge, trait anxiety, or gender), while environmental factors encompass educational or cultural values, as well as the influence of significant individuals in one's life (Luttenberger et al., 2018). The latter may include individuals such as teachers, parents, and other adults who serve as role models and can shape children's attitudes toward mathematics.

Higher math-anxious teachers may (likely unintentionally) create more stressful and less successful math-learning environments for their students, which hinders their math learning and attitudes towards math. Beilock and colleagues (2010) demonstrated that elementary teachers who report being math anxious have students who learn less math and who are more likely to endorse negative stereotypes about mathematics by the end of the school year, even after controlling for the teachers' math content knowledge. The negative relation between teachers' math anxiety and their students' math achievement is not limited to the early years of formal schooling. A similar pattern of results has also been documented among ninth-grade students and their teachers (Ramirez et al., 2018). Though it is not yet clear why higher math anxiety in teachers is linked to lower math achievement among their students, it has been argued that math anxious teachers may be modelling a fear around mathematics, which harms learning (Beilock et al., 2010; Stoehr, 2017). In Gresham (2008), one math anxious teacher reflects that:

> One day I was teaching a concept and literally cried in front of my kids because I didn't get it either … I know that seeing their teacher get frustrated with the math left a long-lasting if not lifelong impression on them. (p. 97)

It has also been suggested that math anxious teachers tend to respond angrily when students request help with mathematics (Cornell, 1999; Fiore, 1999; Jackson & Leffingwell, 1999), and that they teach mathematics in a very inflexible manner that favours traditional and rigid forms of instruction (Markovits, 2011), overemphasize rote learning (Trujillo & Hadfield, 1999; Vinson, 2001), and spend less time attending to students' questions (Bush, 1989) relative to teachers with lower levels of math anxiety.

Parents also influence their children's mathematical well-being. Despite the common (mis)perception that children's math learning remains within the walls of the classroom (see Cannon & Ginsburg, 2008), research highlights the damaging impact that parents' math anxiety can have on their children's math learning and math attitudes. For example, Dahmer (2001) demonstrated that parental math anxiety is inversely related to children's achievement in mathematics. Similarly, Maloney et al. (2015) noted that when parents are high in math anxiety, and they frequently help their children with their math homework, their children learn less math over the course of the school year and develop increased math anxiety themselves. Casad et al. (2015) demonstrated a moderate correlation between parent math anxiety and child math anxiety ($r = 0.5$). In their study, Soni and Kumari (2017) found that parental math anxiety and child math anxiety shared approximately 82% of variance, and that parental math anxiety negatively influenced their child's math attitude. On the other hand, when parents themselves had a positive attitude towards math, their children tend to also have a positive outlook and this positive attitude

indirectly enhances their academic achievement and reduces their math anxiety (Soni & Kumari, 2017).

Therefore, while parental involvement can be beneficial, that is not always the case. These findings, that parents' math anxiety can negatively impact students' mathematical well-being, highlights the need to scaffold the emotional experience of higher math-anxious parents surrounding math homework so that their homework help can prove beneficial. Before designing the necessary tools to help these parents, however, a deeper understanding of the behaviour that occurs during the math homework-helping interaction is required. The focus on examining parents' involvement rather than teachers in the current dissertation is driven by the multifaceted role parents play in their children's education. Parents provide direct assistance during homework, which can significantly influence children's understanding and attitudes towards math. Moreover, the primary attachment relationship between parents and children adds a layer of emotional support and trust that is crucial for children's learning experiences. This dual role of parents—both as homework helpers and primary attachment figures—makes their involvement particularly impactful on children's math anxiety and overall academic development. I will first review the role of homework and parental involvement, and subsequently, I will explain relational theories to further contextualize the importance of examining parental influences.

Homework

When considering the value of traditional homework assignment (i.e., in paper and often from textbooks), there are mixed results. 'Homework' can be defined as "tasks assigned to students by schoolteachers that are meant to be carried out during non-school hours" (Cooper, 1989, p. 7) and it is intended to enhance learning (Bembenutty, 2011). In their meta-analysis, Cooper et al. (2006) found that, overall, homework has positive effects on academic

achievement. In addition to supporting academic learning, homework promotes higher self-efficacy beliefs, self-regulatory skills, engagement in school, and conscientiousness among students (Buijs & Admiraal, 2013; Cooper et al., 2012; Galloway et al., 2013; Göllner et al., 2017). Students who regularly complete their homework and have positive attitudes towards homework tend to have higher academic achievement (Chang et al., 2014; Fan et al., 2017; Fernández-Alonso et al., 2017). In terms of mathematics, when compared with other subjects, the assignment of math homework has been shown to significantly increase students' corresponding test scores (Eren & Henderson, 2011).

In contrast, negative effects may arise when certain characteristics (e.g., the amount of homework, the difficulty level, and the instructional purpose) of homework are not well balanced (Magalhães et al., 2020). Such negative consequences include procrastination behaviours, negative emotions, physical fatigue, as well as pressure to complete homework, which may lead to copying among students (Dettmers et al., 2011; Fulano et al., 2018; Galloway et al., 2013; Trautwein et al., 2009). Homework may also create conflict between parent-child dyads. For example, parents may place too much pressure on their children to complete their homework or confuse them when they are trying to help (Cooper et al., 2006).

Parental Involvement in Homework During Middle Childhood

Parents' involvement in their children's homework has gained attention among researchers seeking to better understand the ways in which student learning and achievement can benefit from parental homework help (Gonida & Cortina, 2014). The middle childhood age range (7-12 years of age) represents a critical period for the development of academic skills that warrants additional empirical focus (Doctoroff & Arnold, 2017). Moreover, the middle childhood range is a period when children spend more time on homework compared to younger years (i.e.,

40.4 to 53.6 minutes per day) and still rely on their parents for homework assistance (Cameron & Bartel, 2008).

Homework help is especially important during the middle childhood age given that this is a period in students' development that they are less able to self-regulate their learning (e.g., study habits; Dufresne & Kobasigawa, 1989; Zimmerman & Kitsantas, 2005; Zimmerman & Martinez-Pons, 1990). In a study surveying 29 countries, parents reported spending an average of 6.7 hours per week helping their children with their homework across all subjects, with Canadian parents helping their children an average of 4.1 hours (The Varkey Foundation, 2018). Effective parental involvement in homework incorporates modelling, reinforcement, and dialogue that encourages the development of positive attitudes, knowledge, and behaviours (Hoover-Dempsey & Sandler, 1995). Each of these factors is suggested to be associated with successful school performance in children.

The greatest factor associated to low academic achievement for most students is the *lack* of parental involvement in their child's schooling (Cotton & Wikelund, 2001; Simon, 2001; Van Voorhis, 2001). Yet, multiple researchers have revealed that, contrary to popular belief, parental homework-helping can sometimes be detrimental to children's learning and can contribute to poor academic outcomes (see Chen & Stevenson, 1989; Cooper et al., 2000; Epstein & Van Voorhis, 2001; Maloney et al., 2015; Wilder, 2014). For example, it has been demonstrated that certain parenting styles may contribute to negative influences on children's mathematics achievement, wherein children with uninvolved or authoritarian/intrusive parents would obtain lower math scores (Chao, 1994; Feldman & Wentzel, 1990; Leung et al., 1988; Schickedanz, 1995; Weiss & Schwarz, 1996). Moreover, researchers have found that while certain forms of parental involvement (e.g., participation in school events and discussion of school with children)

favour student academic achievement, an exception arises when parental involvement is defined as homework assistance (for a review, see Barger et al., 2019; Wilder, 2014).

Although several studies focus on parental homework involvement across subjects (e.g., Dumont et al., 2012; Trautwein & Lüdtke, 2009), the level of parental involvement in homework can differ based on the subject (Wilder, 2014). Given the widespread prevalence of math anxiety, which is linked to lower math performance, and the observed correlation between parental participation in math homework and diminished math achievement in children, further research into parental involvement in math homework is warranted.

The Role of Parent-Child Relationships: A Theoretical Framework to Study the Math Homework-Helping Environment and Related Factors

Parent-child relationships are central in theories of human development, and they are often considered the "engines of development" (Bronfenbrenner & Evans, 2000). Within the bioecological model proposed by Bronfenbrenner (1981), the microsystem is highlighted as the closest contextual layer, representing the immediate environments where children interact daily. These environments are characterized by interactions with significant socialization agents, such as parents (Kumalasari & Sugito, 2020). Therefore, parental involvement is recognized as a key mechanism shaping children's acquisition of culturally relevant skills, including their approach to learning (Rogoff, 2003). Additionally, previous research has identified two prominent theoretical for understanding anxiety development: attachment theory and social learning theory (Dadds & Barrett, 1996). Integrating these theories offers a comprehensive approach to conceptualizing child math anxiety and its impact on math achievement, and the math homework-helping environment serves as a pertinent context for exploring these relationships. To provide a theoretical foundation for Chapter 4 (Study 3), I will first briefly explain Attachment Theory.

Following this, I will review Social Learning Theory and Social Referencing Theory, which together frame the entire dissertation's exploration of parental influences. In Chapter 4 (Study 3), I will provide a more in-depth review of Attachment Theory.

Attachment Theory

The parent-child relationship is essential for the social and emotional development of children (Maccoby, 2007). As mentioned earlier, mathematical well-being includes more than cognitive factors, but also considers affective and emotional domains, including math anxiety. Although there is a slow emergence of studies aiming to understand the differences in math anxiety amongst children, there exists a more established area of research into the origins of broader anxiety-related issues (Murray et al., 2009). Many findings on the development of anxiety indicate that anxiety-related problems stem from ineffective coping mechanisms developed by certain children within the context of insecure attachment relationships (Brumariu & Kerns, 2010; Kerns & Brumariu, 2014; Vasey et al., 2014).

Bowlby's (1969/1982) attachment theory underscores the significance of relationships with primary attachment figures (e.g., parents). Secure attachment patterns, fostered by responsive caregivers, lead children to perceive themselves as competent and others as trustworthy. Conversely, insecure attachment patterns, resulting from insensitive caregivers, lead to perceptions of incompetence and distrust in others. These attachment patterns significantly influence children's anxiety, with securely attached children less prone to anxiety compared to those with insecure attachments (Bowlby, 1973; Kerns & Brumariu, 2014). Studies consistently link insecure attachment styles to anxiety disorders in children and adolescents (Brumariu & Kerns, 2013; Muris et al., 2000; Shamir-Essakow et al., 2005), which supported by meta-analytical evidence (Colonnesi et al., 2011).

Parents play a crucial role in influencing children's mathematics performance, interest, and anxiety (Chang & Beilock, 2016; Chiu & Xihua, 2008; Maloney et al., 2015). Recent studies have begun to explore how attachment to parents relates to math anxiety in children (Bosmans & De Smedt, 2015; Demirtaş & Uygun-Eryurt, 2020). Bosmans and De Smedt's (2015) study revealed a link between insecure attachment and math anxiety in Flemish children, where higher math anxiety was associated with insecure attachment, mediating the relationship between attachment and math achievement. Similarly, Demirtaş and Uygun-Eryurt (2020) found a negative correlation between secure attachment to parents and math anxiety in Turkish adolescents. Each of these studies comprise of self-reported measures to assess the quality of the attachment relationship, which is valuable for understanding individuals' perceptions and experiences. However, they may not always provide the most accurate or complete picture given that indirect measures of the attachment quality, such as self-reports are likely to be more biased than observations measures (see Risi et al., 2021). For example, an anxious parent may not perceive that their child is anxious towards them given that they have normalized these behaviours. Incorporating observational data alongside self-reports may enhance the depth of research findings. Moreover, given the evidence indicating that parental math anxiety is related to children's math anxiety (Casad et al., 2015; Maloney et al., 2015; Soni & Kumari, 2017), an important question remains regarding the way in which the attachment relationship relates to parental math anxiety, in addition to child factors (i.e., math anxiety and math achievement).

Social Learning Theory and Social Referencing

The parent-child relationship stands as a significant context for learning, with parents serving as influential role models (Bandura, 1997; Maccoby & Martin, 1983). Social learning theory suggests that individuals, particularly children, learn by observing the behaviours and the

consequences of those behaviours of influential role models, leading to imitation and modelling of observed actions (Bandura & Walters, 1977). Initially focused on children's aggression, this theory has since expanded to encompass various behaviours across disciplines like human development, psychology, criminology, and education. Applying this framework, parents can play a pivotal role in promoting their children's mathematical well-being by modelling effective math-related behaviours. This modelling extends to homework situations, where parents can demonstrate productive behaviours relating to their attitudes, knowledge, and skills, which children are likely to imitate (Hoover-Dempsey et al., 2001). Moreover, parents can significantly influence children's approaches to learning and attitudes toward homework by showcasing effective problem-solving strategies and enthusiasm.

Given the well-established phenomenon of children learning fear through observation of their parents' reactions, it is plausible to extend this principle to anxiety, including math anxiety. In addition to social learning theory, *social referencing* can provide further insights into the mechanisms through which parental math anxiety is transmitted to children. Although social referencing is often studied in infancy due to its early development, its relevance persists across the lifespan (see Walle et al., 2017). The theory of social referencing suggests that individuals depend on cues from trustworthy social partners (e.g., caregivers) to understand and react to their surroundings, aiding in behaviour regulation and comprehension of the environment (Feinman et al., 1992; Walle et al., 2017). This process involves observing how others react, such as facial expressions and gestures, and adjusting one’s own behaviour accordingly. In uncertain situations where familiarity is lacking, such as when faced with a challenging math problem, social referencing becomes particularly important. Furthermore, studies indicate that social referencing

is closely linked to attachment and co-regulation, as children seek comfort and closeness from social partners in uncertain situations (Ainsworth, 1992; Ehli et al., 2020).

Social referencing has been demonstrated to contribute to the transmission of anxiety from parents to children, as children often seek guidance from their parents in new or ambiguous situations, potentially worsening anxiety-related behaviours (Feinman & Lewis, 1983). Numerous studies have highlighted that children exhibit heightened fear responses when they observe their parents reacting negatively, nervously, or fearfully to specific stimuli (Askew & Field, 2007; de Rosnay et al., 2006; Dubi et al., 2008; Dunne & Askew, 2013; Gerull & Rapee, 2002; Marin et al., 2020). If a parent displays confidence and a positive attitude towards math, it stands to reason that the child may feel more encouraged and confident in their own abilities. Conversely, if the parent exhibits anxiety or frustration towards math, the child may adopt similar feelings. Indeed, Epstein and Van Voorhis (2001) argued that parents who are involved in homework have an opportunity to demonstrate their belief that schoolwork, homework, and learning are important and to show support for what their children are learning (Balli et al., 1998; Levin et al., 1997). Cooper et al. (1998) also found that parent involvement in the form of indicating positive attitudes about homework (e.g., praise) is related to the development of positive attitudes about homework and schoolwork for the student.

Areas for Growth in the Existing Research

Two major areas for growth informed the goals for the current dissertation. The first relates to the need for research to place a stronger emphasis on evaluating dyadic interactions within parent-child math homework interactions. Much of what is known about the homework-helping environment comes from survey and/or interview data in which parents or children are asked to report on how they feel about doing math homework (e.g., Bosmans & De Smedt, 2015;

Demirtaş & Uygun-Eryurt, 2020; Retanal et al., 2021; Silinskas & Kikas, 2019). It has been argued that evaluations of dyad-focused features, such as dyadic synchrony, coordination, and emotional reciprocity, provide more information about the quality of parent–child interactions than evaluations that are only centred on the parent or child alone (Dubois-Comtois et al., 2011). While studies examining the math homework-helping environment do acknowledge dyadic interactions, they predominantly focus on the scaffolding methods utilized by parents (e.g., Hyde et al., 2006; Missall et al., 2017; Zhou et al., 2006). These scaffolding techniques primarily involve pedagogical strategies, wherein more proficient partners (such as teachers or parents) offer tailored support corresponding to the child's performance level (Pea, 2004). Such scaffolding is pivotal for nurturing children's development and promoting their independent performance. However, these techniques often overlook the emotional context of the homework-helping interaction, which encompasses parents' sensitivity to their child's emotional needs, particularly in potentially stressful situations like math. Thus, the current dissertation uses dyadic assessments to comprehensively understand the emotional dynamics of parent-child math homework interactions as they relate to parent and child math factors.

Second, although important strides have been made to distinguish between the quality and quantity of parental involvement in homework (see Moroni et al., 2015), the over-reliance on self-reported data to understand parental involvement in math homework and its influence on children's learning and attitudes presents its limitations. Direct observations of parent-child interactions are vital for understanding the mechanisms involved in social interaction given that they provide insights into real processes and outcomes, including parenting approaches and child behaviour. Additionally, observational methods allow researchers to consistently operationalize behaviours, avoiding reliance on participant interpretations (Aspland & Gardner, 2003).

Despite providing insight into how parents and children perceive interactions, self-reports cannot directly observe the dynamics of math homework-helping interactions. This reliance on self-reports introduces biases, with parents often portraying involvement in a positive light compared to actual observations (Else-Quest et al., 2008; Moorman & Pomerantz, 2010). Zaslow and colleagues (2006) found that evaluating sensitivity through direct observations yields stronger predictions of child outcomes than sensitivity reported by parents.

Moreover, Hunt and Maloney (2022) provide evidence to suggest that variations in how adults appraise previous math experiences are related to math anxiety and attitudes. Specifically, they found negative associations between math anxiety and math attitudes (i.e., perceived mathematical incompetence, enjoyment of math, perceived utility of math, and math self-concept). These findings are consistent with previous findings math anxiety influences one's attitudes and beliefs towards math (Gierl & Bisanz, 1995; Haciomeroglu, 2017; Hembree, 1990). Taken together, it is conceivable that parents with higher levels of math anxiety may perceive math homework-helping interactions differently from the actual occurrences. This evidence strengthens the case for using a multi-method approach to assessing the math homework-helping interaction. In addition to self-reports, in the current dissertation, observations of parent–child dyads interacting are coded in a simulated math homework interaction to garner a richer understanding of the behaviour that occurs when parents and children work to solve math problems.

The Current Studies

The current dissertation's overarching objective is to explore the way in which parent-child interactions during math homework help, as well as the quality of the parent-child relationship, relate to children's math anxiety and math achievement.

Study 1 (see Chapter 2) served as a stepping stone to understand how parents perceive the interactions with their children when they help them with their math homework. In two separate studies (Study 1a [n = 192]: controlling for math knowledge; Study 1b [n = 214]: controlling for math knowledge and general anxiety), parents of school-age children (Grades 1 through 6) were surveyed to assess whether higher math anxiety in parents is related to the time they and their child spend on math homework, as well as to more negative emotions experienced by parents (i.e., lower confidence, and higher frustration, stress, conflict, and feelings of being distant to their child) during math homework help. These factors were investigated while controlling for parental math achievement, given that math ability and math anxiety are related (e.g., higher math-anxious individuals tend to have lower math ability; Hembree, 1990). This study provides insights into the factors contributing to parents' maladaptive behaviours during their math homework-helping interactions with their children, which may influence children's own approaches towards math.

Building upon the latter, Chapter 3 (Study 2) uses a multi-method approach to obtain a deeper understanding of the math homework-helping environment than what has to date been reported in the literature. Specifically, 40 parents and their children (ages 10-12 years; grades 5 to 7) completed self-report measures of math anxiety and general anxiety. Further, standardized assessments of parents' and children's math achievement were obtained. Parents and children were then recorded engaging in a simulated math homework interaction, which was coded by trained coders who assessed the quality of the interaction via parent-child behaviours and the language used (i.e., the frequency of negatively and positively valanced words used by parents and children). The assessment of dyadic behaviours and language provide insights into the

mechanisms behind which parental math anxiety may relate to child math anxiety and math achievement.

In Studies 1 and 2, it was investigated whether higher parental math anxiety leads to a more negative homework-helping interaction, which is associated with more negative child math factors (i.e., lower math achievement and higher math anxiety). In considering parent-child relationships, one cannot omit the role that attachment plays in a child's development. Children's ability to observe and emulate their parents may be influenced by their attachment bond. It is possible that insecurely attached children are less receptive to their parents as role models, even if they display positive behaviours, or they may replicate negative behaviours. Conversely, securely attached children may be more open to learning from their positive role models. In line with this, it is reasonable to speculate that a secure attachment in the parent-child relationship may favour the homework-helping interaction and, in turn, the child's math attitudes and learning, whereas insecurely attached children may develop maladaptive behaviours and attitudes surrounding math. As such, using the same sample as in Chapter 3 (Study 2), Chapter 4 (Study 3) investigates the quality of the attachment relationship within the parent-child dyad through a task distinct from the simulated math homework-helping interaction. This study aims to better understand how the quality of the attachment relationship relates to the quality of the interaction in the simulated math homework-helping task, as well as parents' and children's math anxiety and math achievement.

CHAPTER 2: Study 1

Exploring Math Anxious Parents' Emotional Experience Surrounding Math Homework-Help

Elements from this research were included the following published article:

DiStefano, M., O'Brien, B., Storozuk, A., Ramirez, G., & Maloney, E. A. (2020). Exploring math anxious parents' emotional experience surrounding math homework help. *International Journal of Educational Research, 99,* 101526. https://doi.org/10.1016/j.ijer.2019.101526

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Abstract

In two separate studies, we examined the relation between parents' math anxiety and their perceptions of their math homework-helping interactions with their children (Study 1a: controlling for math knowledge; Study 1b: controlling for math knowledge and general anxiety). Specifically, parents of children in grades 1 through 6 across North America were surveyed on the time they spend helping their child with their math homework and the level of confidence, conflict, stress, frustration, and emotionality that they feel during math homework interactions as a function of their math anxiety. As predicted, parents who were higher in math anxiety reported feeling their interactions surrounding math homework-help as altogether more negative (i.e., less confidence, more conflict, frustration, and stress, and feeling colder and more distant from their child) in both studies. Understanding this dynamic has important implications for educational practices, especially given the push for parents to be involved in their children's learning.

Keywords: mathematics anxiety, parental homework involvement, emotional experience

Exploring Math Anxious Parents' Emotional Experience Surrounding Math Homework-Help

The purpose of this study was to understand the factors contributing to maladaptive behaviours of parents during math homework interactions with their children. Given that the introduction (Chapter 1) provides a comprehensive review of the relevant literature, this section will offer only a brief overview. While the link between math anxiety and low math achievement at an individual level is well-documented (see Dowker et al., 2016), research on the intergenerational effects of math anxiety is limited. Maloney et al. (2015) explored this by examining how parents' math anxiety and the frequency of math homework help impact their children's math anxiety and achievement. They found that children receiving frequent homework help from highly math-anxious parents learned less math and developed math anxiety themselves. A similar relationship was observed by Soni and Kumari (2017).

Most initiatives aimed at improving math competence focus on updating curricula (Beilock & Maloney, 2015). However, success in mathematics involves more than just content knowledge; the attitudes towards math are also crucial. While research highlights the negative effects of math anxiety on math achievement and the likelihood of pursuing STEM fields (for a review, see Maloney & Beilock, 2012), the literature also emphasizes that role models, including parents, influence how students learn and approach math.

Parental involvement in homework has received attention for its potential benefits on student learning and achievement (Gonida & Cortina, 2014). Yet, recent findings suggest that parents' math anxiety can adversely affect their children's math learning and attitudes. This underscores the need to address the emotional experiences of math anxious parents to improve

their homework help. It remains unclear why help from math anxious parents is less effective compared to help from parents with lower math anxiety.

Existing scaffolding interventions indicate that there may be underlying dynamics in the parent-child interactions related to math that significantly influence children's anxiety and achievement in the subject. One promising approach is an educational intervention designed to foster positive math interactions between parents and children. In this intervention, short math story problems are provided through an iPad app, called Bedtime Math (Overdeck et al., 2021). Berkowitz et al. (2015) examined the effectiveness of this app and found that, when used even as little as once per week, children's math achievement increased by the end of the school year. Importantly, the magnitude of this effect was larger for those children with higher math-anxious parents. Yet, the mechanism through which parents' anxiety towards math is transmitted to their children remains unknown. The findings of Berkowitz et al. (2015) do support the notion that scaffolding parents' interaction around math, which can include homework helping, may serve as a way to boost children's math learning, particularly for the most vulnerable. One supposition as to why this intervention works is because it provides parents with a scripted way to talk about math with their children, which in turn provides a less stressful way to engage with math content. Furthermore, Social Learning Theory suggests that parents serve as models for their children, exhibiting attitudes and coping strategies for managing stress that children tend to imitate. Thus, interventions like Bedtime Math not only offer a structured approach for parents to engage with their children but also model effective coping mechanisms for dealing with math anxiety. By promoting a positive and stress-free environment for math learning, these interventions may help break the cycle of anxiety transmission from parents to children, ultimately fostering a healthier and more productive approach to mathematical education within the family dynamic.

Before investigating the factors influencing the pathway from parents' math anxiety to children's math anxiety, we wanted to better understand parents' perspectives on their emotional experiences that may hinder effective math homework assistance. This understanding would inform the rationale and design of Studies 2 and 3 of this dissertation.

Objectives and Hypotheses

In the present design, parents of first- through sixth-grade children were surveyed to assess whether higher math anxiety in parents is related to the time they and their child spend on math homework, as well as to more negative emotions experienced by parents (i.e., lower confidence, and higher frustration, stress, conflict, and feelings of being distant to their child) during math homework help. In Study 1a, these factors were investigated while controlling for parental math knowledge, given that math ability and math anxiety are related (e.g., higher-math-anxious individuals tend to have lower math ability; Hembree, 1990).

We first hypothesized that higher-math-anxious parents would report spending less time helping their child with their math homework (see Hembree, 1990), and that in return, these children would spend less time on their homework, as reported by their parents. Secondly, we hypothesized that higher-math-anxious parents would report experiencing more negative emotions while helping their children with their math homework. The second study (Study 1b) aimed to replicate the findings from Study 1a. Given the association between math anxiety and general anxiety (discussed in Chapter 1), Study 1b controlled for general anxiety in parents, alongside their math knowledge, to ensure that the relations between parents' self-reported math anxiety and the variables of interest were not confounded by general anxiety.

Study 1a

In Study 1a, parents of children in first through fifth grade completed a series of questionnaires designed to explore how their math homework helping experiences vary as a function of their own math anxiety. Given that parents report frequently helping their child with their homework in the junior grades, and less so as children enter high school (Cameron & Bartel, 2008), we chose to focus this study on parents of children in elementary school.

Method

Participants

Two hundred and ninety-nine participants were recruited as part of a larger study via Amazon Mechanical Turk, an open online marketplace, which allows individuals to conduct research (Buhrmester et al., 2016). As compensation, participants were paid at a rate of $8.00 (USD) per hour for completing the survey. A rigorous approach to data screening and cleaning was applied based on guidelines provided by Storozuk et al. (2020). A total of 107 respondents were excluded from the sample. One hundred and three participants were removed because they failed to complete all necessary measures, with certain scales omitted in their entirety, making imputation analysis unfeasible. In addition, longstring analysis was used to identify participants who used the same response category, consecutively, throughout measures that required reverse scoring. Four participants were removed from the sample because they answered a string of consistent responses greater than the number of non-reversed items on any of the three scales. For example, in a scale that has 20 items total with 9 reverse-coded items; a score of greater than 13 is deemed unacceptable.

Participants who were retained included parents (n = 192) of children in grades 1 through 5 (Gr.1 = 62, Gr.2 = 27, Gr.3 = 39, Gr.4 = 33, and Gr.5 = 31; 107 boys). One hundred and three parents identified their own gender as female and 89 identified as male. Parents reported a range

of education levels: less than high school (0.52%), high school or GED (9.90%), at least 1 year of college (20.83%), associate degree or equivalent 2-year undergraduate degree (15.63%), bachelor's degree or equivalent 2-year undergraduate degree (35.94%), some graduate training (not completed) (3.65%) and graduate degree (13.54%). The median education level was a bachelor's degree.

Procedure

Parents began the online survey by completing a series of demographic questions. They then completed the AMAS (Hopko et al., 2003), the homework interaction items (i.e., time spent on math homework and parents' emotional experience during this interaction), followed by the math knowledge measure.

Materials

Math Anxiety. Parents' math anxiety was measured using the nine-item Abbreviated Math Anxiety Scale (AMAS; Hopko et al., 2003), a widely used scale measuring math anxiety among children, adolescents, and adults. Participants were required to rate how anxious they feel in a variety of math-related situations (e.g., "Having to use the tables in the back of a math book" and "Listening to a lecture in math class") on a five-point Likert scale ranging from 1 = Lower Anxiety to 5 = Higher Anxiety. Good to excellent internal consistency (α = .83 to .90) and good test-retest reliability (r = .83; four-month time frame) have been reported for this measure (Hopko et al., 2003). Strong convergent validity has been shown between the original Math Anxiety Rating Scale-Revised (MARS-R; Hopko, 2003) and the AMAS (r = .85), the AMAS-learning math anxiety subscale (r = .70), and the AMAS-math evaluation anxiety subscale (r = .81).

Homework-Helping Interaction. To measure the extent to which parents helped children with their homework, parents responded to the question, "How often do you help your child with their math homework?" Parents responded using a six-point scale ranging from 'never' to 'every day.' This single item was used to ensure consistency with previous research on parent math anxiety and homework help (Maloney et al., 2015). Parents also provided answers to the open-ended question, "On an average school day, how many minutes does your child spend on math homework?" An additional five items measured parents' emotional experience surrounding the math homework-helping interaction using a seven-point scale. These included parents' confidence in their math homework helping skills (ranging from 'not at all confident' to 'very confident'), parents' frustration during the math homework-helping interaction (ranging from 'not at all frustrating to me' to 'very frustrating to me'), the frequency of conflict between the parent and child during the homework interaction (ranging from 'no conflict' to 'a lot of conflict'), parents' level of stress during the interaction (ranging from 'not at all stressful' to 'very stressful'), and finally the emotionality felt by parents towards their children during the interaction (ranging from 'feels close or warm' to 'feels distant or cold'). Note that the confidence variable was subsequently reverse-coded, wherein a higher score indicates lower confidence.

Parent Math Knowledge Measure. To quantify their math knowledge, parents were asked to complete a 22-item multiple-choice measure designed to assess mathematical reasoning among community college students (Stigler et al., 2011). The items focused on key concepts of 6^{th} to 12^{th} grade mathematics, including comparison of fractions, equivalence of percentages, and evaluation of algebraic expressions (e.g., "A pound of apples costs $1.98. How much will 0.75 pound cost?").

Results

Preliminary Analyses

A missing values analysis was conducted and indicated that there were no missing values in the dataset. All variables were screened for parametric test assumptions. Data were evaluated for outliers, linearity, independence of residuals, homoscedasticity, multicollinearity, and normality. Eight univariate outliers with z-scores greater than +/- 3.29 were removed. As recommended by Tabachnick and Fidell (2013), we identified and removed 2 multivariate outliers using Mahalanobis distance, evaluated at $p < .001$ and X^2 (chi squared) with degrees of freedom equal to the number of variables. For all three regressions, linearity was assessed using partial regression plots and studentized residuals against predicted values. Independence of residuals was confirmed with Durbin-Watson statistics (1.812, 1.957, and 1.760, respectively). Homoscedasticity was verified through visual inspection of studentized residuals versus unstandardized predicted values. No multicollinearity was found, as tolerance values were greater than 0.1. The assumption of normality was met using P-P plots. Based on these results, the analysis proceeded for each regression. The analyses presented below are based on a total sample of 182 participants.

All analyses were executed using IBM SPSS Statistics for Windows, Version 25.0 (2017). See Table 2.1 for means, standard deviations, and zero-order correlations.

Table 2.1

Means, Standard Deviations and Correlations Matrix for Study 1a

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1. Parent Gender (1=male; 2=female)	1.54	.50	-	.02	.88**	.06	-.50	.05	-.06	.29**	.25**	.23**	.25**	.16**
2. Child Gender (1=male; 2=female)	1.45	.50		-	.04	.09	-.02	-.19*	.03	.08	.02	.02	-.03	-.03
3. Child Grade	2.73	1.46			-	.06	-.08	.11	-.09	.31**	.26**	.27**	.28**	.16*
4. Math Anxiety	2.40	.82				-	-.39	.13	.01	.39**	0.33**	.20**	.29**	.22**
5. Math Knowledge	.72	.19					-	-.12	-.06	-.30**	-.26**	-.19*	-.28**	-0.03
6. Time spent by child (min.)	33.49	19.40						-	.26**	.01	.16*	.12	.15*	.06
7. Frequency of parental help	4.88	.99							-	-.26**	.01	.08	.04	-.03
8. Confidence	2.31	1.54								-	.50**	.28**	.42**	.46**
9. Frustration	2.98	1.78									-	.79**	.82**	.66**
10. Conflict	2.69	1.70										-	.81**	.61**
11. Stress	2.88	1.84											-	.65**
12. Emotionality	2.60	1.52												-

Note. * $p < .05$; ** $p < .01$; *M* = mean; *SD* = standard deviation. Note that the confidence variable was reverse-coded, wherein a higher score indicates lower confidence.

Time Spent on Math Homework

We first tested the hypotheses that higher math-anxious parents would help their children less often with their math homework and that their children would spend less time (per day) working on their math homework. A linear regression in which parental math knowledge, parent and child gender, child's grade and parents' math anxiety predicted the amount of time children spent on their math homework (i.e., total number of minutes), yielded no significant relation between parents' math anxiety and the amount of time their child spent on their math homework, $F(5,176) = 3.214$, $p > .05$, adj. $R^2 = .06$. In a parallel linear regression predicting the frequency with which parents help their children with their math homework, again, parents' math anxiety was not a significant predictor $F(5,176) = .605$, $p > .05$, adj. $R^2 = -.01$. For the full models, see Table 2.2.

Table 2.2

Summary of Multiple Regression Analyses Predicting for Time Children and Parents Spent on Math Homework

Variable	*B*	SE_B	β
Child Time Spent			
Constant	46.27	10.42	
Parent Gender	-8.51	5.96	-.22
Child Gender	-8.06	2.82	-.21**
Child Grade	3.95	2.04	.30t
Parental Math Knowledge	-7.04	7.91	-.07
Parental Math Anxiety	2.62	1.86	.11
Parent Time Spent Helping			
Constant	5.12	.55	
Parent Gender	.24	.32	.12
Child Gender	.07	.15	.04
Child Grade	-.14	.11	-.20
Parental Math Knowledge	-.38	.42	-.07
Parental Math Anxiety	-.03	.10	-.02

Note. $^t p < .10$; * $p < .05$; ** $p < .01$; *B* = unstandardized regression coefficient; SE_B = standard error of the coefficient; β = standardized coefficients.

Emotional Experience Surrounding the Math Homework Environment

A principal component analysis (PCA) was run on the 5-item questionnaire measuring the emotional experience surrounding the math homework environment for 196 parents. Given the high correlations between the five items of interest (i.e., confidence, frustration, conflict, stress, and emotionality), a PCA was conducted in order to reduce the five correlated variables into a single artificial variable (i.e., a component). Inspection of the correlation matrix (see Table 2.1 above) showed that all variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.83 with individual KMO measures all greater than 0.7, classifications of 'middling' to 'meritorious' (Kaiser, 1974). Bartlett's test of sphericity was statistically significant ($p < .001$), indicating that the data is likely factorizable.

PCA revealed only one component that had an eigenvalue greater than one and which explained 69.05% of the total variance. Visual inspection of the scree plot (see Supplementary Material in Appendix B, Figure B1) indicated that only one component should be retained (Cattell, 1966). Given that only one component was retained, the solution could not be rotated. See Table B1 for the component matrix.

A single linear regression was conducted to examine the relation between parental math anxiety and parents' emotional experience surrounding the math homework environment. This analysis controlled for parents' math knowledge, parent and child gender, and child's grade.

Math anxiety significantly predicted the emotional experience during math homework help reported by parents, with higher-math-anxious parents reporting significantly more negative emotions during the math homework-helping interaction, $F(5,176) = 9.826$, $p < .001$, adj. $R^2 = -.20$. Additionally, parental math knowledge marginally predicted parents' emotional experience during math homework, indicating that lower math knowledge is related to more negative

emotional interactions, $F(5,176) = 9.826$, $p < .10$, adj. $R^2 = -.20$. See Table 2.3 for the full model. A summary of multiple regression analyses predicting for individual items related to parents' emotional experience surrounding the math homework environment (i.e., confidence, frustration, conflict, stress, and emotionality) is provided in Appendix B, Table B2.

Table 2.3

Summary of Multiple Regression Analysis Predicting for Emotional Experience Surrounding the Math Homework Environment

Variable	*B*	SE_B	β
Constant	1.48	.69	
Parent Gender	.17	.39	.06
Child Gender	-.09	.19	-.03
Child Grade	.22	.14	.23
Parental Math Knowledge	-.92	.53	-.13^{t}
Parental Math Anxiety	.48	.12	.28***

Note. ^{t} $p < .10$; *** $p < .001$; B = unstandardized regression coefficient; SE_B = standard error of the coefficient; β = standardized coefficients. Males = 1 and Females = 2.

Discussion

The results of Study 1a provide compelling evidence that parents' own math anxiety relates to how they perceive their math homework-helping interactions. While neither the amount of time that children spent doing math homework, nor the frequency with which parents helped their children with their math homework, varied as a function of parents' level of math anxiety, higher-math-anxious parents reported more negative interactions overall (i.e., a more negative emotional experience) than did those with lower math anxiety. Importantly, these findings were not attributable to differences in mathematical competence between higher- and lower-math-anxious parents.

Given that Study 1a is the first (to my knowledge) to assess how parents' own math anxiety is related to their perceptions of their math homework-helping experience, we felt it

prudent to conduct a follow-up study (Study 1b) to serve as a replication. Importantly, in Study 1a, we controlled for parents' math knowledge. However, we did not control for anxiety in general (indeed, math anxiety and general anxiety are reported to be moderately correlated; Hembree, 1990). As such, in Study 1b, we aimed to both replicate the findings from Study 1a, and to extend these findings by also controlling for parents' levels of anxiety in general.

Study 1b

In this second study, we surveyed parents of first- to sixth-grade children with the intent of replicating and extending the findings of Study 1a. Importantly, here, parents' general anxiety was also assessed to ensure that the relations with math anxiety observed in Study 1a were not driven by parental anxiety in general. None of the participants from Study 1a also completed Study 1b.

Method

Participants

Once again, participants were recruited via Amazon Mechanical Turk to complete a survey on Qualtrics and were compensated at a rate of $8.00 (USD) per hour for completing the survey. The same approach to data screening and cleaning was applied based on guidelines provided by Storozuk et al. (2020). Out of 592 participants, a total of 378 respondents were excluded from the sample. Multiple participants failed to meet more than one inclusion criterion. A total of 339 participants were eliminated because they failed to complete all necessary measures, with certain scales omitted in their entirety, making imputation analysis unfeasible. Additionally, six participants identified through longstring analysis were excluded. Further exclusion criteria were applied: 22 participants whose child's grade fell outside the range of

grades 1 to 6, 13 participants whose age was under 18 years old, and 37 participants whose child's age did not fall between 5 and 12 years old.

The final sample consisted of 214 parents of children in grades 1 through 6 (Gr.1 = 69, Gr.2 = 42, Gr.3 = 31, Gr.4 = 26, Gr.5 = 20, and Gr.6 = 26; 129 boys). Ninety-five parents identified their own gender as female and 119 as male. Parents reported a range of education levels: high school diploma (20.56%), college diploma (12.62%), bachelor's degree (50.93%), master's degree (14.95%) and doctoral degree (0.93%). The median education level was a bachelor's degree.

Procedure

Study 1b followed the same procedure as Study 1a, with the inclusion of the STAI-Y.

Materials

All questionnaires from Study 1a were included in the second study. In addition to these, a measure of general anxiety was also included.

Generalized Anxiety. To assess parents' general trait anxiety, the State-Trait Anxiety Inventory Form Y (STAI-Y; Spielberger et al., 1983) was used. This 20-item self-report measure includes items such as "I worry too much over something that really doesn't matter" and "I am content; I am a steady person" (Spielberger et al., 1973). The items were rated on a four-point scale ranging from "Almost Never" to "Almost Always," with higher scores indicating greater anxiety. Good to excellent internal consistency (α = .86 to .95) has been reported for this measure and test-retest reliability coefficients have ranged from .65 to .75 over a two-month interval (Spielberger, 1989). Content validity has been measured with other measures of anxiety, including the Taylor Manifest Anxiety Scale and the Cattell and Scheier's Anxiety Scale Questionnaire (r = .73 and .85, respectively; Julian, 2011).

Results

Preliminary Analyses

A missing values analysis was conducted and indicated that there were no missing values in the dataset. All variables were screened for parametric test assumptions. Data were evaluated for outliers, linearity, independence of residuals, homoscedasticity, multicollinearity, and normality. Data were evaluated for outliers, normality, independence of residuals, linearity, homoscedasticity and multicollinearity. Seven univariate outliers with z-scores greater than +/- 3.29 were removed. An additional two multivariate outliers were removed as indicated by Mahalanobis distance evaluated at $p < .001$ and X^2 (chi squared) with degrees of freedom equal to the number of variables. For all three regressions, linearity was assessed using partial regression plots and studentized residuals against predicted values. Independence of residuals was confirmed with Durbin-Watson statistics (2.050, 2.052, and 1.835, respectively). Homoscedasticity was verified through visual inspection of studentized residuals versus unstandardized predicted values. No multicollinearity was found, as tolerance values were greater than 0.1. The assumption of normality was met using P-P plots. Based on these results, the analysis proceeded for each regression. The analyses presented below are based on a total sample of 205 participants.

All analyses were executed using IBM SPSS Statistics for Windows, Version 25.0 (2017). See Table 2.4 for means, standard deviations, and zero-order correlations.

Time Spent on Math Homework

A series of linear regressions were conducted in order to determine whether the relation found between parental math anxiety and time spent on math homework found in Study 1a would replicate before and after controlling for parents' general anxiety (in addition to

controlling for parent and child gender, child grade, and parental math knowledge). Before controlling for general anxiety, parents' math anxiety was positively associated with the time children spent on their math homework, $F(5,199) = 6.207$, $p < .001$, adj. $R^2 = .113$. This finding was in line with the original hypothesis but did not align with the findings of Study 1a. When controlling for general anxiety, this association remained true, $F(6,198) = 5.147$, $p < .001$, adj. $R^2 = .11$. Moreover, contrary to Study 1a, there was a statistically significant positive association between parents' math anxiety and the frequency with which they help their child with their math homework, $F(5,199) = 3.810$, $p < .05$, adj. $R^2 = .06$. This finding remained true after controlling for parental general anxiety, $F(6,198) = 3.265$, $p < .05$, adj. $R^2 = .06$. For the full models after controlling for general anxiety, see Table 2.5.

Table 2.4

Means, Standard Deviations and Correlations Matrix for Study 1b

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Parent Gender (1=male; 2=female)	1.43	.50	-	.09	.12	.11	-.11	.06	.03	.02	.11	.05	.03	.11	-.03
2. Child Gender (1=male; 2=female)	1.40	.49		-	-.07	-.04	.11	.07	-.01	-.01	.01	-.15*	-.13	-.11	-.05
3. Child Grade	2.82	1.75			-	-.13	.09	-.10	.13	-.15*	.04	-.01	-.05	.00	-.10
4. Math Anxiety	2.45	.99				-	-.42**	.56**	.32**	.24**	.32**	.61**	.63**	.65**	.56**
5. Math Knowledge	.64	.22					-	-.23**	-.16*	-.22**	-.33**	-.31**	-.35**	-.32**	-.32**
6. Generalized Anxiety	2.03	.53						-	.18*	.10	.32**	.42**	.38**	.45**	.44**
7. Time spent by child (min.)	32.40	19.92							-	.10	.20**	.25**	.19**	.25**	.13
8. Frequency of parental help	5.13	.69								-	-.07	.10	.12	.13	.13
9. Confidence	2.39	1.37									-	.42**	.31**	.44**	.38**
10. Frustration	3.39	1.76										-	.72**	.75**	.66**
11. Conflict	3.15	1.67											-	.81**	.75**
12. Stress	3.27	1.71												-	.72**
13. Emotionality	3.13	1.59													-

Note. * $p < .05$; ** $p < .01$; *M* = mean; *SD* = standard deviation. Note that the confidence variable was reverse-coded, wherein a higher score indicates lower confidence.

Table 2.5

Summary of Multiple Regression Analyses Predicting for Time Children and Parents Spent on Math Homework

Variable	*B*	SE_B	β
Child Time Spent			
Constant	12.64	9.35	
Parent Gender	-1.24	2.72	-.03
Child Gender	1.15	2.75	.03
Child Grade	2.03	.77	.18**
Parental Generalized Anxiety	-.18	3.06	-.01
Parental Math Knowledge	-3.33	6.78	-.04
Parental Math Anxiety	6.82	1.76	.34***
Parent Time Spent			
Constant	5.34	.33	
Parent Gender	-.00	.10	-.00
Child Gender	.02	.10	.01
Child Grade	-.04	.03	-.11
Parental Generalized Anxiety	-.08	.11	-.06
Parental Math Knowledge	-.44	.24	-.14t
Parental Math Anxiety	.14	.06	.20*

Note. t $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$; B = unstandardized regression coefficient; SE_B = standard error of the coefficient; β = standardized coefficients.

Emotional Experience Surrounding the Math Homework Environment

A principal component analysis (PCA) was run on the 5-item questionnaire that measured the emotional experience surrounding the math homework environment for 205 parents*. Again, a single linear regression analysis was conducted to determine whether parents' math anxiety is associated with negative parental emotions surrounding math homework-helping interactions, as

* The suitability of PCA was assessed prior to analysis. Inspection of the correlation matrix (see Table 2.4 above) showed that all variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.85 with individual KMO measures all greater than 0.7, classifications of 'middling' to 'meritorious' according to Kaiser (1974). Bartlett's test of sphericity was statistically significant ($p < .001$), indicating that the data is likely factorizable. PCA revealed only one component that had an eigenvalue greater than one and which explained 69.02% of the total variance. Visual inspection of the scree plot (see Supplementary Material in Appendix B, Figure B2) indicated that only one component should be retained (Cattell, 1966). Given that only one component was retained, the solution could not be rotated. See Table B3 for the component matrix.

was seen in Study 1a, even after controlling for general anxiety. For the full model after controlling for general anxiety, see Table 2.6.

As was the case in Study 1a, math anxiety significantly predicted the emotional experience during math homework help reported by parents, with higher-math-anxious parents reporting significantly more negative emotions during the math homework-helping interaction, $F(6,198) = 33.103$, $p < .001$, adj. $R^2 = .486$. Additionally, parental math knowledge also significantly predicted parents' emotional experience during math homework, indicating that lower math knowledge is associated to more negative emotional interactions, $F(6,198) = 33.103$, $p < .05$, adj. $R^2 = .486$. A summary of multiple regression analyses predicting for individual items related to parents' emotional experience surrounding the math homework environment (i.e., confidence, frustration, conflict, stress, and emotionality), controlling for parental generalized anxiety, is provided in Appendix B, Table B4.

Table 2.6

Summary of Multiple Regression Analyses Predicting for Emotional Experience Surrounding the Math Homework Environment

Variable	*B*	SE_B	β
Constant	1.106	.50	
Parent Gender	-.05	.14	-.02
Child Gender	-.22	.14	-.08
Child Grade	.05	.04	.06
Parental Generalized Anxiety	.43	.16	.17**
Parental Math Knowledge	-.74	.35	-.12*
Parental Math Anxiety	.74	.09	.54***

Note. * $p < .05$; ** $p < .01$; *** $p < .001$; B = unstandardized regression coefficient; SE_B = standard error of the coefficient; β = standardized coefficients. Males = 1 and Females = 2.

Discussion

The aim of Study 1b was to serve as a replication and extension of Study 1a. As in Study 1a, parents who reported being more anxious about mathematics also reported more negative

interactions while helping their children with their math homework than those were less math anxious. It is important to note that these relations are not better explained by the mathematical knowledge and generalized anxiety of higher-math-anxious parents.

While the majority of the relations observed in Study 1a were replicated in Study 1b, there was one discrepancy. Specifically, in Study 1a, there was no relation between parents' math anxiety and the amount of time that their child spent on math homework or the amount of time that the parents helped with math homework. However, in Study 1b, parents' math anxiety was positively associated with the time that children spent on their math homework. The implication of these findings and some of the limitations of these studies are discussed below.

General Discussion

In two separate studies, a relation between parent's math anxiety and their experience of helping their child with their math homework was demonstrated. As predicted, parents who are higher in math anxiety report perceiving their homework helping interaction with their children as being more negative overall. Importantly, these relations are not due to differences in either mathematical competence or general anxiety between higher and lower math-anxious parents. These results provide important insights into what the math homework helping interactions look like for parent-child dyads when the parents are higher in math anxiety.

Understanding this dynamic has important implications, especially given the push for parents to be involved in their children's learning (e.g., Ministry of Education, 2022) The fact that parents who are higher in math anxiety report a more negative experience overall than their lower math-anxious peers while helping their children with their math homework may provide some insight into *why* higher math-anxious parent's math homework help can backfire. As reported in Maloney et al. (2015), when higher-math-anxious parents help their children

frequently with mathematics homework, their children learn less math and increase in math anxiety themselves (relative to when higher math-anxious parents help less or not at all). Given the results from the current studies, it is plausible that the increased negativity experienced by higher math-anxious parents is also experienced (or, at least, perceived), by their children, given that children tend to observe and imitate the behaviours and emotional responses of their role models (i.e., parents; Bandura & Walters, 1977; Hoover-Dempsey et al., 2001). Consequently, when children witness their parent expressing negativity towards math, they may internalize these attitudes and beliefs, leading to decreased engagement and learning in math-related activities. Children also look to their parents for cues on how to interpret and respond to unfamiliar or ambiguous situations (e.g., Ehli et al., 2020). Therefore, if children perceive their parents exhibiting negative emotions towards math, they may interpret math-related tasks as threatening or aversive, consequently heightening their own levels of math anxiety. This increased negativity may lead children to learn less math and to develop negative associations with mathematics, resulting in increases in their own math anxiety.

Encouraging a push for higher involvement among math-anxious parents has the potential to simply lead to more conflict and hostility among parents and their children. Moreover, children who spend their time at home in conflict with their parents are at risk for developing a negative emotional relationship with math. In fact, according to the social cognitive view of motivation, the models to which people are exposed, along with their own self-efficacy, are two of the strongest predictors of students' own motivation to learn (Foley et al., 2017). Hence, any possible benefit afforded by parents helping their children complete math homework may be washed away by students developing a more enduring negative disposition towards math.

The data reported here are consistent with a previous report suggesting that when working to understand the etiology of math anxiety, it is important to understand the relationship between parents and children. Bosmans and de Smedt (2015) argued that the development of math anxiety might reflect, at least in part, a maladaptive affect regulation mechanism that is characteristic of insecure attachment relationships. Specifically, they reported that higher levels of math anxiety in children seem to be associated with insecure attachment to mothers in middle childhood and that math anxiety mediates the association between insecure attachment and mathematical achievement. Note that Bosmans and de Smedt (2015) did not examine the relation between math anxiety and attachment to male caregivers (e.g., fathers). The fact that parent gender was not a significant predictor in the present studies suggest that examining the attachment between male caregivers and children in relation to math anxiety is an important next step (a future direction that is also highlighted in Bosmans & de Smedt, 2015).

Another strength of these studies is the relatively balanced representation of male and female parents who participated. Indeed, many studies examining parental homework involvement skew towards more female parents responding than males (e.g., Cannon & Ginsburg, 2008; Daches Cohen & Rubinsten, 2017; Maloney et al., 2015). Interestingly, with two relatively gender-balanced samples, there were no significant relations between parents' gender and the outcomes assessed in these studies.

Limitations and Future Research

The results of the present studies clearly indicate that when parents are higher in math anxiety, they perceive their homework helping interaction with their children to be more negative overall. While these results are compelling and robust (i.e., they are seen in two separate samples and persist even after controlling for parents' math ability and general anxiety), there are

limitations to this work that need to be taken into account when designing future studies in this area. For example, parents' perceptions of the math homework-helping interaction were assessed, but the child's perspective or the child's math outcomes were not included. Thus, while taken together, the results of this study and that of Maloney et al. (2015) would seem to suggest that the reason parents' math anxiety causes children to learn less math when they help them with their homework is because the math homework-helping environment is a highly negative one. However, it is important to note that this conclusion cannot be drawn in fact. Rather, what can be concluded from the current work and from that of Maloney et al. (2015) is that when parents are higher in math anxiety and they help their children with their math homework, not only do children learn less math and become more anxious about math themselves (Maloney et al., 2015), but parents experience more negative emotions during that interaction than do their lower math-anxious peers.

It is also important to note that the relations between parents' math anxiety and the time that they spend helping their children with their math homework were not consistent between Study 1a and Study 1b. This discrepancy may be due, in part, to the fact that not all schools assign the same amount of math homework. Indeed, while some school policies may require schools to send children home with homework every day, others might assign homework much less often. As such, the response options to the items in question may be less relevant for some parents and children compared to others. Another potential demographic factor worth considering would be the socio-economic status of the families included in the survey. It is of course possible that homework assignment and parental input may vary as a function of school-level socio-economic status. Furthermore, a large portion of each sample was excluded from the analyses if they did not complete measures in their entirety. Although this raises the question of

whether these values were missing at random, we felt it prudent to implement this rigorous data cleaning approach given that we used Amazon Mechanical Turk to recruit data, which can sometimes attract professional participants or even bots in these sample pools (see Aruguete et al., 2019; Rouse, 2015). Future research may want to consider these factors and is thus needed before strong claims can be made regarding any potential relation between parents' math anxiety and the time that they spend helping their children with their homework. Lastly, it is important to note that, while these two studies provide a first glimpse into the relation between parents' math anxiety and the math-homework-helping environment, they do not give us an indication of what actually happens during these homework helping interactions. Direct observation is required before any concrete recommendations can be made as to how to create a more positive and enjoyable math homework-helping experience.

While these studies add support to the idea that it will be helpful to design scaffolding materials to assist parents in helping their children with their math homework, it cannot yet be concluded in which maladaptive strategies higher-math-anxious parents engage. However, one promising empirically supported approach involves an educational intervention designed to promote more positive interactions between children and their parents with regards to math. In this intervention, short math story problems are provided through an iPad app (Overdeck et al., 2021). Berkowitz and her colleagues (2015) examined the effectiveness of this app and found that, when used even as little as once per week, children's math achievement increased by the end of the school year. Importantly, the magnitude of this effect was larger for those children with higher-math-anxious parents. It is important to note here that Berkowitz et al. (2015) do not know the mechanism through which using the app lead to increased achievement but do suggest that this may have occurred through improving parents' math interactions with their children. It

is not suggested that this particular intervention (i.e., Bedtime Math) is the most optimal intervention, or even the most optimal means of delivering an intervention (i.e., through a tablet), to help parents help their children with math. However, the findings of Berkowitz et al. (2015) do support the notion that scaffolding parents' interaction around math and, thus, their homework helping, may serve as a way to boost children's math learning, particularly for those most vulnerable.

Implications and Conclusions

In the current paper, important steps were taken towards understanding where parents are going wrong during their math homework helping interactions with their children. In two separate studies, we demonstrated a relation between parent's math anxiety and their emotional experience whilst helping their child with their math homework. Because higher math-anxious parents are experiencing much more negative emotions during this interaction, they are potentially hindering their child's math learning experience. With the overarching intent being to discover the mechanisms by which parents' math anxiety is transmitted to their children, this study is a stepping-stone towards understanding the relational behaviours used between parent-child dyads during the homework-helping interactions. With the Government of Ontario pushing for parental engagement in children's learning (Ministry of Education, 2022), it is hoped that this study will both (1) highlight the importance of developing and evaluating scaffolding tools to help parents help their children with math and (2) lead to the sensitization of parents in terms of homework involvement. Hopefully, these data, along with those of Maloney et al. (2015), will encourage parents to be mindful of the negative emotions that they may be transmitting to their children during the math homework-helping interaction and the long-term consequences that these negative emotions may have for their children's academic and career trajectories.

CHAPTER 3: Study 2

Relations between Math Achievement, Math Anxiety, and the Quality of Parent–Child Interactions While Solving Math Problems

Elements from this research were included the following published article:

DiStefano, M.*, Retanal, F.*, Bureau, J. F., Hunt, T. E., Lafay, A., Osana, H. P., ... & Maloney, E. A. (2023). Relations between math achievement, math anxiety, and the quality of parent–child interactions while solving math problems. *Education Sciences, 13*(3), 307. https://doi.org/10.3390/educsci13030307

*These authors contributed equally to the work.

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Abstract

In Study 2, we used a multi-method approach to understand the quality of math homework-helping interactions between parents and their children, and how parents' and children's own math achievement and math anxiety relate to the quality of the interaction. Forty parents and their children (ages 10-12 years; grades 5 to 7) completed self-report measures of math and general anxiety. Parents and children completed standardized assessments of math achievement and were then recorded as they engaged in a simulated math homework interaction. Coders first used the Parent-Child Interaction Scale for the Preschool and School Periods (Moss et al., 1996) to assess parental and child behaviours the math homework-helping interaction. Parent-child dyads generally performed well on the simulated math homework task. Nevertheless, task performance was correlated with the quality of the interaction, with higher quality interactions associated with higher accuracy on the math task. Furthermore, the variability in the quality of the interaction was associated with parents' and children's math achievement, and with the math anxiety of the children, but not the parents. Coders then used the Linguistic Inquiry and Word Count (LIWC-22; Boyd et al., 2022) to measure the frequency of negative and positive words used by parents during the math homework-helping interaction. There was a positive correlation between parents' and children's use of negative words during the interaction. Additionally, the variability in the frequency of positive words used by parents was associated with parents' math achievement and accuracy on the math task. Identifying the elements that influence parent-child interactions in math-related situations is essential to developing effective interventions to scaffold children's math learning and attitudes.

Keywords: math anxiety, math achievement, homework help, parent-child interaction

Relations between Math Achievement, Math Anxiety, and the Quality of Parent–Child Interactions While Solving Math Problems

Findings from Chapter 2 (Study 1) provide evidence to support that when parents are higher in math anxiety, the interactions surrounding math homework are altogether more negative (i.e., less confident, as well as more conflict-ridden, stressful, frustrating, and emotionally distanced/cold). These findings must be interpreted cautiously, however, given that they stem from self-reported measures of parents' perceptions of the math homework-helping interaction and do not include the child's perspective or math outcomes. Thus, taken together with the work of Maloney et al. (2015), it can be asserted that when parents are higher in math anxiety, and they help their children with their math homework, not only do children learn less math and become more anxious about math themselves (Maloney et al., 2015), but higher math-anxious parents experience more negative emotions during that interaction than do their lower math-anxious counterparts (Chapter 2; Study 1). While it is reasonable to assume that the math homework interactions of higher math-anxious parents and their children are more negative than those of their peers, this remains an empirical question. Although self-reports provide an understanding of how parents and children perceive the interaction, self-reports do not allow researchers to directly observe what is happening during the math homework-helping interaction. Indeed, there is evidence to suggest variation in how adults appraise previous math experiences, and such appraisals are related to math anxiety and attitudes (see Hunt & Maloney, 2022). This strengthens the case for necessitating behavioural observations.

In the current study, observations of parent-child dyads interacting were coded in a simulated math homework interaction to garner a richer understanding of the behaviours that occur when parents and children work to solve math problems. Additional analyses were

conducted to explore the negative and positive language used by both parents and children during the interaction. The study also examined the relations between key parent and child factors and the quality of the math homework-helping interaction.

Quality of the Math Homework-Helping Interaction

Parent-child interactions play a crucial role in children's development (Lamb & Lewis, 2013). Through the lens of Social Learning Theory, children often observe and internalize parental behaviours, cognitions, and communication patterns, which can influence various aspects of their development (Bandura, 1986, 2001, 2006). During math-related tasks, children may unwittingly absorb maladaptive coping strategies and attitudes from their parents, thus contributing to the onset and perpetuation of math anxiety. Moreover, empirical studies have consistently demonstrated that the quality of parent-child interaction is a significant predictor of children's outcomes (Bradley & Corwyn, 2007; Yap & Jorm, 2015), suggesting a potential pathway for intergenerational transmission of behaviours and attitudes. In the present study, the quality of parent-child interaction is operationalized in two distinct ways: first, by examining parental and child behaviours, and second, by analyzing parental and child language patterns.

Behaviours During the Parent-Child Math Homework-Helping Interaction

Parents' involvement in their children's homework across various subjects has garnered attention among researchers aiming to comprehend how student learning and achievement can benefit from parental assistance with homework (Gonida & Cortina, 2014). Homework involvement presents parents with an opportunity to actively support their child's development (Doctoroff & Arnold, 2017), and effective parent homework involvement entails modelling, reinforcement, and dialogue that fosters the development of positive attitudes, knowledge, and behaviours in children (Hoover-Dempsey & Sandler, 1995). Furthermore, research indicates that

an autonomy-supportive approach to homework assistance, such as allowing the child to solve problems independently with parental guidance, can promote a more positive sense of well-being and improve academic outcomes for children (Dumont et al., 2014; Hoover-Dempsey et al., 2001). However, parental involvement in homework can sometimes have adverse effects on children's attitudes and learning (see Chen & Stevenson, 1989; Cooper & Lindsay, 2000; Maloney et al., 2015; Wilder, 2017). Parents who exhibit intrusive homework-helping behaviours, such as regulating the child's behaviour or pressuring outcomes using commands, directives, or withdrawal of affection, are associated with lower academic outcomes for children (Hill & Tyson, 2009; Pomerantz & Eaton, 2001). Parental overcontrol, overprotection, conflict, rejection, and criticism are linked to childhood anxiety (see Ginsburg & Schlossberg, 2002). Some parents may engage in these controlling behaviours while assisting children with their math homework, leading to adverse effects on children's math anxiety and math achievement.

Although many studies primarily focus on parental behaviours, it has been argued that evaluations of dyad-focused features (e.g., dyadic synchrony, coordination, emotional reciprocity, etc.) provide more information about the quality of parent-child interactions than evaluations that are only centred on the parent or child alone (Dubois-Comtois et al., 2011). These findings underscore the importance of measuring both parent and child behaviours to gain insight into how the quality dyadic interactions during math homework help may be associated to children experiencing higher levels of math anxiety and lower math achievement.

Language During the Parent-Child Math Homework-Helping Interaction

Language has been argued as being pivotal in guiding a child's socio-cognitive growth, acting as the mechanism through which thoughts are structured and moulded (Vygotsky, 1978).

As such, it is essential to consider the affective language used by parents and children during the simulated math homework-helping interaction, in addition to the observed behaviours.

It is plausible that the explicit mentions of one's own math abilities or beliefs about math may influence children's own attitudes and beliefs. For instance, it has been suggested that math-anxious teachers are more likely to reassure students that their difficulties are to be expected, possibly with reference to their own experiences (Unglaub, 1997). It may be the case, then, that parents also make similar comments when trying to reassure their children. In asking why children of parents who are higher math anxiety and frequently help with math homework go on to develop math anxiety themselves, Ramirez et al. (2018) state the following:

> One possibility is that these frequent interactions create opportunities for parents to overtly express their negative beliefs about math (i.e., "Math is so confusing") or their own experiences around math (e.g., "I was always scared of math"), which normalizes a fear of math and ultimately leads children to internalize these same negative attitudes. (p. 149)

Thus, the present study investigates whether higher-math-anxious parents communicate more negative math messages to their children while helping them with their homework, and further explores whether these children tend to reciprocate with negative language during the interaction.

Factors Contributing to the Quality of the Math Homework-Helping Environment

It is important to study both parent and child factors that may relate to the quality of the math homework-helping interaction. Child factors (e.g., behaviour, mental health) have primarily been researched as an *outcome* of the quality of parent-child interactions (Ryan et al., 2017). Yet, the transactional model of development, which emphasizes bidirectional interplays between the

child and the environment, suggests that the interaction is shaped not only by parent characteristics but also by those of the child (Sameroff, 2009).

Parent Math Anxiety and Math Achievement in the Context of Math Homework-Help

Little is known about the parental factors that relate to variability within the math homework-helping environment. A study conducted in seven Arab countries revealed that children with parents who are more frequently involved in their math homework have lower math achievement (Alreshidi et al., 2022). The researchers suggest that parents may exhibit controlling behaviours that may interfere with children's learning. In considering previous research by Maloney et al. (2015), another factor that may contribute to this finding is parents' math anxiety. Specifically, Maloney and colleagues found that when higher math-anxious parents frequently helped with math homework, their children learned less math than children of lower math-anxious parents or than those who received less frequent homework help. The math anxiety of these children themselves also increased over the course of a school year. Similarly, Cosso et al. (2023) demonstrated that the degree to which children's math achievement is influenced by the frequency of parent-child math interactions depends on parents' math anxiety. These studies, however, did not assess the *quality* of the math interactions. Findings discussed in Chapter 2 (Study 1) proposed that one reason the math homework help of higher math-anxious parents is less beneficial than that of their lower math-anxious counterparts is because the quality of the math homework interactions involving higher math-anxious parents is lower. Specifically, higher math-anxious parents tended to be lower in math achievement, and reported feeling increased levels of stress, tension, and frustration, as well as feeling more distant from their child when helping with their math homework.

As proposed by Alreshidi and colleagues (2022), parents who are frequently involved in their children's math homework may be more intrusive in the process. In line with this, previous research has identified parents' lower math achievement and higher math anxiety as factors that are associated with fewer autonomy-supportive and more controlling-supportive homework-helping behaviours (Retanal et al., 2021). Although the research reported in Chapter 2 (Study 1) and in Retanal et al. (2021) opened the door to the possibility that parents' own levels of math anxiety and math achievement relate to how they help their children with their math homework, the data are comprised solely of self-reports from the parents. As such, it is difficult to know whether children of higher math-anxious parents also experience their math homework interactions to be less optimal than do children of lower math-anxious parents. It is also difficult to determine whether the quality of the math homework-helping interaction of higher math-anxious parents is indeed suboptimal (e.g., less autonomy supportive, more emotionally negative), or if they simply perceive the interactions to be so. To capture the essence of the quality of the math homework-helping interaction, considering both children and parents, we felt it prudent to take into consideration the behavioural observations of trained coders, as well as the linguistic analysis of the interaction.

Child Math Anxiety and Math Achievement in the Context of Math Homework-Help

It is important to consider both parent and child factors when assessing individual differences regarding how the math homework-helping interaction unfolds. Drawing from research in the classroom, students in a negative mood are likely to have a worse learning experience than students in a positive mood (Leone & Richards, 1989). Relatedly, Trautwein and colleagues (2009) argued that homework is likely to be most effective if students *do not* typically experience unpleasant emotions while doing their assignments. Although the focus of this study

is not to investigate children's mood directly, emotional factors are considered and further explained in the Method section. Trautwein et al. (2009) reported a reciprocal relation between achievement and homework-related emotions, such that lower academic achievement in children predicted higher levels of unpleasant homework-related emotions, and higher levels of unpleasant homework-related emotions, in turn, predicted lower achievement. In line with this, recent research suggests that when children are having difficulties with their math homework or expressing frustration, higher math-anxious parents' responses during the homework-helping situation are more negative (i.e., more controlling, and negatively emotionally charged; see Oh et al., 2022; Wu et al., 2022). These findings support the notion that when working to understand not only how math homework interactions vary, but also what factors relate to this variability, the picture will be more complete if one takes into consideration both parent- and child-level factors.

Objectives and Hypotheses

In the present study, a multi-method approach was used to obtain a deeper understanding of the math homework-helping environment than what has to date been reported in the literature. Specifically, using self-report, parents' and children's levels of math and general anxiety were assessed. Further, standardized assessments of parents' and children's math achievement were obtained. Parents and children were then recorded engaging in a simulated math homework interaction, which was coded by trained coders who assessed the quality of the interaction via parent-child behaviours and the language used (i.e., the frequency of negatively and positively valanced words used by parents and children).

The first objective was to provide a general description of the math homework-helping interaction of the sample. The second objective was to describe whether the performance on the simulated math homework task varied as a function of the observed quality of the interaction.

Finally, we sought to investigate how parents' and children's own math achievement and math anxiety relate to the quality of the interaction.

The findings of the present study are categorized into two concurrent sections for analysis: 1) parental and child behaviours, and 2) parental and child language. In both sections, we hypothesized that the success on the math homework task would be related to the quality of the homework-helping interaction, in that a poorer quality of the interaction would be associated with lower score on the math task (Hypothesis 1). We further hypothesized that the parent-child interaction would be altogether more negative for lower math-achieving parents (Hypothesis 2a) and children (Hypothesis 2b). Similarly, we expected that the homework-helping interaction would be altogether more negative for higher math-anxious parents (Hypothesis 3a) and children (Hypothesis 3b).

Method

Participants

Prior to the beginning of the COVID-19 pandemic, 41 parent-child dyads (children in grades 5 to 7) were recruited and participated in the present study. Participants were recruited through online advertisements (i.e., Facebook and Twitter), community centres (e.g., summer camps and recreational centres), advertisements through a school board, and a participant pool from a Canadian university. To be eligible to participate in this study, parents were required to be their child's primary homework helper and to be fluent in English. Non-biological caretakers (e.g., adoptive parents or stepparents) were also invited to partake in the study, although none participated.

One dyad was removed from the sample because of an audio error. All 40 parents (n = 34 women; M_{age} = 43.5 years) reported that they were the primary math homework-helping parent.

Parents reported a range of education levels: some college with no diploma (15%), college diploma (25%), bachelor's degree (32.5%), master's degree (22.5%), and doctoral degree (5%). The median education level was a bachelor's degree. As for the children, 13 were in Grade 5 (n = 10 girls; M_{age} = 10.0 years), 21 were in Grade 6 (n = 13 girls; M_{age} = 11.0 years), and 6 were in Grade 7 (n = 2 girls; M_{age} = 11.8 years).

Procedure

As part of a larger study, children participated in a two-hour video-recorded session with their primary homework-helping parent. Participants had the option to participate in the study in the lab (n = 3) or at their home (n = 37), in which case the research assistants travelled with the necessary testing materials. After completing parental consent and child assent, the parents and children completed a series of tasks, including the simulated math homework-helping task and an online questionnaire, followed by the WJ-IV. Each task was administered in a counterbalanced order for each dyad (i.e., all six possible orders of task administration were used, counterbalanced across participants) in order to evenly distribute the effects of the task sequence.

Experimenters explained to the dyad that the objective of the simulated math homework-helping task was for the child to solve each math problem. The parent was informed that they were allowed to help their child with the task where they saw fit, just as they would normally if this were a regular homework assignment. The child and parent were allotted a maximum of 30 minutes to complete the task, with the flexibility to conclude earlier if they found they required less time. Dyads were given the option to work directly in the booklet or use a whiteboard to work through the math problems. Final answers were to be recorded directly in the booklet.

After completing the homework-helping task, one experimenter asked the parent to follow them into a separate testing room and the other experimenter stayed in the room with the

child. Both parent and child were asked to complete questionnaires on a computer. Additionally, the parents and children separately completed subtests of the WJ-IV in individual rooms to assess participants' mathematical achievement.

Materials

Mathematics Anxiety

Participants' (both parent and child) math anxiety was measured using the nine-item Abbreviated Math Anxiety Scale (AMAS; Hopko et al., 2003), which is described in Chapter 2 (Study 1a).

Generalized Anxiety

To assess parents' trait anxiety, the State-Trait Anxiety Inventory Form Y (STAI-Y; Spielberger et al., 1983)—described in Chapter 2 (Study 1b)—was administered.

In addition, children completed the Trait-Anxiety subscale from the State-Trait Anxiety Inventory for Children (STAIC; Spielberger et al., 1973). For each of the 20 statements, participants indicated how they generally feel on a three-point scale ranging from "hardly ever" to "often" (e.g., "I feel unhappy" and "I have trouble deciding what to do"), with higher scores indicating greater anxiety. Acceptable to good internal consistency (α = .78 and .81; males and females, respectively) and acceptable test-retest reliability (r = .65 and .71; males and females, respectively) have been reported for this measure (Spielberger et al., 1973). The concurrent validity of the STAIC has been supported by high correlations with similar measures, such as the Children's Manifest Anxiety Scale (r = .75), the General Anxiety Scale for Children (r = .63), and the Hamilton Anxiety Rating Scale Interview (r = .58) (Kirisci & Clarck, 1992).

Mathematics Achievement

A composite of the Math Facts Fluency and Calculation assessments from the Woodcock-Johnson IV (WJ-IV; Schrank & Wendling, 2018; copyrighted) was used as a measure of mathematics achievement. The WJ-IV is a standardized, nationally norm-referenced achievement test appropriate for individuals aged 2 to 90 years old. For this study, all parents were administered the WJ-IV Tests of Achievement Form A and all children were administered the WJ-IV Tests of Achievement Form B.

Math facts fluency. Participants were provided a booklet of 160 single-digit arithmetic problems (i.e., addition, subtraction, and multiplication). All participants began with Item 1 and were given three minutes to complete as many calculations as possible. Participants were scored on the total number of correct responses. This task has test-retest reliabilities of .95 for children aged 7 to 9 years and for adults (Mather & Wendling, 2014).

Calculation. Participants were provided a booklet of 57 math problems of increasing difficulty. Depending on age-appropriateness, items included numerical operations (i.e., addition, subtraction, multiplication, and division), geometric, trigonometric, logarithmic, and calculus operations. Children in grades 5 and 6 began with Item 19, children in grade 7 began with Item 23, and adults began with Item 27. Once participants successfully completed six items in a row (i.e., they reached the basal criterion), testing proceeded until the six highest-numbered items administered were responded to incorrectly (i.e., they had reached the ceiling criterion), or until Item 57 was administered. Participants were scored on the total number of correct responses. This task has a median reliability of .93 for 5- to 19-year-olds and for adults (Mather & Wendling, 2014).

Performance on the Simulated Math Homework Task

Parent-child dyads were given one of three paper booklets with nine math questions. The booklet provided depended on the grade of the child (i.e., Grade 5, 6, or 7). The questions created for the simulated math homework interaction reflected the five strands of mathematics from the Ontario Mathematics Curriculum (Ontario Ministry of Education, 2005). The five strands include: 1) number sense and numeration, 2) measurement, 3) geometry and spatial sense, 4) patterning and algebra, and 5) data management and probability. These questions were developed by a mathematics school curriculum consultant and were designed to be appropriate for students in grades 5-7 (ages 10-12). To guarantee that the child has already been exposed to the material being presented to them, the questions administered to the fifth graders were based on the grade 4 curriculum, the sixth graders on the grade 5 curriculum, and the seventh graders on the grade 6 curriculum. To score the participants' performance on the math task, one point was attributed for each correct answer. A percentage was then computed to conduct statistical analyses. All questions are provided in Appendix A.

Quality of the Homework-Helping Interaction

The quality of the math homework-helping interaction between parent-child dyads was assessed using two measures, which are described below. Both measures were chosen to obtain a more global view of the quality of the homework-helping interaction, wherein parents' affective expressions and the interchange between parents and children are each taken into consideration.

Parent-child behaviours during math homework help. To assess the parents' and children's behaviours during simulated math homework-helping interaction, three two-minute increments at the beginning, middle, and end of the video recordings were assessed, given the variability in the time that it took each family to complete the task. The interactions within these three two-minute increments were coded using the Parent-Child Interaction Scale for the

Preschool and School Periods (Moss et al., 1996) adapted for the simulated math task. The instrument consists of ten subscales reflecting different dimensions of parent-child interactions. Three of the subscales were classified as "Parental Behaviour" and seven subscales as "Dyadic Interaction." In the Parental Behaviour category, the scales included: (a) Parental Sensitivity, (b) Respect for the Child's Rhythm, and (c) Parental Effort. In the Dyadic Interaction category, scales included: (a) Relaxation, (b) Neutrality-Joy, (c) Intimacy, (d) Coordination, (e) Appropriate Role, (f) Synchronized Emotions, and (g) Attention Centred on the Task. Each subscale is assigned a score between 1 (absence of the dimension's characteristics) and 4 (most optimal quality of the interaction). For example, on the "Parental Sensitivity" scale, a score of 1 would indicate insensitivity that could be characterized by a rigid and controlling behaviour pattern of the parent, among other presentations, whereas a score of 4 would reflect a flexible parent who fully supports their child's need for autonomy.

The Parent-Child Interaction Scale was originally developed to assess parent-child interactions in middle childhood during snack time (Moss et al., 1996) and has since been used in a variety of contexts, including a playful interaction task (Bureau et al., 2021). Although this study is the first to use the scale in an education-related context, it is nonetheless ideal because it captures the elements that are important in parent-child relationships. Additionally, this scale has revealed links with academic performance in children (for example, see Moss & St-Laurent, 2001).

A training on the Parent-Child Interaction Scale was required prior to using the coding system. The coders participated in an official training session and were certified to code the current sample. Inter-rater reliability (Pearson's intraclass correlations, *rICC*) for each dimension was calculated for eight randomly selected videos, which represented 20% of the total sample.

All the scales demonstrated good to excellent inter-rater reliability: Parental Sensitivity (*rICC* = 0.73), Respect for the Child's Rhythm (*rICC* = 0.87), Parental Effort (*rICC* = 0.89), Relaxation (*rICC* = 0.82)[†], Neutrality-Joy (*rICC* = 0.74)[*], Intimacy (*rICC* = 0.87), Coordination (*rICC* = 0.96), Appropriate Role (*rICC* = 0.78), Synchronized Emotions (*rICC* = 0.78), and Attention Centred on the Task (*rICC* = 1.00). Coders debated any discrepancies for the entire sample until they came to an agreement.

Parent and child affective language during math homework help. The frequency of negative and positive words used by parents during the math homework-helping interaction was measured with the 2022 version of the Linguistic Inquiry and Word Count (LIWC-2022) text analysis software (Boyd et al., 2022). Specifically, transcripts of parent dialogue of each audio-recorded session were entered into the software. While there are several categories within the LIWC-22 Dictionary, only the "Emotion" subcategory was selected for the purpose of this study. This category includes 1030 words and was carefully developed by its creators (for additional information, see Boyd et al., 2022). The "Emotion" category is categorized into subsets, including "Positive emotion" (e.g., good, love, hope) and "Negative emotion." Within the "Negative emotion" category, emotions such as "Anxiety" (e.g., worry, fear, afraid, nervous), "Anger" (e.g., hate, mad, angry, frustrated), and "Sadness" (e.g., sad, disappointed, cry) are further categorized. Though the reported internal validity using Cronbach's alpha varies between poor and questionable (α = .25-.61; see Boyd et al., 2022), it is important to note that the psychometrics of natural language are not straightforward, given that once a person says something, they do not repeat it again, as it would be considered a bad form of language. For this

[†] Given that reliability was initially poor for the Relaxation (*rICC* = 0.44) and Neutrality-Joy (*rICC* = 0.50) subscales, an additional 12 videos were subsequently double coded, accounting for 50% of the total sample.

reason, reliability coefficients are naturally lower than those seen in other psychological tests (e.g., self-reported questionnaires), wherein the repetition of an idea is essential. For this reason, the Kuder-Richardson Formula 20 (Kuder & Richardson, 1937) is deemed a more appropriate measure of internal consistency in this context (KR-20 = .80-.97), given that it is specifically designed for dichotomous items and is more suitable for assessing internal consistency in measures where responses are not repeated.

Results

Preliminary Analyses

One dyad's interaction during the homework-helping session was conducted primarily in French, which could not be assessed using the LIWC-22 software, as it is designed only for interpreting English transcripts. Therefore, the sample size for each analysis is noted in Table 3.1. Occasionally, some participants did not respond to an item in a scale (<2.5% on any given scale). To confirm that data was missing completely at random (MCAR), a Little's MCAR test was performed. Non-significant results indicate that the data was MCAR, χ^2 (285) = 57.72, p = 1.00. Thus, to address missing data, a multiple imputation was conducted with a maximum of 25 iterations.

All variables were screened for parametric test assumptions. However, various criteria were not met, notably including the presence of outliers, non-normally distributed data, and non-linear relationships. Furthermore, due to the combination of a limited sample size and the ordinal nature of the data, it was concluded that a parametric test would not be suitable for conducting most analyses. Therefore, the majority of correlation analyses in the subsequent section were performed using Spearman's rank correlation analyses (Spearman's Rho). Spearman's Rho was selected for its versatility and robustness in handling data that may not meet the assumptions of

Pearson's correlation coefficient. However, for two of the analyses in the subsequent sections, the nature of the variables made them more suitable for a Pearson's R correlation. Consequently, we indicated the analyses conducted using a Pearson's R correlation.

Descriptive Statistics

Descriptive statistics and correlations among parent and child measures are shown in Table 3.1 and Table 3.2. In general, parents and children reported experiencing "moderate anxiety" surrounding math-related events specified in the AMAS. A Spearman's Rho correlation was performed to examine the relation between parent and child math anxiety. The relation between these variables was found to be marginally significant, $r_s(38) = 0.28$, $p < .10$. All math achievement analyses were conducted using participants' W scores‡, given that they are the recommended metric for statistical analyses (McGrew et al., 2014). Parents' mean W score of 536.95 ($SD = 14.73$) indicates that, on average, parents' math achievement was equivalent to approximately the average performance of individuals older than 21 years old within the normative sample. Children's mean W score of 490.93 ($SD = 17.60$) indicates that, on average, children's math achievement was equivalent to approximately the average performance of 9-year-olds within the normative sample. A Pearson's R correlation was performed to examine the relationship between parent and child math achievement. The relation between these variables was not found to be statistically significant, $r(38) = 0.14$, 95% Confidence Interval [-0.181, 0.431], $p = .395$.

Table 3.1

Descriptive Statistics for All Measures

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‡ W scores are created by converting raw scores into Rasch-scales scores with equal intervals. W scores are centred on a value of 500, which approximately represents the average performance of a 10-year-old within the normative sample (Mather & Wendling, 2014).

	Parents			Children		
	Mean	SD	Range	Mean	SD	Range
General Anxiety[a]	1.97	0.55	1.05-3.55	1.67	0.40	1.10-2.65
Math Anxiety[a]	2.25	0.97	1.00-4.67	2.31	0.86	1.22-4.44
Math Achievement[a]	536.95	14.73	503.00-565.00	490.93	17.60	450.00-526.00
Math Task Score[a,b,c]	80.58	22.87	18.20-100	80.58	22.87	18.20-100
Parental Behaviour[a]						
Parental Sensitivity[a]	2.96	0.59	1.50-4.00			
Respect for Child's Rhythm[a]	3.23	0.79	1.00-4.00			
Parental Effort[a]	3.58	0.53	2.00-4.00			
Dyadic Interaction[a]						
Relaxation[a,b]	3.19	0.71	1.00-4.00	3.19	0.71	1.00-4.00
Neutrality-Joy[a,b]	2.83	0.50	1.50-3.50	2.83	0.50	1.50-3.50
Intimacy[a,b]	3.15	0.59	2.00-4.00	3.15	0.59	2.00-4.00
Coordination[a,b]	3.07	0.68	2.00-4.00	3.07	0.68	2.00-4.00
Appropriate Roles[a,b]	3.26	0.72	1.50-4.00	3.26	0.72	1.50-4.00
Synchronized Emotions[a,b]	3.23	0.63	1.50-4.00	3.23	0.63	1.50-4.00
Attention Centred on Task[a,b]	3.34	0.62	1.50-4.00	3.34	0.62	1.50-4.00
Total Word Count[d]	1455.23	695.86	380-3133	1100.64	375.83	357-1931
Positive Word Count[b,c,d]	0.63	0.65	0-3.52	0.19	0.21	0-0.74
Negative Word Count[b,c,d]	0.09	0.13	0-0.47	0.15	0.18	0-0.82

Note. [a]$n = 40$; [b]applies to both parent and child; [c]percentages; [d]$n = 39$.

Table 3.2

Spearman's Rho Correlations for Parent and Child Measures

	1	2	3	4	5	6
1. Parent General Anxiety	-	0.23	0.12	0.09	-0.05	-0.07
2. Parent Math Anxiety		-	-0.41**	0.16	0.28[t]	-0.36*
3. Parent Math Achievement			-	0.15	-0.20	0.14[a]
4. Child General Anxiety				-	0.63***	-0.24
5. Child Math Anxiety					-	-0.19
6. Child Math Achievement						-

Note. [a]This analysis was performed using a Pearson's R correlation; [t]$p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Section 1: Parent-Child Behaviours During the Math Homework-Helping Interaction

Describing the Quality of the Simulated Math Homework Task Interaction in Relation to Parent and Child Behaviours

The quality of the parent-child interaction during the simulated math homework task was evaluated based on the levels of parental sensitivity, respect for the child's rhythm, parental effort, relaxation, neutrality-joy, intimacy, coordination, appropriate roles, emotional synchronization, and attention centred on task. As shown in Table 3.3, the subscales were mostly positively correlated (r_s values: 0.37 to 0.85). Figure 3.1 illustrates the distribution of each subscale of the quality of the homework-helping interaction in parent-child dyads, further described below.

Figure 3.1

Distribution of the Quality of Math Interaction subscales (n = 40)

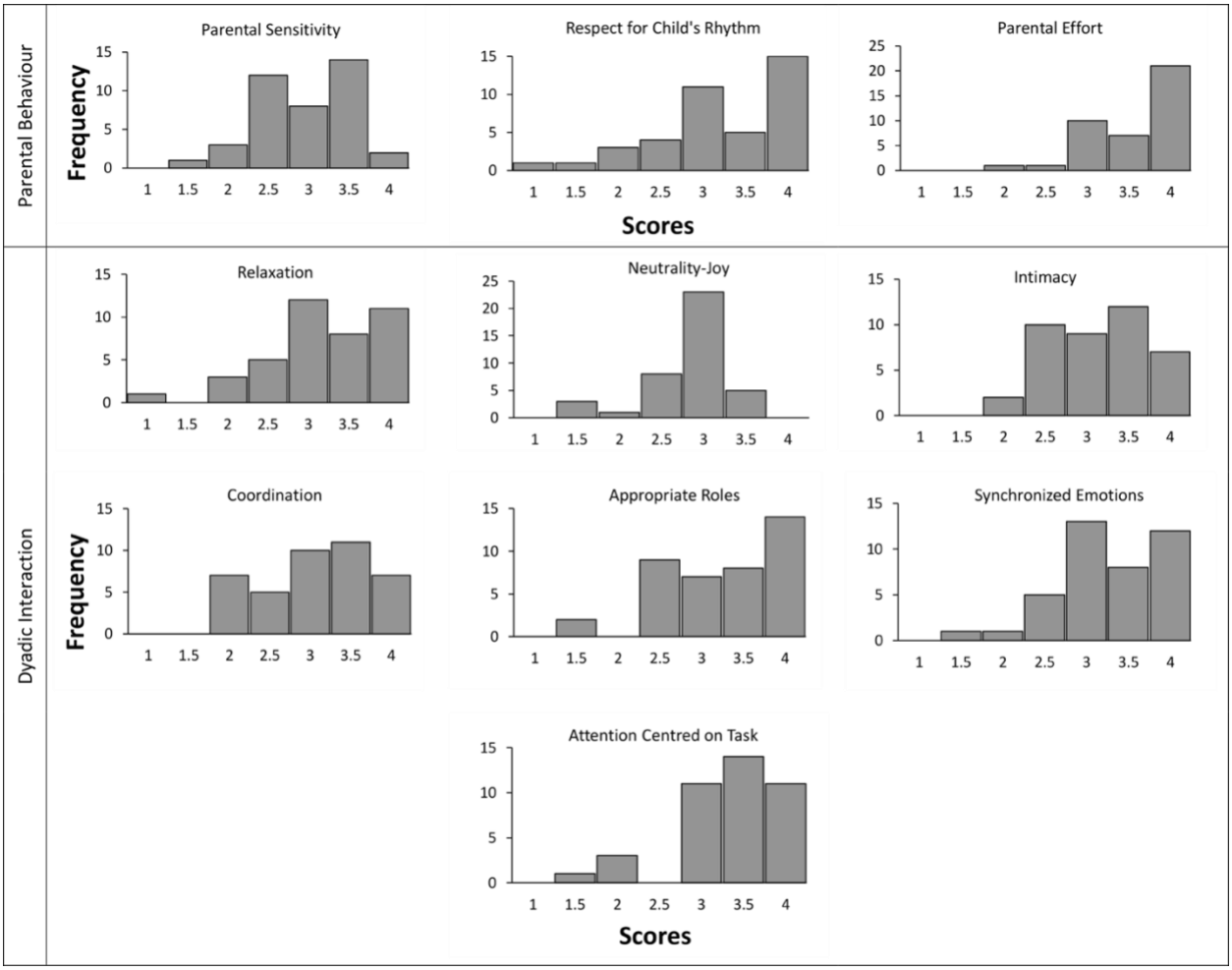


Table 3.3

Spearman's Rho Correlations between Quality of Interaction Subscales

	1	2	3	4	5	6	7	8	9	10
1. Parental Sensitivity	–	0.71***	0.39*	0.56**	0.62***	0.73***	0.85***	0.65***	0.64***	0.24
2. Respect for Child's Rhythm		–	0.14	0.79***	0.64***	0.77***	0.81***	0.63***	0.63***	0.35*
3. Parental Effort			–	0.24	0.11	0.27	0.37*	0.25	0.02	0.26
4. Relaxation				–	0.60***	0.61***	0.78***	0.63***	0.69***	0.15
5. Neutrality-Joy					–	0.59***	0.76***	0.45*	0.63***	0.22
6. Intimacy						–	0.83***	0.54***	0.53***	0.43**
7. Coordination							–	0.71***	0.72***	0.44**
8. Appropriate Roles								–	0.52***	0.25
9. Synchronized Emotions									–	0.25
10. Attention Centred on Task										–

Note. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Parental Behaviour.

Parental Sensitivity. Parents across the sample displayed autonomy-supportive behaviours, such as allowing their child to lead the homework activity, paying attention to the child, and offering help and encouragement when needed. Nevertheless, there was variability in the frequency of autonomy-supportive behaviours ranging from 1.5 (i.e., the parent very rarely supported the child's need for autonomy or provided help when needed, and the parent displayed a rigid behaviour pattern) to 4 (i.e., the parent was flexible in their approach and fully supported the child's need for autonomy). Most scores fell between 2.5 (i.e., rarely to sometimes supported the child's need for autonomy) and 3.5 (i.e., sometimes to fully supported the child's need for autonomy). Parents' mean score was 2.96 (SD = 0.59), indicating that, on average, parents sometimes to mostly exhibited sensitive behaviours towards their child.

Respect for Child's Rhythm. In general, parents respected the rhythm of the child (i.e., they were not overly intrusive) during the simulated math homework task (M = 3.23; SD = 0.79). Although parents' intrusion scores ranged from 1 (i.e., the parent took over the task) to 4 (i.e., the parent followed the rhythm of the child), most parents scored a 3 or 4 (i.e., the parent temporarily lost a little of the child's rhythm). That is, most parents allowed their child to lead the math task (e.g., determining which question to solve first or the way to solve the question).

Parental Effort. Parental availability to help on the task ranged from 2 (i.e., the parent appeared unsure how to help the child with the homework task, but help was sometimes made available) to 4 (i.e., the parent's help was always available, and the parent continually tried to help their child with their homework). No score of 1 was observed in the sample, meaning that all parents were available to help on the task at some point during the interaction. A total of 21 out of 40 dyads scored a 4 on the scale with the remaining dyads ranging between scores of 3

and 4. Overall, the participants' mean score was 3.58 (*SD* = 0.53), indicating that, on average, parents made themselves available to help their child with their homework for the majority of the interaction.

Dyadic Interaction.

Relaxation. In total, 31 of the 40 dyads scored a 3 or greater (out of 4) on the scale and the mean score was 3.19 (*SD* = 0.71), suggesting that, overall, interactions were more relaxed than tense. A score of 3 or greater indicates that most dyads were relaxed with slight levels of anxiety and presence of rigidity, but with no apparent nervousness. Only one dyad's interaction scored a 1, meaning that the interaction was rigid with many nervous behaviours and activities (e.g., overexcited).

Neutrality-Joy. Generally, dyadic interactions were neutral, rather than negative or fun. No dyad scored a 1 (i.e., negative) or 4 (i.e., fun). The lowest score given for this subscale was 1.5, meaning that the dyad interacted with some negativity from one of the partners. Further, 23 of the 40 dyads scored a 3 (i.e., neutral), with the remaining dyads mostly scoring around 3 (2.5 or 3.5). Indeed, the mean score was 2.83 (*SD* = 0.50); meaning, on average, the parent-child dyads' affect appeared neutral, indicating that they displayed no overt signs of negativity or pleasure.

Intimacy. With respect to the level of distance/intimacy, interactions were more intimate than distant. The lowest score recorded was a 2 (of 4) for two dyads, indicating that there was a marked use of distance and proximity in an uncomfortable way (e.g., the child did not appear at ease sitting beside their parent or was unable to ask their parent for help) between the parent and child, but it did not characterize the whole interaction. The rest of the dyads' scores were distributed from 2.5 to 4. The mean score was 3.15 (*SD* = 0.59), indicating that, on average, the

dyads appeared generally comfortable in proximity and the child was generally comfortable asking their parent for help on the task. Additionally, the parent and child often appeared comfortable talking to each other, and the tone of voice was occasionally positive (vs. neutral).

Coordination. Generally, the dyads were more coordinated than not during the interaction. Dyads' scores ranged from 2 (i.e., indicating non-collaboration from a member of the dyad) to 4 (i.e., coordination throughout the interaction). The mean score was 3.07 (*SD* = 0.68), indicating that, on average, the communication between the parent-child dyad was generally clear, direct, and appropriate, though short episodes that lacked coordination (e.g., little flexibility, confused activities and messages, uncomfortable silences) were observed.

Appropriate Roles. Most dyads assumed appropriate roles during the task. The lowest score recorded was a 1.5 for two dyads, which indicates that role reversal was present. That is, the child took on the role of the caregiver (e.g., the child gave direction to the adult, cared too much about the adult's well-being, or the child entertained the adult). The remaining dyads scored between 2.5 (i.e., the child tried to control) to 4 (i.e., appropriate roles). The mean score was 3.26 (*SD* = 0.72), indicating that, on average, the parent had more control in the situation than the child for most of the interaction. That is, the parent was able to establish limits and reward desired behaviours.

Synchronized Emotions. There was more emotional sharing than emotional imbalance between the dyads during the interaction. Dyads' scores ranged from 1.5 (i.e., significant mood fluctuations were observed between the dyad and/or there was a stark mismatch between parent and child affect) to 4 (i.e., emotional reciprocity between parent and child dyad; no abrupt changes in the emotional quality of the interaction). Most scores fell between 2.5 (i.e., parent and child rarely shared the same emotions) to 4. The dyad's mean score was 3.23 (*SD* = 0.63),

indicating that, on average, the emotional quality of the interaction in this sample occasionally changed throughout the interaction (e.g., from a neutral interaction to a negative interaction) or that the parent and child mostly showed the same emotion, but sometimes did not.

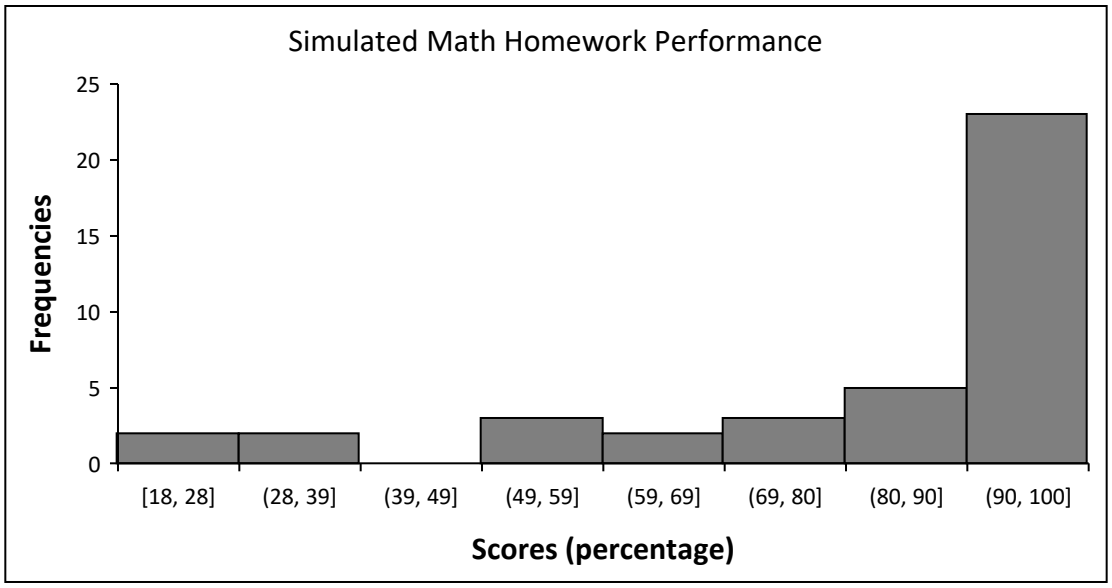
Attention Centred on the Task. Overall, dyads were observed as being focused on the math homework task rather than distracted. The sample's scores ranged from 1.5 (i.e., both the parent and child were distracted from the task for most of the interaction; infrequent eye contact) to 4 (i.e., the parent and child were almost always on task and focused on the homework). The sample's scores predominantly fell between 3 (i.e., mostly on task and focused on the homework) to 4. The mean score was 3.34 (SD = 0.62), indicating that, on average, the parent and child were usually on task and focused on the homework, but sometimes discussed topics unrelated to the task.

Hypothesis 1: Parent-Child Behaviours and Simulated Math Homework Task Performance

We next examined how the dyads' math task performance varied in association with the quality of the interaction. Task accuracy scores within the sample ranged from 18.20% to 100% (see Figure 3.2) indicating that all the dyads attempted at least one problem on the task. Overall, most parent-child dyads performed well on the task, 58% of the dyads scored 90 or higher on the task (M = 80.58; SD = 22.87). As shown in Table 3.4, the simulated math homework task performance was positively correlated with eight of the interaction quality subscales: appropriate role, relaxation, neutrality-joy, intimacy, coordination, synchronized emotions, parental sensitivity, and parental respect for the child's rhythm (r_s values: 0.47 to 0.60). Thus, overall, higher quality interactions were associated with better performance on the math task.

Figure 3.2

Distribution of Parent-Child Dyads' Performance on the Simulated Math Homework Task (n = 40)



Hypothesis 2: The Quality of the Interaction and Math Achievement

Hypothesis 2A: The interaction is more negative for lower math-achieving parents. There was a positive correlation between parents' math achievement and seven of the interaction quality subscales: relaxation, intimacy, coordination, appropriate roles, synchronized emotions, parental sensitivity, and parental respect for the child's rhythm observed during the math-related task interaction (r_s values: 0.32 to 0.44; see Table 3.4). That is, the dyads were more likely to assume their appropriate roles and the interaction was more relaxed, intimate, coordinated, and emotionally synchronized for parents with higher math achievement compared to parents with lower math achievement. Parents with higher math achievement also had higher parental sensitivity scores and lower parental intrusion scores than parents with lower math achievement.

Hypothesis 2B: The interaction is more negative for lower math-achieving children. In contrast to the findings between the quality of the interaction and parents' math achievement,

children's math achievement was only related to the degree of parental sensitivity and synchronized emotions displayed during the simulated math homework task (r_s = 0.36 and 0.35 respectively; see Table 3.4). Specifically, higher child math achievement was associated with more sensitive parental engagement and shared emotions in the parent-child dyad. Additionally, there was a marginal positive association between children's math achievement and the dyad's observed neutrality-joy during the task.

Hypothesis 3: The Quality of the Interaction and Math Anxiety

Hypothesis 3A: The interaction is more negative for higher math-anxious parents. When controlling for parents' generalized anxiety, there was no significant correlation between parents' math anxiety and any of the subscales measuring the quality of the interaction during the simulated math homework task.

Hypothesis 3B: The interaction is more negative for higher math-anxious children. When controlling for children's general anxiety, there was a significant, negative correlation between children's math anxiety and eight of the interaction quality subscales: relaxation, neutrality-joy, intimacy, coordination, appropriate role, synchronized emotions, parental sensitivity and, parental respect for the child's rhythm (*r* values: -0.43 to -0.60; see Table 3.4). That is, the interactions of children with higher math anxiety were less relaxed, less intimate, less coordinated, less emotionally synchronized, and characterized by increased role reversal relative to parent-child interactions where the children were lower in math anxiety. Further, parents of higher math-anxious children were lower in sensitivity and higher in intrusion during the interaction than parents of lower math-anxious children.

Table 3.4

Spearman's Rho Correlations between Parent-Child Behaviours and Individual Differences

Subscales	Task Performance	Math Achievement		Math Anxiety	
		Parent	Child	Parent	Child
Parental Behaviour					
Parental Sensitivity	0.55***	0.40**	0.36*	-0.21[a]	-0.58***[b]
Respect for Child's Rhythm	0.55***	0.44**	0.09	-0.24[a]	-0.59***[b]
Parental Effort	-0.09	0.07	-0.15	-0.06[a]	-0.25[b]
Dyadic Interactions					
Relaxation	0.50***	0.32*	0.19	-0.06[a]	-0.53***[b]
Neutrality-Joy	0.60***	0.18	0.29[t]	-0.26[a]	-0.57***[b]
Intimacy	0.50**	0.42**	0.16	-0.06[a]	-0.43**[b]
Coordination	0.57***	0.44**	0.26	-0.25[a]	-0.60***[b]
Appropriate Roles	0.47**	0.39*	0.16	-0.22[a]	-0.54***[b]
Synchronized Emotions	0.56***	0.36*	0.35*	-0.13[a]	-0.44**[b]
Attention Centred on Task	-0.04	0.04	0.03	-0.14[a]	-0.06[b]

Note. [t] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; [a]partial correlations controlling for parents' general anxiety; [b]partial correlations controlling for children's general anxiety; see Table C1 for Spearman's Rho correlations without controlling for general anxiety.

Section 2: Parent-Child Affective Language During the Math Homework-Helping Interaction

In this section, one dyad was excluded from the sample due to the predominant use of French language during the interaction, rendering it unassessable using the LIWC-2022 text analysis software. Consequently, the subsequent results are based on the analysis of 39 dyads.

Describing the Quality of the Simulated Math Homework Task Interaction in Relation to the Parent-Child Affective Language

Total Word Count. Across the parent sample, there was variability in the number of total words spoken during the simulated math homework task interaction ranging from 380 total spoken words to 3133 total spoken words. On average, parents spoke 1455.23 words (*SD* = 695.86). Children's total spoken words during the interaction was also variable and ranged from 357 to 1931 spoken words. On average, children spoke 1100.64 words (*SD* = 375.83). There was no statistically significant correlation between parents' and children's total word count during the interaction.

Positive Word Count. During the interaction, parents' use of positive words ranged from 0% to 3.52% of their total word count. Such words included, but were not limited to, "good," "confident," "awesome," "yay," and "excellent." On average, parents' use of positive words accounted for 0.63% of their total word count (*SD* = 0.65). The variability in the percentage of positive words used by children during the interaction was smaller, with children's use of positive words ranging from 0% to 0.74% of their total word count. On average, children's use of positive words accounted for 0.19% of their total word count (*SD* = 0.21). There was no statistically significant correlation between parents' and children's positive word count during the interaction.

Negative Word Count. Parents' use of negative words during the simulated math homework helping interaction ranged from 0% to 0.47% of their total word count. Such words included, but were not limited to, "stress," "worry," "angry," "tired," and "confusing." On average, parents' use of negative words accounted for 0.09% of their total word count (*SD* = 0.13). Children's use of negative words during the interaction ranged from 0% to 0.82% of their total word count. On average, children's use of negative words accounted for 0.15% of their total word count (*SD* = 0.18). As demonstrated in Table 3.5, there was a marginally significant, positive correlation between parents' and children's use of negative words, $r_s(37) = .30$, $p < .10$.

Table 3.5

Spearman's Rho Correlations Between Parent and Child Word Count

	1	2	3	4	5	6
1. Total Word Count (Parents)	-	-0.27	0.20	0.14[a]	0.14	-0.00
2. Positive Word Count (Parents)[b]		-	-0.17	-0.06	0.18	-0.06
3. Negative Word Count (Parents)[b]			-	-0.05	-0.08	0.30[t]
4. Total Word Count (Children)				-	0.25	0.14
5. Positive Word Count (Children)[b]					-	0.10
6. Negative Word Count (Children)[b]						-

Note. [a]This analysis was performed using a Pearson's R correlation; [b]percentages; [t] $p < 0.10$.

Hypothesis 1: Parent-Child Affective Language and Simulated Math Homework Task Performance

Here, we examined how the dyads' math task performance varied in association to the parents' and children's affective language during the interaction. Recall that task accuracy in the sample varied from 18.20% to 100%, with 58% of parent-child dyads scoring 90% or higher on the task (M = 80.58; SD = 22.87; see Figure 3.2). As shown in Table 3.6, the simulated math homework task performance was positively correlated with parents' positive word count, $r_s(37)$ = .64, $p < .001$.

Hypothesis 2: Parent-Child Affective Language and Math Achievement

Hypothesis 2A: Parent and child language is more negative for lower math-achieving parents. There was no statistically significant correlation between parents' math achievement and negative word counts by parents or children. However, the relation between parents' positive word count and their math achievement was found to be statistically significant, $r_s(37) = 0.36$, $p < .05$, indicating that the percentage of positively valanced words used by parents during the simulated math task interaction was lower when they scored lower in math achievement.

Hypothesis 2B: Parent and child language is more negative for lower math-achieving children. In line with the hypothesis, the relation between children's negative word count and child math achievement was found to be statistically significant, $r_s(37) = -0.32$, $p < .05$, indicating that the percentage of negatively valanced words used by children during the simulated math task interaction was higher when they scored lower in math achievement. In

contrast, there was no statistically significant correlation between children's math achievement and negative word counts by parents.

Hypothesis 3: Parent-Child Affective Language and Math Anxiety

Hypothesis 3A: Parent and child language is more negative for higher math-anxious parents. When controlling for parents' generalized anxiety, there was no significant correlation between parents' math anxiety and negative word counts by parents or children.

Hypothesis 3B: Parent and child language is more negative for higher math-anxious children. Similarly, when controlling for children's generalized anxiety, there was no significant correlation between children's math anxiety and negative word counts by parents or children. However, the relation between parents' positive word count and children's math anxiety was found to be statistically significant, $r_s = -0.52$, $p < .001$, indicating that the percentage of positively valanced words used by parents during the simulated math task interaction was lower when they had higher math-anxious children.

Table 3.6

Spearman's Rho Correlations between Parent-Child Affective Language and Individual Differences

Affective Language	Task Performance	Math Achievement		Math Anxiety	
		Parent	Child	Parent[b]	Child[c]
Positive Word Count (Parents)[a]	0.64***	.0.36*	0.18	-0.10	-0.52***
Negative Word Count (Parents)[a]	-0.19	-0.02	-0.19	-0.07	0.28
Positive Word Count (Children)[a]	0.09	0.03	0.12	0.19	-0.18
Negative Word Count (Children)[a]	-0.06	0.13	-0.32*	0.07	-0.01

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; [a]percentages; [b]partial correlations controlling for parents' generalized anxiety; [c]partial correlations controlling for children's generalized anxiety; see Table C2 for Spearman's Rho correlations without controlling for general anxiety.

Discussion

In the present study, parent-child dyads were recorded engaging in a simulated math homework interaction, which was then coded to assess the quality of the homework-helping interaction through parent-child behaviours and affective language. Further, parents' and children's levels of math and general anxiety were obtained using self-reported measures, and standardized assessments of parents' and children's math achievement were administered. In terms of parents' and children's behaviour during the interaction, the overall quality for the sample was found to be more positive than negative. Regarding language, the analyses revealed that both parents and children actively participated in verbal communication during the interaction. The quality of the interaction did vary, and portions of this variability were associated with performance on the simulated homework task, parents' and children's math achievement, and children's math anxiety.

Relations Between the Quality of Interaction and Math Task Performance

Generally, participants performed well on the simulated math homework task, with more than half of the dyads (23 of 40) scoring greater than 90%. However, the dyads' performance on the math task varied in relation to the quality of the interaction. In terms of the parent-child behaviours, dyads who obtained higher scores on the simulated math task were observed to be more relaxed, neutral-joyful, intimate, coordinated, and emotionally synchronized, and they exhibited appropriate roles. Further, dyads who obtained higher scores on the simulated math homework task had parents who were observed to be more sensitive and respectful of their child's rhythm. In terms of the affective language, there was no relation between the use of negative words during the interaction and the performance on the simulated math task, thus disconfirming the initial hypothesis. However, parents who spoke more positive words in total obtained higher scores on the simulated math homework task with their children. Because of the

correlational nature of analyses, one cannot conclude from the present data set whether the higher quality interaction led to better performance on the simulated math homework task or whether performing well on the simulated math homework task led the dyads to engage in a high-quality interaction.

Relations Between the Quality of the Interaction and Math Achievement

The quality of the interaction during a simulated math homework task, as defined by parents' and children's behaviours, was found to be more relaxed, intimate, coordinated, and emotionally synchronized for parents with higher math achievement compared to parents with lower math achievement. Moreover, higher math achieving parents were more sensitive to their child's needs, respectful of their child's rhythm, and were able to take on an appropriate parental role during the homework intervention. It is possible that parents who are higher in math achievement simply have higher quality interactions with their children across other domains as well, such as science and language arts. It is, however, more reasonable to hypothesize that having a higher level of domain-specific expertise (here, math), allows a parent to be more comfortable and confident themselves in that domain, which, in turn, allows them to facilitate higher quality domain-specific interactions with their child. With respect to children, higher math achieving children exhibited dyadic behaviours that were more emotionally synchronized and that were slightly more neutral-joyful. Higher math achieving children also had parents who showed higher levels of sensitivity (i.e., lower intrusiveness) during the simulated math homework task interaction, compared to those dyads in which the children had lower math achievement scores. These findings align with those reported by Trautwein et al. (2009), who reported that lower achievement in children is related to less pleasant homework-related emotions.

Regarding the affective language, parents, but not children, were found to speak more positive words during the simulated math task interaction with their children when they were higher in math achievement. Considering the findings of Chapter 2 (Study 1) that found that parents who are higher in math knowledge report increased confidence in their ability to help their child with their math homework, it is possible that higher math achieving parents' confidence is conveyed through their use of positive language during the homework-helping interaction. On the other hand, children, but not parents, were found to speak more negative words during the interaction when they were lower in math achievement, thus partially confirming the hypothesis that increased negative language use would relate to poorer math achievement. It is conceivable that the negative language spoken by children reflects their self-efficacy in mathematics. Self-efficacy in this subject represents a person's beliefs about their abilities to successfully carry-out a math-related task (Hackett & Betz, 2020). Importantly, research has linked low levels of math achievement with self-efficacy (Ferla et al., 2009; Lee, 2009; Pajares & Miller, 1994).

Relations Between the Quality of the Interaction and Math Anxiety

The relations between parents' and children's math anxiety (controlling for their general anxiety) and the quality of their interaction were also explored. In previous research, Maloney et al. (2015) showed that when math-anxious parents frequently helped their child with their math homework, their child learned less math and became more math anxious than children of math anxious parents who did not frequently help their child with math homework. To explain Maloney et al.'s (2015) findings, Retanal et al. (2021) hypothesized that parents' math anxiety contributes to a poorer quality of math homework-helping interactions (i.e., more negatively charged and with more parental control), which in turn leads to less optimal math outcomes in

children. The current findings did not support this hypothesis. Although parent and child math anxiety were found to be marginally positively related (i.e., parents who were higher in math anxiety tended to have children who were also higher in math anxiety), parental math anxiety was not related to the parent-child behaviours, nor the affective language, during the simulated math homework interaction. These findings, along with those of Chapter 2 (Study 1), which reported that higher math-anxious parents perceive the math homework-helping environment to be more negative (i.e., more distant/cold, frustrating, conflict-ridden, and stressful), suggest that although higher math-anxious parents perceive their math homework-helping interactions as more negative than do lower math-anxious parents, those interactions are not rated as more negative by trained coders. Thus, higher math-anxious adults may generally *perceive* math-related experiences more negatively than do lower math-anxious adults. This conclusion is consistent with the findings of Hunt and Maloney (2022), who found that adults' math anxiety was related to their appraisals of previous math experiences.

On the other hand, children's math anxiety was negatively related to the quality of the interactional behaviours, during math homework-helping interaction. Specifically, the dyads with higher math-anxious children displayed less relaxation, neutrality-joy, intimacy, coordination, and emotional synchronization. Further, parents of higher math-anxious children exhibited lower sensitivity to their child's needs and less respect for their child's rhythm, and these dyads were more frequently found to inverse roles in their relationship. Regarding language, parents with higher math-anxious children spoke less positively valanced words during the interaction. Again, because these data are correlational, it cannot be inferred whether lower quality math-related interactions between parents and their children occur as a result of children having increased math anxiety or whether lower quality math-related interactions result in children developing

math anxiety. It is also, of course, possible that a reciprocal relation exists between children's math anxiety and the quality of their math-related interactions with their parents.

Taken together, the results of the current study revealed that although parent-child dyads generally performed well on the simulated math homework task, and that task performance varied in relation to the quality of the interaction. Specifically, higher performance on the math homework task was associated with a higher quality of the interactional behaviours, coupled with the increased use of positive words used by parents. The present findings also indicated a positive relation between the parents' and children's math achievement and the higher quality of the interactional behaviours. Moreover, the current results demonstrated that only children's math anxiety was associated to the variability of the quality of the interactional behaviours, which seemingly contradict the notion that parents' math anxiety contributes to poorer quality math homework-helping interactions, in turn leading to less optimal math outcomes in children (cf. Chapter 2 [Study 1] and Retanal et al., 2021). Finally, when considering the quality of the affective language, parents' and children's use of negatively valanced words were marginally associated, thus supporting the notion that children may be imitating actions that are modelled by their parent. Moreover, positive words employed by parents during the interaction related to higher math achievement in parents and to a better performance on the simulated math task. The current findings further suggest that the fewer positive words used by parents related to higher levels of math anxiety in children. There is a vast amount of research indicating that parental praise is beneficial to children's outcomes when reflecting the child's effort on the task at hand (e.g., higher level of motivation, improved problem-solving skills, and increased persistence; Henderlong & Lepper, 2002). It is plausible that the positive words used by parents reflect a type of praise for the child's work on the simulated math task (e.g., "excellent" and "amazing"), thus

leading to a better performance on the task overall. Higher math achieving parents may experience more confidence in their ability to assist their child in their math homework, leading to more positive language use.

Limitations and Future Research

This study offers novel insights into the quality of homework-like math interactions between parents and their 10- to 12-year-old children. Several factors were identified (i.e., parents' and children's math achievement and children's math anxiety) that were associated with the variability in the quality of the homework-helping interaction and accuracy on the homework task. We acknowledge, however, that this study has limitations. Data from this study were derived from a small sample (n = 40) and thus effect sizes should be interpreted with caution. Moreover, controlling for the effect of the testing environment is an important step to ensure that any associations between variables are due to the variables of interest rather than external factors. However, only three out of forty participants were tested in their homes, making it difficult to reliably estimate the effect of the testing environment.

Because the study was correlational and the data were collected at a single time point, inferences cannot be made about the causal direction of the observed relations. In future research, a longitudinal design may provide more information about whether children's math anxiety develops *because* of the negative quality of the homework-helping interaction or if, rather, higher math-anxious children's engagement with their parents affects how the quality of the interaction unfolds. It is also possible that there are reciprocal relations between children's math anxiety and their experiences in homework interactions. Else-Quest et al. (2008) provide some insight into the current findings. According to their study, mothers were more likely to show negative emotions (i.e., contempt) towards their child during a math homework-helping

interaction if their child performed poorly on a prior math task. Further, the emotions that mothers and their child displayed when working on mathematics problems at home were found to be significantly positively correlated, regardless of the emotional valence. The researchers posit that this relation may demonstrate how parents may influence their child's emotions during homework-helping interactions.

In terms of the quality of the language spoken during the interaction, the present findings were limited by the linguistic analysis software. While the current findings provide a sense of the types of words used during the math homework-helping interaction, they do not consider the tone in which these words are communicated. Additionally, certain words employed by parents were quantified as negative (e.g., "I know you're *tired*"); however, the nature of this form of communication has been demonstrated to have beneficial effects for children's psychological well-being. Indeed, recognizing and affirming emotions, a fundamental aspect of parenting often associated with the philosophy of 'emotion coaching' (Gottman et al., 1996), has been correlated with favourable developmental outcomes in children, such as improved emotion regulation (Gottman & DeClaire, 1997), reduced externalizing and internalizing problems (Shipman et al., 2007), enhanced academic performance (Raver et al., 2007), and stronger parent-child relationships (Katz et al., 2012).

Finally, in the present study, we focused on the primary math homework-helping parent and their child. Reciprocal determinism—a notion derived from Bandura's Social Learning Theory—suggests that there is a constant interplay between individual behaviour, cognitive processes (e.g., attitudes and beliefs), and the larger environment (e.g., parents, teachers) (Bandura, 1978). Other factors that may account for variability in the quality of the interaction between parents and their children were not considered in the current study. For example,

children may have access to resources in their environment (e.g., school support, tutoring, help from other members of the household, etc.), which could influence their approach to math-related activities. Given that recent research highlighted a relation between lower frequency of home numeracy activities and higher levels of math anxiety in children (Guzmán et al., 2023), future research should take the time parents spend engaging in math activities with their children into account to provide context for the homework-helping interaction.

Implications and Conclusions

One major strength of this study lies in the measurement of both parent and child factors, as well as the direct observation of dyadic interactions, to investigate the relations between math anxiety, math achievement, and the math homework-helping interaction. The results underscore the role of positive interactional behaviours, including the use of positively valanced language by parents, in enhancing children's performance on math-related tasks. This highlights the potential benefits of fostering a supportive and attuned environment during homework-helping interactions, which could influence children's motivation and confidence in tackling mathematical challenges. Understanding the factors associated with the variability in such interactions provides insight into why some math homework-helping interactions are more optimal than others. For example, parents who demonstrate proficiency in math may be better equipped to provide effective support and guidance to their children. This emphasizes the importance of fostering parental confidence and competence in math-related activities, potentially through targeted interventions or educational resources aimed at enhancing parental math skills.

Finally, the findings not only highlight the importance of understanding how cognitive and emotional factors can relate to the quality of dyadic math-related interactions, but also the

importance of using multiple study methods. Indeed, the story told by the self-report data did not align perfectly with that told by experimenter observation. Thus, in order to garner a rich understanding of the various factors at play, multiple approaches must be used. This study represents the first, to our knowledge, to have taken this innovative approach to studying the relations between parent and child math anxiety, math achievement, and interactions within a math-related context.

CHAPTER 4: Study 3

Beyond the Homework-Helping Interaction: The Influence of Parent-Child Attachment on Mathematics Achievement and Anxiety

Author's Note

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Disclaimer: Impact of COVID-19 Pandemic on Research Analyses

In light of the unprecedented global challenges posed by the COVID-19 pandemic, it is imperative to acknowledge its substantial impact on the nature of the present research. The ongoing pandemic necessitated adaptations to the original research design and subsequently influenced the outcomes and conclusions presented in this paper.

The original intent of this study was to examine 77 parent-child dyads (G*Power analysis: effect size = 0.3, $\alpha = 0.05$, Power = 0.95), with the aim of conducting moderated mediation analyses. However, due to the limitations imposed by the COVID-19 pandemic, which halted data collected in early 2020, we were unable to resume participant recruitment while also maintaining the integrity of the research design. Consequently, we were unable to execute the initially proposed analyses as outlined in the research proposal. The inability to achieve the originally planned sample size and execute the initially intended analyses led to a modified research approach. As such, the paper primarily reports on correlational associations within the available dataset, rather than extensive inferential analyses. Nonetheless, in the spirit of transparency and scholarly rigour, the originally proposed analyses were conducted with the available dataset for demonstrative purposes. The detailed results of these analyses can be found in Appendix D, which provides insight into the potential trajectory the research would have taken under different circumstances.

Abstract

Parental involvement in the home math environment—including the quality of the parent-child interaction during homework help—has been shown to be beneficial for children's mathematical well-being. Previous research has linked the quality of parent-child interactions with feelings of confidence that the child has developed towards their parent (i.e., attachment security; Moss et al., 1998). However, further investigation is necessary to understand how the behavioural manifestations of attachment relate to children's math anxiety and math achievement. Thus, the aim of the current study was to investigate whether a child's attachment security/insecurity is associated with the quality of interactions observed with the parent during math homework-helping sessions, and subsequently, how this relates to their levels of math anxiety and math achievement. Thirty-eight parents and their children (ages 10-12 years; grades 5 to 7) completed self-report measures of math and general anxiety. Parents and children completed standardized assessments of math achievement and were then recorded as they engaged in 1) a simulated math homework interaction, and 2) a conflict task, which were then coded to assess for the quality of the interaction and attachment security/insecurity. Greater attachment insecurity in the child was linked to lower quality interactions in the math task. Additionally, insecure attachment in the child was correlated with increased math anxiety in children when controlling for parents' math anxiety, but not with math achievement. These results suggest that educators and researchers should embrace a more holistic approach, considering attachment relationships along with cognitive and emotional factors to gain a deeper understanding of children's math experiences.

Keywords: parent-child interactions, math anxiety, math achievement, attachment, homework

Beyond the Homework-Helping Interaction: The Influence of Parent-Child Attachment on Mathematics Achievement and Anxiety

Parental involvement in math-related activities at home, which has been associated with significant benefits for children's math outcomes (Daucourt et al., 2021), underscores the importance of the quality of interaction between parent-child dyads—particularly during homework assistance—in shaping children's attitudes and achievements in math (Cooper et al., 2000; Maloney et al., 2015; Wilder, 2014). Social learning theory suggests that children's behaviours, attitudes, and emotional responses evolve through observational learning, notably from influential role models (Bandura, 1985). The parent-child relationship serves as a significant context for such learning (Maccoby & Martin, 1983). During homework-helping interactions, parents have the capacity to significantly influence their children's mathematical well-being by exemplifying effective math-related behaviours, namely during homework sessions, where they can model behaviours, attitudes, and emotional responses that children are likely to emulate (Hoover-Dempsey et al., 2001). In addition to this, the quality of parent-child interactions contributes to the confidence children develop towards both their parents and themselves, often arising within the framework of a secure parent-child attachment relationship (Moss et al., 1998).

Previous studies have associated insecure parental attachment and lower academic achievement (Keller et al., 2008; Moss & St-Laurent, 2001). Furthermore, extensive research highlights the adverse influence of math anxiety (i.e., the level of fear, apprehension, or discomfort when engaging with mathematical tasks or concepts; Ashcraft, 2002) on mathematics achievement (e.g., Ashcraft et al., 2007; Beilock & Maloney, 2015; Hembree, 1990; Ma & Xu, 2004; Maloney et al., 2015). Recent investigations suggest that insecure attachment to parents

can exacerbate math anxiety. However, exploration of attachment's role in children's math anxiety remains limited, with only two studies to date examining this aspect (see Bosmans & De Smedt, 2015; Demirtaş & Uygun-Eryurt, 2020). These studies used primarily self-reported data and overlooked parental math anxiety, which plays a role in children's levels of math anxiety. Therefore, more comprehensive research methodologies are needed to explore the links between attachment and children's mathematical well-being. In this study, children's attachment relationship to their homework-helping parent was investigated, using a task separate from a simulated math homework-helping interaction. The overarching aim was to understand how children's attachment security/insecurity to their parent, evaluated through behavioural manifestations of attachment, would relate to their mathematics achievement and math anxiety.

Attachment Theory

Attachment theory holds immense significance in the field of child development. Since its emergence, attachment theory has shed light on the crucial role played by relationships between children and their caregivers, and the lasting consequences they yield. Notably, parent-child attachment styles predict several developmental trajectories, particularly in social, emotional, and psychopathological domains (e.g., DeKlyen & Greenberg, 2008; Sroufe, 2005).

Attachment theory conceptualizes attachment styles in terms of security and insecurity, which significantly influence children's developmental trajectories. Secure attachment typically arises when caregivers demonstrate sensitivity (Ainsworth et al., 1978), fostering children's confidence in the caregiver's ability to provide comfort and support in distressing times through a safe haven. Further, securely attached children find solace in their caregivers and feel secure to explore their surroundings due to the presence of a secure base. Conversely, children exposed to insensitive caregiving are prone to developing insecure attachments, lacking trust in caregivers

as sources of comfort and support. These insecure attachments can manifest in various forms, such as avoidance, ambivalence, or disorganization (Cassidy, 1994; Lyons-Ruth & Jacobvitz, 2016). Disorganized attachment patterns, including controlling-caregiving and controlling-punitive behaviours, often emerge in response to inappropriate caregiver responses (Lyons-Ruth & Jacobvitz, 2016). These attachment patterns have been observed across various developmental stages, from preschool to late adolescence (Bureau et al., 2009; Moss et al., 2011; Obsuth et al., 2014).

Further, Bowlby (Bowlby, 1969/1982, 1973, 1980) proposed that children's attachment relationships shape their development through the formation of internal working models. These internal working models are cognitive structures formed by expectations about caregiver availability and responses (Bowlby, 1973). Consistently sensitive support from caregivers can shape a child's internal working models, fostering expectations of help and love when needed. This responsiveness communicates the child's worthiness of attention and affection, influencing their evaluation of self-worth and perceptions of caregiver accessibility. Bretherton and Munholland (2008) hypothesized that children who have developed secure attachment models are more likely to feel confident in their own abilities, to be more willing to explore new environments, and to seek support from trusted adults when needed. Ultimately, this enhances the child's self-image and belief in their capabilities. On the other hand, a child with an insecure attachment, characterized by rejection or unpredictability, may develop an internal working model marked by a more negative self-perception, such as unworthiness and self-reliance (Bowlby, 1969/1982). Bowlby suggested that these internal working models, akin to attachment patterns, contribute to psychopathology and child development (Bowlby, 1969/1982).

Academic Achievement, Math Anxiety, and the Attachment Relationship

Previous research has linked insecure attachment to parents with lower academic achievement (Keller et al., 2008; Moss & St-Laurent, 2001). Specifically, school-aged children with insecure attachment tend to exhibit lower verbal ability, reading comprehension, and overall academic performance (Granot & Mayseless, 2001; Jacobsen & Hofmann, 1997; Pianta & Harbers, 1996; Weinfeld et al., 1999). Regarding mathematics, studies have identified a correlation between attachment insecurity and poorer math achievement (Keller et al., 2008; Moss & St-Laurent, 2001). A recent meta-analysis by Deneault et al. (2023), which included a total of 125 studies, found that that attachment security was associated with increased child cognition, which includes problem-solving, memory, attention, and reasoning abilities. Such skills a necessary for success in mathematics. Deneault et al. (2023) further suggest that attachment may influence cognition through mechanisms such as the attachment-exploration hypothesis, which posits that securely attached children may be more inclined to explore their environment, leading to increased cognitive stimulation. Consequently, children with secure attachments may feel more confident in their abilities to tackle math-related problems, finding support and encouragement from their caregivers in their academic pursuits.

The perception of mathematics as inherently stressful and challenging is widespread (Beilock & Willingham, 2014), especially among individuals who experience math anxiety (Ashcraft, 2002; Richardson & Suinn, 1972). Research consistently demonstrates that math anxiety negatively impacts achievement in mathematics (e.g., Ashcraft et al., 2007; Beilock & Maloney, 2015; Hembree, 1990; Lyons & Beilock, 2012; Ma & Xu, 2004). Parental influences also play a significant role in shaping children's attitudes towards and performance in math. Studies have found a positive relationship between parental and child math anxiety (e.g., Casad

et al., 2015; Maloney et al., 2015; Soni & Kumari, 2017), with parents' math anxiety inversely linked to children's math achievement (Dahmer, 2001).

Recent research suggests that attachment to parents can also contribute to math anxiety. To date, only two studies have explored the role of attachment relationships on children's math anxiety (see Bosmans & De Smedt, 2015; Demirtaş & Uygun-Eryurt, 2020). Bosmans and De Smedt (2015) took the first steps in investigating the way in which insecure attachment may play a role in the development of math anxiety. In a sample of 87 Flemish children (M_{age} = 10.34 years, SD = 0.63) from a variety of socioeconomic backgrounds, the authors found that math anxiety might develop in the context of insecure parent-child attachment relationships, wherein the link between insecure attachment and poor mathematics achievement is mediated by child math anxiety. Specifically, the authors showed that higher levels of math anxiety in children were associated with insecure attachment, and math anxiety mediated the relation between insecure attachment and math achievement. In 2020, Demirtaş and Uygun-Eryurt investigated the relationships among attachment to parents, hope, perceived school climate, and math anxiety in early adolescents in a Turkish sample of 300 secondary school students (grades 7 and 8) and found that attachment was negatively correlated with math anxiety. Both of these studies used the Experiences in Close Relationships Scale-Revised adapted for children (Brenning et al., 2011), a self-reported measure to assess the quality of the attachment relationship. Moreover, given the evidence indicating that parental math anxiety is related to children's math anxiety (Casad et al., 2015; Maloney et al., 2015; Soni & Kumari, 2017), it is important to consider the influence of parental math anxiety when investigating the associations between attachment and key child factors, such as math anxiety and math achievement.

It is conceivable that children who are insecurely attached and have parents with higher levels of math anxiety may internalize a belief that they are incapable of managing challenging tasks such as math. Consequently, they may feel unable to depend on their parent for homework support, especially if the parent has consistently been unresponsive or rejecting during times of distress. These children may be more prone to making mistakes on math-related tasks, or they may avoid such tasks altogether. This dynamic provides one possible pathway to explain why children with higher math-anxious parents develop math anxiety themselves. Conversely, securely attached children, regardless of their parent's levels of anxiety towards math, may be better able to regulate their stress when confronted with a math task. A secure attachment to the math homework-helping parent could foster a sense of confidence in the child regarding their own abilities, as well as a sense of trust that their parent will offer emotional support if necessary. A securely attached child would thus find a secure base in their homework-helping parent, enabling them to tackle challenging math tasks with greater ease and openness during interactions with the parent. Within this line of thought, a secure attachment may actually serve as a buffer between the transmission of parent math anxiety to child math anxiety.

Math Homework and Assessment of Attachment During Middle Childhood

The middle childhood age, as discussed in Chapter 1, stands out as an optimal developmental period for examining children's mathematical well-being in the context of homework assistance. This stage represents a phase where children dedicate more time to homework compared to their younger years. Additionally, they still heavily depend on parental support for completing their homework assignments.

The majority of research concerning middle childhood typically uses various methods to assess attachment, broadly categorized as representational measures. These methods include

story stem procedures (e.g., Granot & Mayseless, 2001; Kerns et al., 2011), autobiographical interviews (e.g., Kriss et al., 2013), script story assessments evaluating secure base knowledge (e.g., Psouni & Apetroaia, 2014; Waters et al., 2015), and the use of questionnaires (e.g., Kerns et al., 2001). However, Main et al. (1985) proposed that evidence of attachment processes should be discernible not only in attachment representations but also in observable attachment behaviours. Thus, in this study, the Middle Childhood Attachment Strategies (MCAS; Brumariu et al., 2018)—an observational assessment of attachment—was employed to measure parent-child attachment patterns.

The MCAS was developed to evaluate the behaviours and interactions that characterize attachment relationships in children in middle childhood. In their study involving 87 children aged 10-12 and their mothers, Brumariu et al. (2018) employed various criteria, including associations with other attachment measures, parenting styles, social competence, and indicators of psychopathology, to validate the MCAS. Their findings indicated significant associations between the MCAS and theoretically relevant constructs such as maternal warmth/acceptance and psychological control, as well as children's social competence, depression, and behavioural problems. Furthermore, the study examined the construct validity of the MCAS by comparing it with other measures of attachment in middle childhood. It was observed that MCAS security correlated with security levels assessed using the security scale (Kerns et al., 2001), and each MCAS attachment pattern corresponded with its equivalent identified through a story stem procedure.

These findings provide preliminary support for the psychometric properties of the MCAS and its ability to capture subtle behavioural nuances associated with attachment, parenting, and

child adjustment during middle childhood. Additionally, they highlight the usefulness of this measure in assessing attachment dynamics during this developmental stage.

Objectives and Hypotheses

In Chapter 3 (Study 2), we demonstrated that children's performance on a simulated math homework task increased when the quality of the homework-helping interaction with their parents was more positive. Additionally, the quality of the interaction varied in terms of parents' and children's math achievement, as well as children's math anxiety. Research has established a link between the quality of parent-child interactions and the attachment relationship within the dyad (Moss et al., 1998). However, further investigation is needed to better understand how a child's attachment to their parent influences the quality of math homework-helping interactions, as well as how the accuracy on a math task varies as a function of the child's attachment to their homework-helping parent. Finally, in this study, the objective was to examine the relationship between children's attachment to their parent, assessed through observation, and their levels of math anxiety and math achievement. The analysis controlled for parents' math anxiety, given its influence on children's math anxiety and achievement.

In the present study, it was first hypothesized that a higher quality of the math interaction would be associated with attachment higher security and lower attachment insecurity (Hypothesis 1). It was further hypothesized that higher attachment security would relate to a better performance on the math homework task and higher attachment insecurity would relate to a poorer performance on the math homework task (Hypothesis 2). Finally, it was hypothesized that greater attachment security would be associated with lower math anxiety, while greater attachment insecurity would be linked to higher math anxiety (Hypothesis 3A). Similar patterns

were expected for math achievement (Hypothesis 3A) in children, after accounting for parents' levels of math anxiety.

Method

Participants

Before the onset of the COVID-19 pandemic, 41 pairs of parents and children (children in grades 5 to 7) were recruited to take part in this study. Potential participants were contacted through various methods, including online advertisements on platforms like Facebook and Twitter, community centres (such as summer camps and recreational centres), announcements distributed by a school board, and by distributing flyers with a brief study description at the University of Ottawa. The recruitment took place in a large Eastern Ontarian city in Canada. To be eligible for participation, children had to be in grade 5, 6, or 7, and both parents and children needed to be proficient in English. Additionally, parents were required to be the primary homework helpers for their child. Non-biological caretakers were also welcomed (e.g., adoptive parents or stepparents) to join the study, although none partook in the study. As a token of appreciation for their participation, parents received $20 CAD, and children were given the option to choose between a small toy or a $5 Tim Horton's gift card.

One dyad was removed from the sample because of an audio recording error, and two more dyads were removed because they did not complete all necessary tasks, resulting in an analytical sample of 38 participants. All parents (n = 32 women; M_{age} = 43.61 years) reported that they were the primary math homework-helping parents. Parents reported a range of education levels: some college with no diploma (15.8%); college diploma (26.3%); bachelor's degree (31.6%); master's degree (21.1%); and doctoral degree (5.3%). The median education level was a bachelor's degree. As for the children, 12 were in Grade 5 (n = 9 girls; M_{age} = 10.00

years), 20 were in Grade 6 (n = 12 girls; M_{age} = 10.90 years), and 6 were in Grade 7 (n = 2 girls; M_{age} = 11.83 years).

Procedure

The present study followed the same procedure as the one outlined in Chapter 3 (Study 2). In addition to completing the simulated math homework-helping task and an online questionnaire, followed by the WJ-IV, which were detailed in Chapter 3 (Study 2), dyads participated in a conflict task (Brumariu et al., 2018). Given the potential confounding influence of the conflict task on child and parent behaviours during the other tasks, this task was systematically administered last to reduce contamination risks.

The conflict task was used to assess child-parent attachment in middle childhood (Brumariu et al., 2018). Dyads were asked to discuss a conflict in their relationship, using the prompts, "*why* is this a problem?" and "what are your *feelings* about the problem?" They were also asked to attempt to find a solution to this conflict. Participants were given 10 minutes to complete this task. The conflict task is designed to evoke attachment behaviours by prompting discussion of an emotionally salient topic. Additionally, this task provides a context in which an older child expresses their views, while navigating their parent's potentially opposing views (Allen et al., 2002; Obsuth et al., 2014).

Materials

Mathematics Anxiety

Participants' (both parent and child) math anxiety was measured using the nine-item Abbreviated Math Anxiety Scale (AMAS; Hopko et al., 2003), which is described in Chapter 2 (Study 1a).

Child Mathematics Achievement

Children's mathematics achievement was measured using a composite of the Math Facts Fluency and Calculation assessments from the Woodcock-Johnson IV (WJ-IV; Schrank & Wendling, 2018; copyrighted). This measure is described in detail in Chapter 3 (Study 2).

Performance on the Simulated Math Homework Task

Materials and protocols to assess participants' performance on the simulated math homework task are detailed in Chapter 3 (Study 2).

Quality of the Homework-Helping Interaction

The quality of the homework-helping interaction was coded using the Parent-Child Interaction Scale for the Preschool and School Periods (Moss et al., 1996), which is described in Chapter 3 (Study 2). For the purposes of this study, a composite score was generated by combining all ten subscales into a single variable.

Middle Childhood Attachment Strategies

Video-recordings of the parent-child dyad discussing a conflict in their relationship was coded using the Middle Childhood Attachment Strategies Coding System (MCAS; Brumariu et al., 2018) to assess the quality of the attachment relationship. The MCAS assesses attachment patterns in the middle childhood development period (i.e., security, ambivalence, avoidance, disorganization/disorientation, caregiving/role-confusion, and hostile/punitive) (see Lyons-Ruth & Jacobvitz, 2016; Obsuth et al., 2014).

All six patterns of attachment included in the MCAS are rated on a 9-point continuous scale with 1 = none or slight/isolated minor evidence of a specific pattern that does not characterize child's behaviour and interaction overall; 3 = slight/isolated evidence of a specific pattern that can be clearly observed/coded, but does not primarily characterize the child's behaviour and interaction overall; 5 = clear evidence of a specific pattern that is brief, and could

or could not primarily characterize child's behaviour and interaction overall; 7 = moderate evidence of a specific pattern, which characterizes most of child's behaviour and interaction; and 9 = marked and persistent evidence of a specific pattern which predominantly characterizes child's behaviour and interaction.

The sample was coded by two independent coders who received training from and achieved reliability with the creator of the MCAS. Coders were blind to other information on the participants. Coder A was responsible for coding the total sample, while Coder B coded 50% of the video-recordings (n = 20). Given that none of the dyads displayed a predominantly hostile/punitive style of attachment, this subscale was excluded from the analyses. Inter-rater reliability (Pearson's intraclass correlations, *rICC*) for each scale was calculated for eighteen randomly selected videos, which represented approximately 47% of the total sample: Security (*rICC* = .93); Avoidance: (*rICC* = .87); Ambivalence (*rICC* = .92); Caregiving/Role-confusion (*rICC* = .73); Disorganization/Disorientation (*rICC* = .72).

Results

Preliminary Analyses

All variables were screened for parametric test assumptions. Preliminary analyses identified no outliers (i.e., there were no z scores greater than ± 3.29; Tukey, 1962). Not all variables followed a normal distribution, and not all relationships between variables were linear. Additionally, due to the combination of a limited sample size and the ordinal nature of the data, it was concluded that a parametric test would not be suitable for conducting analyses. Therefore, the analyses in the subsequent section were performed using Spearman's rank correlation analyses (Spearman's Rho). Spearman's Rho was selected for its versatility and robustness in handling data that may not meet the assumptions of Pearson's correlation coefficient.

Descriptive Statistics

Descriptive statistics amongst variables of interest and correlations amongst attachment patterns are shown in Table 4.1 and 4.2, respectively. Considering the small sample size, a composite score named the "Insecure" attachment variable was constructed by combining Avoidance, Ambivalent, Caregiving, and Disorganized attachment patterns. This composite score was derived by calculating the average across the four attachment patterns. The original Secure score was retained to measure attachment security. A Spearman's Rho correlation was conducted to explore the relationship between Secure and Insecure attachment patterns, revealing a statistically significant association, $r_s(36) = -0.66$, $p < .001$.

Table 4.1

Descriptive Statistics for All Measures

	Parents			Children		
	Mean	SD	Range	Mean	SD	Range
Math Anxiety	2.39	0.96	1.11-4.67	2.35	0.86	1.22-4.44
Math Achievement	-	-	-	490.31	17.62	450-526
Math Task Score[a]	-	-	-	79.69	23.13	18.20-100
Quality of Math Homework Task Interaction[a]	-	-	-	3.16	0.47	2.25-3.80
Attachment Patterns						
Secure	-	-	-	3.24	1.95	1.0-7.5
Insecure	-	-	-	2.76	0.70	1.38-4.0
Avoidance	-	-	-	2.64	2.53	1.0-8.0
Ambivalence	-	-	-	2.71	2.15	1.0-8.0
Caregiving	-	-	-	2.70	2.16	1.0-8.0
Disorganization	-	-	-	3.0	2.00	1.0-9.0

Note. The "Insecure" variable was created as a composite score using all four insecure attachment patterns (i.e., Avoidance, Ambivalence, Caregiving, Disorganization). [a]Parent and child scores.

Table 4.2

Spearman's Rho Correlations Between Attachment Patterns

Variables	1	2	3	4	5
1. Secure	-	-0.04	-0.15	-0.01	-0.36*

2. Avoidant	-	-	-0.44**	-0.21	-0.43**
3. Ambivalent	-	-	-	-0.26	0.25
4. Caregiving	-	-	-	-	0.02
5. Disorganized	-	-	-	-	-

Note. * $p < 0.05$, ** $p < 0.01$.

Hypothesis 1: Quality of Math Task Interaction and Secure/Insecure Attachment Patterns

A Spearman's Rho correlation was performed to examine how the math task interaction varied in association to the child's attachment. Attachment security and the quality of the math task interaction were marginally correlated, $r_s(36) = 0.28$, $p = .09$, with attachment security explaining approximately 8% of the variation in the quality of the math task interaction. There was a statistically significant, moderate negative correlation between attachment insecurity and the quality of the math task interaction, $r_s(36) = -.37$, $p = .02$, with attachment insecurity explaining approximately 14% of the variation in the quality of the math task interaction.

Hypothesis 2: Attachment Security/Insecurity and Math Homework Task Performance

Next, the variation in math homework task performance in association with the dyad's secure and insecure attachment patterns was examined. Attachment security and the performance on the math homework task were not statistically significantly correlated, $r_s(36) = .21$, $p = .21$, with attachment security explaining approximately 4% of the variation in the math homework task performance. Similarly, attachment insecurity and the performance on the math homework task were not statistically significantly correlated, $r_s(36) = -.24$, $p = .14$, with attachment insecurity explaining approximately 6% of the variation in the math homework task performance.

Hypothesis 3: Relation Between Attachment Security/Insecurity, Child Math Anxiety, and Child Math Achievement, Controlling for Parent Math Anxiety

Hypothesis 3A: Attachment Security/Insecurity and Child Math Anxiety

When controlling for parental math anxiety, the relation between attachment security and child math anxiety was not found to be statistically significant, $r_s(36) = -.27$, $p = .10$, with attachment security explaining approximately 7% of the variation in children's self-reported math anxiety. On the other hand, after controlling for parental math anxiety, there was a statistically significant, positive correlation between attachment insecurity and child math anxiety, $r_s(36) = .46$, $p < .01$, with attachment insecurity explaining approximately 21% of the variation in children's self-reported math anxiety.

Hypothesis 3B: Attachment Security/Insecurity and Child Math Achievement

When controlling for parental math anxiety, the relation between attachment security and child math achievement was not found to be statistically significant $r_s(36) = .03$, $p = .88$, with attachment security explaining 0.09% of the variation in children's math achievement. Similarly, when controlling for parental math anxiety, the relation between attachment insecurity and child math achievement was not found to be statistically significant $r_s(36) = -.14$, $p = .43$, with attachment insecurity explaining approximately 2% of the variation in children's math achievement.

Discussion

Previous research has linked insecure attachment to parents with lower academic achievement (Keller et al., 2008; Moss & St-Laurent, 2001). Additionally, a robust body of evidence underscores the detrimental influence of math anxiety on mathematics achievement (e.g., Ashcraft et al., 2007; Beilock & Maloney, 2015; Hembree, 1990; Lyons & Beilock, 2012; Ma & Xu, 2004). Recent investigations have further highlighted that attachment to parents can exacerbate math anxiety. However, the exploration of attachment's role in children's math anxiety remains limited, with only two studies to date delving into this domain (see Bosmans & De

Smedt, 2015; Demirtas & Uygun-Eryurt, 2020). Although these studies represent strides in investigating the association between attachment and children's math anxiety, they both relied on self-reported data and omitted consideration of parental math anxiety, which is a significant factor in understanding children's math anxiety levels. Thus, there is a need for more comprehensive research methodologies to explore the relationship between attachment, parental influences, and children's mathematical well-being.

The current study sought to address these gaps. Parent-child dyads were videorecorded during a simulated math homework-helping task to assess the quality of their interaction. Dyads were also recorded during their participation in a "conflict task" and an observational measure—the MCAS (Brumariu et al., 2018)—was used to assess the attachment insecurity/security. To comprehensively capture the spectrum of math anxiety, both parents' and children's levels were assessed through self-reported measures. Further, parents' and children's levels of math anxiety were obtained using self-reported measures, and standardized assessments of parents' and children's math achievement were administered.

Quality of Math Interaction and Attachment Security/Insecurity

Higher attachment insecurity observed in the dyad was associated to a poorer quality of the math task interaction. Although attachment security displayed only a marginal association with a higher quality of the math task interaction, it is essential to acknowledge the constraints imposed by the small sample size and limited power of the study.

As previously discussed, mathematics is perceived by many to be an inherently difficult and stress-inducing subject (Beilock & Willingham, 2014). When children feel threatened, anxious, or vulnerable, they often turn to their attachment figure (i.e., parent or caregiver; Bowlby, 1973, 1988). Although securely attached children may experience stress or frustration

when faced with a challenging math problem, their parents' likely ability to effectively attune and respond to their child's emotional cues empowers the child to approach goal-oriented tasks, such as math homework, with heightened ease and openness during interactions with their parent. Consequently, this relates to an overall more positive interaction with their parent. These findings align with Bureau et al. (2014)'s research, which indicated that paying attention to the child's emotional cues, responding in a synchronous fashion, and being sensitive are associated with a greater likelihood of secure attachment in children.

On the other hand, insecurely attached children may have parents who struggle to tune into their needs. Parental responsiveness is critical in shaping attachment patterns and influencing children's emotional regulation abilities (Ainsworth et al., 1978; Bowlby, 1988). When parents are less responsive, insecurely attached children may experience greater difficulty regulating their emotions during homework tasks, which may further exacerbate the negativity of the overall homework-helping interaction. Furthermore, even if the parents display positive behaviours during the homework-helping interactions, insecurely attached children may show reduced responsiveness to their parents as role models, given the child's reduced confidence in their parents' ability to provide them with support. This lack of responsiveness may further hinder the effectiveness of parental assistance during homework sessions and contribute to a poorer quality of the dyadic interaction.

Math Task Performance and Attachment Security/Insecurity

In examining the relationship between secure/insecure attachment and math homework task performance, the results indicated that neither attachment security nor attachment insecurity were related to math homework task performance. These findings could be attributed to a significant portion of the sample scoring high on the math task, with more than half achieving a

score of 90%. Consequently, this could have led to diminished variability within an already modest sample size.

Children's Math Anxiety, Math Achievement and Attachment Security/Insecurity

The final objective of the current study explored the association between secure/insecure attachment, child math anxiety, and child math achievement while controlling for the influence of parent math anxiety. While numerous studies have investigated the correlation between attachment and anxiety among children in middle childhood (e.g., Colonnesi et al., 2011; Kerns & Brumariu, 2014; Manassis, 2011), a mere two studies have investigated how attachment styles influence children's math anxiety (see Bosmans & De Smedt, 2015; Demirtaş & Uygun-Eryurt, 2020). The findings of the current study did not yield significant results between secure attachment and child math anxiety. However, the results align with those of the two previous studies indicating a link between attachment insecurity and higher math anxiety among children, even when controlling for parental math anxiety. These findings suggest that even when employing more robust methodologies, such as observational assessments of attachment, and taking into account the influence of parent math anxiety, the findings hold.

Regarding child math achievement, neither attachment security nor attachment insecurity demonstrated statistically significant associations with children's performance on a standardized measure of math achievement when controlling for parental math anxiety. These results were somewhat surprising given the previous findings that indicate that children who are insecurely attached to their parents have poorer math achievement (e.g., Keller et al., 2008; Moss & St-Laurent, 2001). In their study, Bosmans and de Smedt (2015) found that there was a correlation between math achievement and attachment anxiety, but not with attachment avoidance. When they further investigated the indirect relationship between math anxiety and these attachment

patterns, using child math anxiety as a mediator, they found that both models were significant. The absence of a correlation between child math achievement and attachment in the present study could therefore be attributed to the mediating effect of child math anxiety. However, a more plausible explanation for the lack of statistically significant findings may be due to the nature of the small sample size, which may limit the ability to detect true effects in the population.

Limitations and Future Research

This study contributes to the understanding of the associations between attachment, math anxiety, and math achievement in children, with an emphasis on the role of attachment to important role models (i.e., parents) in shaping interactions and emotional experiences during math-related tasks. Although the child attachment security toward the parent did not appear to significantly influence children's math achievement, attachment insecurity was found to be associated with poorer quality in math task interactions and higher math anxiety in children.

It is important to note, however, that this study has certain limitations. The data in this study were derived from a relatively small sample (n = 38), and therefore, it is important to exercise caution when interpreting the findings. Indeed, given the limited sample size, it was not possible to adequately run moderated mediation analyses to determine whether a secure attachment acts as a buffer against negative math outcomes. The limited explanatory power of attachment styles on math outcomes highlights the need for further exploration. Additionally, the insecure attachment scales (i.e., Avoidant, Ambivalent, Caregiving, Disorganized) were combined to create a composite score due to the limited sample size of this study. This approach was intended to mitigate the impact of sampling variability and provide more robust results. However, the scales either did not correlate or were negatively correlated. While it is

theoretically consistent for scales like avoidance and ambivalence to be inversely correlated due to their opposing behaviours, combining these scales into a single composite score without considering their distinct nature might obscure meaningful differences. Increasing the sample size in future research would allow for the examination of each insecure attachment dimension individually and help capture distinct patterns in the results.

Additionally, despite being developed by a curriculum specialist, the simulated math homework task's efficacy was diminished by its 90% success rate. This high success rate rendered it ineffective in distinguishing between participants' performances, potentially masking any effects. It is also worth noting that this study was conducted with a Canadian sample. Consequently, it is advisable to be cautious when generalizing the current results to parent-child math homework-helping interactions in other regions worldwide. Future research should consider exploring cross-cultural differences in dyadic homework-helping practices.

Finally, in this study, the focus was solely on the primary math homework-helping parent and their child. Other variables that could potentially impact the quality of these parent-child interactions were not considered in addition to their math achievement and math anxiety. For instance, children may have access to supplementary resources such as school support, tutoring, or assistance from other family members, which might shape their approach to math-related tasks. Recent research by Guzmán et al. (2023) has highlighted a connection between decreased participation in home numeracy activities and heightened math anxiety in children. Therefore, future investigations should also encompass the time parents invest in engaging in math-related activities with their children to offer a more comprehensive framework for comprehending homework-helping dynamics.

Implications and Conclusions

The results of this study provide insights into the relation among attachment, parent-child interactions during math-related tasks, children's math anxiety, and their math achievement. To our knowledge, this study is only the third to explore how attachment dynamics might intersect with math anxiety (cf. Bosmans & De Smedt, 2015; Demirtaş & Uygun-Eryurt, 2020), and importantly, the first to rely on observational data. Indeed, attachment insecurity within the parent-child dyad was demonstrated to be associated with less favourable interactions during the simulated math homework task. Further, insecure attachment styles were correlated with higher levels of math anxiety in children, even when controlling for parental math anxiety.

Although these findings did not reveal a significant link between attachment and math achievement, it is essential to keep in mind that success in mathematics is influenced by multiple factors. Math anxiety has been found to predict a host of negative math outcomes, including math achievement, and the present data emphasize the important role that the parent-child relationship can have within the context of math homework-helping interactions and children's math anxiety. Further, building upon previous research highlighting the effectiveness of social learning theory parenting interventions in promoting attachment-based caregiving (O'Connor et al., 2013), the findings from this study, in conjunction with those detailed in Chapter 3 (Study 2), underscore the importance of integrating interventions tailored to enhance parenting practices, which would aim to cultivate a secure attachment bond between parents and children, and ultimately foster an enhanced math learning environment in the home. Taken together, this study's findings suggest that educators and researchers alike should embrace a more comprehensive approach to understanding children's math learning experiences. Considering attachment relationships alongside cognitive and emotional factors can yield more profound insights into children's strengths and difficulties in the realm of mathematics.

CHAPTER 5: General Discussion

Proficiency in mathematics serves as a strong predictor not only of later academic success but also of financial stability and future career opportunities (Charette & Meng, 1998; Duncan et al., 2007; Romano et al., 2010). Yet, there is an alarming decline in students' mathematics achievement in Canada (see OECD, 2013). For this reason, enhancing mathematical well-being across North America is pivotal for future economic prosperity. Numerous studies on mathematical well-being, encompassing cognitive functioning as well as affective and emotional domains (Clarkson et al., 2010), have identified various factors associated with math achievement that go beyond content knowledge (e.g., Good et al., 2008; Maloney & Beilock, 2012; Parker et al., 2014; Passolunghi et al., 2016; Peng et al., 2016, 2020; Raghubar et al., 2010). Although math anxiety is known to be a barrier to later academic and career success, most research has examined math anxiety individualistically rather than relationally (i.e., how math anxiety may relate to parent-child dynamics). In addition to these individual factors contributing to children's mathematical well-being, researchers have highlighted the influence of parental involvement in children's education (for reviews, see Hill & Tyson, 2009; Hoover-Dempsey et al., 2001; Patall et al., 2008; Walker et al., 2004). This thesis examined math anxiety in the context of parent-child relationships and does so using direct observation, moving beyond self-report measures used in past research. The current dissertation built upon Maloney et al. (2015) and Poisall et al. (2023)'s studies that found that frequent parental homework help with children's math homework has a negative effect on children's math anxiety and achievement in math.

Parental involvement is recognized as a key mechanism shaping children's acquisition of culturally relevant skills, including their approach to learning (Rogoff, 2003). Drawing from Social Learning Theory (Bandura, 1997), which underscores how individuals learn through

observation and imitation of influential role models, like parents, it becomes evident that parents play a significant role in shaping their children's attitudes and behaviours, including in mathematical contexts (Hoover-Dempsey et al., 2001). Moreover, Social Referencing Theory highlights the importance of cues from trusted social partners, such as caregivers, in shaping children's reactions to their environment (Feinman et al., 1992). In the case of math anxiety, children may develop this anxiety if they observe their parents exhibiting negative attitudes towards math (Askew & Field, 2007). Recent studies have delved into the relationship between attachment to parents and math anxiety in children, revealing a negative correlation between attachment insecurity and math anxiety levels (Bosmans & De Smedt, 2015; Demirtaş & Uygun-Eryurt, 2020). This implies that the quality of the parent-child relationship can significantly impact a child's emotional response to mathematics. Ascribing to this theoretical framework, the current dissertation sought to explore the way in which parent-child interactions during math homework help, as well as the quality of the parent-child relationship, relate to children's math anxiety and math achievement. It also aimed to address two areas for growth in the existing literature concerning parent-child interactions during math homework. Firstly, it emphasized the importance of examining *dyadic* interactions, moving beyond sole reliance on individually reported data. Secondly, it highlighted the limitations of self-reported data in understanding the *quality* of parental involvement in homework, highlighting the need for direct observations of parent-child interactions.

More specifically, Study 1 surveyed parents of school-age children to understand if higher parental math anxiety correlates with negative emotions during math homework help, controlling for parental math achievement. Study 2 used a multi-method approach including self-reports, standardized assessments, and videorecorded interactions to delve deeper into the math

homework-helping environment. It assessed dyadic behaviours and language to understand how parental math anxiety relates to child math anxiety and achievement. Finally, Study 3 investigated the quality of parent-child attachment and its relation to the quality of homework-helping interactions, as well as parental and child math anxiety and achievement. It examined how attachment quality may relate to math anxiety and math achievement. The major findings from Study 1, 2, and 3 are summarized below.

Summary of Major Findings

Study 1 Findings

Study 1 comprised two separate investigations exploring the link between parents' math anxiety and their perceptions of their math homework-helping interactions with their children. In Study 1a, parents of first- through sixth-grade children completed surveys to determine if higher levels of math anxiety in parents related with increased time spent on math homework and heightened negative emotions during homework assistance (such as decreased confidence, elevated frustration, stress, conflict, and feelings of distance from their child). Study 1b aimed to replicate and expand upon these findings by controlling for parental general anxiety, considering the known relationship between general anxiety and math anxiety (Hembree, 1990), in addition to math knowledge.

Study 1a. While neither the amount of time that children spent doing math homework, nor the frequency with which parents helped their children with their math homework, varied as a function of parents' level of math anxiety, higher math-anxious parents reported more negative interactions overall (i.e., a more negative emotional experience) than did those with lower math anxiety. Importantly, these findings were not attributable to differences in mathematical competence between higher- and lower-math-anxious parents. Given the novelty of Study 1a in

examining the association between parents' math anxiety and their perception of math homework help, a follow-up study (Study 1b) was conducted to validate these findings. Importantly, in Study 1a, parents' math knowledge was included as a control variable. However, anxiety in general was not controlled for (indeed, math anxiety and general anxiety are reported to be moderately correlated; Hembree, 1990). Therefore, Study 1b aimed to replicate and extend Study 1a's findings by also considering parents' levels of general anxiety.

Study 1b. Similar to Study 1b, in Study 1a, parents with higher math anxiety reported more negative interactions during math homework help compared to those with lower math anxiety. Notably, these associations were not influenced by parents' mathematical knowledge or general anxiety levels. Although most findings from Study 1a were replicated in Study 1b, there was one discrepancy: while Study 1a found no association between parents' math anxiety and the time children spent on math homework or the time parents spent helping with math homework, Study 1b revealed a positive association between parents' math anxiety and the time children spent on math homework.

Study 2 Findings

In Study 2, initial findings revealed that parent-child dyads (Grades 5 to 7) generally performed well on the simulated math homework task, with over half of them scoring above 90%. However, the performance on the task varied based on the quality of the interaction. Dyads achieving higher scores demonstrated behaviours such as relaxation, emotional neutrality or joy, intimacy, coordination, emotional synchronization, and appropriate role-taking during the task. Additionally, parents of higher-scoring dyads displayed greater sensitivity and respect towards their child's pace. Interestingly, the use of negative language during the interaction did not correlate with task performance, contrary to the initial hypothesis. However, dyads who had

parents use more positive language overall tended to achieve higher scores on the task. Due to the correlational nature of the analyses, it remains uncertain whether the observed high-quality interaction led to better task performance or vice versa.

Moreover, when assessing the association between the quality of interaction between parent-child dyads and parents' math achievement, it was observed that parents with higher math achievement engaged in more relaxed, intimate, coordinated, and emotionally synchronized interactions compared to those with lower math achievement. Higher-achieving parents also displayed greater sensitivity to their child's needs and were better at assuming appropriate parental roles during the homework task. Higher math-achieving parents also tended to use more positive words during the homework-helping interaction. In terms of children's math achievement, those with higher math achievement exhibited more emotionally synchronized interactions and slightly more neutral or joyful behaviours. Furthermore, higher math-achieving children had parents who displayed lower intrusiveness and higher sensitivity during the task. Taken together, these findings are consistent with prior research indicating that lower achievement in children is linked to less positive emotions during homework (Trautwein et al., 2009). Further, children, but not parents, tended to use more negative words during the homework-helping interaction when children were lower in math achievement.

Finally, in assessing the connection between the quality of parent-child interaction and parents' math anxiety, no significant associations were found with either dyadic behaviours or the affective language used during math homework-helping interactions. In contrast, higher math-anxious children engaged in less relaxed, less intimate, less coordinated and less emotionally synchronized homework-helping interactions. These interactions were also characterized by increased role reversal, and parents of higher math-anxious children were lower in sensitivity and

higher in intrusion during the math task. Although there was no relation between children's math anxiety and the negative word counts employed by parents or children, higher levels of math anxiety in children were associated with lower positive word counts by parents during the interaction.

Study 3 Findings

In Study 3, the findings revealed that higher levels of attachment insecurity within the parent-child dyad were associated with a lower quality of interaction during the math task. Although there was only a marginal association between attachment security and a higher quality of interaction, it is important to acknowledge the limitations of this study, including the small sample size and limited statistical power.

When exploring the relation between attachment security/insecurity and math homework performance, no significant associations were found. This lack of association may be due to the high performance of a substantial portion of the sample, with more than half scoring 90% or higher on the math task. Consequently, the limited variability within the modest sample size may have influenced these results.

Furthermore, the investigation into the association between secure attachment and child math anxiety did not yield significant findings. However, the findings were consistent with those of the two previous studies, indicating a link between attachment insecurity and higher math anxiety among children (cf. Bosmans & De Smedt, 2015; Demirtaş & Uygun-Eryurt, 2020), even after controlling for parental math anxiety. These results suggest that even with more robust methodologies, such as observational assessments of attachment, and considering the impact of parental math anxiety, these findings remain. Finally, when considering child math achievement, neither attachment security nor attachment insecurity showed statistically significant links with

children's performance on standardized math tests when parental math anxiety was taken into account.

Collective Interpretation of Findings Across Studies 1, 2, and 3

The three studies from the current dissertation built on each other to offer corroborating findings. Study 1 took initial steps towards understanding the factors contributing to ineffective math homework-helping interactions. It revealed that parental math anxiety might hinder effective support during math homework sessions, potentially due to conveying negative emotions or lacking confidence in their own abilities. These findings should be interpreted cautiously given that they rely on self-reported measures and lack the child's perspective or math outcomes. Nonetheless, in conjunction with Maloney et al. (2015), it becomes evident that when parents with elevated math anxiety assist their children with math homework, not only do the children's math learning outcomes diminish, and their own math anxiety increase (Maloney et al., 2015), but also these parents experience heightened negative emotions during such interactions compared to parents with lower levels of math anxiety. While it is reasonable to assume that the math homework interactions of higher math-anxious parents and their children are more negative than those of their peers, Study 1 did not demonstrate how these interactions veritably unfold. Although self-reports provide an initial understanding of how parents and children perceive the interaction, self-reports do not permit researchers to directly observe what is happening during the math homework-helping interaction. Indeed, there is evidence to suggest variation in how adults appraise previous math experiences, and such appraisals are related to math anxiety and attitudes (see Hunt & Maloney, 2022). Study 2 provided insights into what is actually happening during the math homework-helping interaction between parents and children.

While Study 2 revealed a positive correlation between parent and child math anxiety (i.e., parents with higher math anxiety tended to have children with higher math anxiety), parental math anxiety was not found to influence parent-child behaviours or affective language during simulated math homework-helping interactions. These findings, combined with those of Study 1, which indicated that parents with higher math anxiety perceive math homework-helping environments as more negative, imply that although higher math-anxious parents perceive these interactions negatively, trained coders do not rate them as more negative. Therefore, while higher math-anxious adults may generally view math-related experiences more negatively than lower math-anxious adults, it does not necessarily mean that the interactions themselves are more negative. This aligns with Hunt and Maloney's (2022) findings, suggesting a link between adults' math anxiety and their appraisals of past math experiences. Conversely, children's math anxiety appears to correlate more closely with the quality of interactional behaviours during homework help, impacting math task performance. It is possible, then, that children are more susceptible to picking up on cues related to math anxiety from their immediate environment, such as interactions during homework help. In line with Social Referencing (Feinman et al., 1992; Walle et al., 2017), if parents do not overtly express math anxiety but demonstrate poor interactional behaviours during math homework-helping sessions, children may sense tension or negativity, potentially leading to their own development of math anxiety. Parents might not express explicit math anxiety themselves, but if their interactions during homework help are not conducive to a positive learning environment, children may struggle. On the other hand, supportive interactions can potentially mitigate math anxiety and improve task performance, regardless of the parents' own anxiety levels. However, it is important to note that the findings of the current dissertation cannot definitively ascertain this claim due to the correlational nature of the results. Further

empirical testing is warranted to establish a causal relationship between parental interactions, math anxiety, and task performance.

Furthermore, while it is possible that parents with higher math achievement engage more effectively with their children in multiple domains like science and language arts, it is more plausible to theorize that possessing expertise in a specific domain, such as math, fosters confidence in that particular domain. This, in turn, may enable parents to facilitate higher-quality interactions with their child. The findings of Study 1, suggesting that parents with stronger math knowledge feel more confident when assisting their child with math homework, when combined with the results of Study 2, may indicate that the confidence of high-achieving math parents is reflected through their positive language during homework help. There is a vast amount of research indicating that parental praise is beneficial to children's outcomes when reflecting the child's effort on the task at hand (e.g., higher level of motivation, improved problem-solving skills, and increased persistence; Henderlong & Lepper, 2002). It is plausible that the positive words used by parents, such as "excellent" and "amazing," reflect praise for the child's work on the simulated math task, leading to better performance overall. However, it is also likely that the children's already high performance prompts increased praise from parents. Additionally, children's negative language during these interactions may reflect their self-efficacy in mathematics, representing their beliefs about their ability to perform math tasks (Hackett & Betz, 2020). Indeed, research has linked low math achievement with lower feelings of self-efficacy (Ferla et al., 2009; Lee, 2009; Pajares & Miller, 1994).

Finally, Bosmans and De Smedt (2015) argued that the development of math anxiety, which adversely affects mathematics achievement, could partly stem from a maladaptive mechanism for regulating emotions, particularly evident in insecure attachment relationships. In

Study 3, greater attachment insecurity in children was found to be linked to lower-quality interactions during math homework and increased math anxiety, even when controlling for parental math anxiety. Mathematics is perceived by many to be an inherently difficult and stress-inducing subject (Beilock & Willingham, 2014). When children feel threatened, anxious, or vulnerable, they often turn to their attachment figure (i.e., parent or caregiver; Bowlby, 1973, 1988), and an attuned parent can effectively respond to their child's emotional cues, which empowers the child to approach the task at hand. Conversely, a lack of responsiveness may further hinder the effectiveness of parental assistance during math homework-helping sessions and contribute to a poorer quality of the dyadic interaction.

Taken together, the findings from the three studies collectively provide further support for the notion that factors influencing children's mathematical well-being go beyond just the classroom setting and the time spent on homework. They also shed light on the findings of Maloney et al. (2015) and Poisall et al. (2023), emphasizing the importance of emotional dynamics in parent-child interactions during math homework. The presence of positive and supportive interactions, as seen across these studies, fosters an environment conducive to learning. This dissertation's studies highlight how individual parental and child factors, along with the dyadic features, influence the effectiveness of the math homework-helping interaction. Additionally, the influence of attachment relationships on children's emotional experiences during math-related activities underscores the need for a more comprehensive approach to supporting mathematical well-being.

Research, Practical and Clinical Implications

The current dissertation holds important implications for research, as well as for practical and clinical implications. In terms of research implications, one major strength of these studies,

especially Studies 2 and 3, lies in the measurement of both parent and child factors, as well as the direct observation of dyadic interactions, to investigate the relations between math anxiety, math achievement, and the math homework-helping interaction. Much of what is known about the homework-helping environment comes from survey and/or interview data in which parents *or* children are asked to report on how they feel about doing math homework (e.g., Bosmans & De Smedt, 2015; Demirtaş & Uygun-Eryurt, 2020; Retanal et al., 2021; Silinskas & Kikas, 2019). While studies examining the math homework-helping environment do acknowledge dyadic interactions, they predominantly focus on the scaffolding methods utilized by parents (e.g., Hyde et al., 2006; Missall et al., 2017; Zhou et al., 2006). However, these techniques often overlook the emotional context of the homework-helping interaction, which encompasses parents' sensitivity to their child's emotional needs, particularly in potentially stressful situations like math. Findings from this dissertation provide preliminary evidence that there are indeed emotional dyadic features associated with children's math anxiety and achievement that warrant further investigation.

Moreover, the over-reliance on self-reported data to understand parental involvement in math homework and its influence on children's learning and attitudes presents its limitations. Indeed, the story told by the self-report data in the current studies did not align perfectly with that told by experimenter observation. Direct observations of parent-child interactions are vital for understanding the mechanisms involved in social interaction given that they provide insights into real processes and outcomes, including parenting approaches and child behaviour. Additionally, observational methods allow researchers to consistently operationalize behaviours, avoiding reliance on participant interpretations (Aspland & Gardner, 2003). The findings in this

dissertation strengthen the case for using a multi-method approach to assessing the math homework-helping interaction to garner a richer understanding of the various factors at play.

The findings of the present dissertation also offer an initial foundation for practical and clinical uses. The fact that the quality of parent-child interactions relates to children's math anxiety and math achievement support the need to apply interventions designed to support more positive interactions surrounding math-related tasks. One effective approach supported by empirical evidence involves an educational intervention aimed at fostering more positive interactions between children and their parents concerning math. Within this intervention, brief math story problems are provided through an iPad application (Overdeck et al., 2021). Berkowitz et al. (2015) assessed the efficacy of this application and found that, when used even as little as once per week, children's math achievement increased by the end of the school year. Notably, the extent of this improvement was greater among children whose parents exhibited higher levels of math anxiety. The results of Berkowitz et al. (2015) support the notion that scaffolding parents' interaction around math may serve as a way to enhance children's math learning, particularly for the most vulnerable. One proposed explanation for the effectiveness of this intervention is that it provides parents with a scripted way to talk about math with their children, which in turn provides a less stressful way to engage with math content. Furthermore, Social Learning Theory suggests that parents serve as models for their children, exhibiting attitudes and coping strategies for managing stress that children tend to imitate. Consequently, interventions such as Bedtime Math not only provide parents with a structured approach to engage with their children, but also to model effective coping mechanisms for dealing with math anxiety. By promoting a positive and stress-free environment for math learning, an intervention like this one may help break the cycle of anxiety transmission from parents to children, ultimately fostering a healthier and more

productive approach to mathematical education within the family dynamic. However, while applications like Bedtime Math offer valuable benefits, they may pose greater challenges when applied within specific contexts, such as the homework-helping interaction. This is because they focus on storytelling-style math engagement rather than homework assistance, which typically requires targeted guidance and support tailored to the specific challenges faced by the child.

The results presented in Study 3, combined with those of Bosmans and De Smedt (2015), and Demirtaş and Uygun-Eryurt (2020), highlight the need to go beyond scaffolding materials and to design interventions that foster the attachment bond to enhance the math learning atmosphere. Although there is some evidence to support the transmission of math anxiety from parent to child (see Maloney et al., 2015), findings from Study 2 suggest that addressing parental math anxiety alone might not be sufficient, given that the quality of interactional behaviours appears to be related to children's but not parents' math anxiety. Emotion coaching (Gottman et al., 1996; Gottman & DeClaire, 1997) offers a promising strategy for improving parental engagement in math homework-helping interactions. More importantly, it provides a method to enhance the overall quality of the parent-child relationship, which may, in turn, boost math achievement and reduce math anxiety in children. By focusing on understanding and responding to a child's underlying attachment and emotional needs, emotion coaching fosters a supportive and empathetic environment within the parent-child relationship. Research by Chen and colleagues (2012) indicates a positive correlation between emotion coaching and secure attachment, suggesting that this approach strengthens the emotional bons between children and significant adults, like parents. Through emotion coaching, children learn essential skills for regulating their emotions and behaviours (Shortt et al., 2010). This equips them with the tools

necessary to manage challenging emotions effectively, which is relevant in the context of tackling math-related stress and anxiety.

Furthermore, the benefits of emotion coaching extend beyond emotional regulation to encompass academic achievement and resilience. Gottman et al. (1996) demonstrated that children who have experienced emotion coaching exhibit improved academic performance, emotional stability, and resilience in the face of adversity. This suggests that by fostering a supportive emotional environment and equipping children with effective coping mechanisms, emotion coaching can positively influence various aspects of children's development, including their performance in mathematics. If parents adopt an emotion coaching approach during homework sessions, they create a safe space for children to express their frustrations and difficulties with math, without fear of judgment or criticism. By acknowledging and validating these emotions, parents can help children develop a more positive attitude towards math and homework, ultimately promoting a sense of competence and confidence in their mathematical abilities.

Limitations and Directions for Future Research

This dissertation added to the body of literature on parental involvement in math homework help; however, future research must prioritize addressing several limitations and gaps in knowledge that still require attention. Firstly, while the studies included in this dissertation have provided valuable insights into the relation between parent-child interactions, math anxiety, and math achievement, they have predominantly relied on correlational designs with data collected at a single time point. This cross-sectional approach limits the ability to draw causal inferences regarding the causal direction of the observed relations. Future research would greatly benefit from adopting a longitudinal design, which would provide more information about

whether children's math anxiety develops *because* of the negative quality of the homework-helping interaction or if, rather, higher math-anxious children's engagement with their parents affects how the quality of the interaction unfolds.

Further, an important oversight in this dissertation includes the lack of consideration for how learning disabilities, such as dyscalculia, might influence the observed relations documented in the studies. Dyscalculia, characterized by difficulties in understanding and performing mathematical operations (American Psychiatric Association, 2022), has been shown to significantly influence children's experience with math and contribute to math anxiety (García-Planas & García-Camba, 2022). Future research should address this gap by accounting for learning disabilities when examining the relation between parent-child interactions and math anxiety. Understanding how children with learning disabilities navigate homework-helping interactions and the potential impact on their math anxiety is crucial for developing targeted interventions and support strategies. Additionally, it remains to be determined how the introduction of the new Ontario curriculum (Government of Ontario, 2020) may influence math anxiety, as well as parent-child interactions surrounding math homework. This aspect warrants further investigation to fully understand the broader implications of curriculum changes on students' mathematical experiences and family dynamics.

The current dissertation has provided valuable insights into the dynamics of parent-child math homework-helping interactions, focusing primarily on the primary math homework-helping parent and their child. However, this narrow focus has led to an oversight of several potentially influential variables that could significantly shape the quality of these interactions. For instance, while the role of the primary homework-helping parent is undoubtedly crucial, other supplementary resources such as school support, tutoring services, or assistance from other

family members may exert substantial influence on children's approach to math-related tasks, such as homework. Further, research by Guzmán et al. (2023) has underscored the importance of home numeracy activities in shaping children's attitudes towards mathematics and their levels of math anxiety. By neglecting to account for the impact of these additional resources and activities, the current understanding of homework-helping dynamics remains incomplete. Therefore, future investigations must broaden their scope to encompass these factors, offering a more comprehensive framework for understanding the complexities of the parent-child math homework-helping environment. By considering the variability in access to resources and the extent of parental involvement in math-related activities, researchers can gain deeper insights into the mechanisms underlying children's math anxiety and academic achievement.

Finally, the homogeneity of the sample, characterized by its predominantly Caucasian composition and the over-representation of mothers as primary homework-helping parents, poses a significant limitation to the generalizability of findings. While the inclusion of diverse populations is essential for capturing the full spectrum of parent-child interactions across various demographic groups, the existing literature has often overlooked this imperative. Variations in parental involvement in children's education across demographics, including educational attainment, race, ethnicity, and gender, may significantly influence parent-child interactions in mathematical learning contexts (Barger et al., 2019; Kim & Hill, 2015; Sibley & Dearing, 2014). Furthermore, cultural norms and expectations regarding parental involvement in education may vary across different geographical regions and cultural contexts. Therefore, future research should prioritize the inclusion of diverse populations to explore potential cultural differences in parent-child homework-helping practices.

Conclusion

The present dissertation investigated the multifaceted dynamics of parent-child interactions during math homework help and their influence on children's achievement and anxiety towards math. A major strength of this study is that it explored both parent and child factors to understand relations between math anxiety, achievement, and the math homework-helping environment. Using a multimethod approach across three studies, the findings emphasize that effective parental support extends beyond mere academic assistance, encompassing emotional dynamics crucial for fostering a positive learning environment. This research will hopefully lead to the sensitization of parents in terms of homework involvement, especially when considering the Government of Ontario's push for parental engagement in children's learning (Ministry of Education, 2022). The implications of these findings extend to both research and practical domains, advocating for interventions that promote positive parent-child interactions and relationships to mitigate math anxiety and enhance math achievement in children.

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Appendix A

Supplemental Materials

16/01/2018

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number	H-12-17-226
Titre du projet / Project Title	Understanding the homework environment
Type de projet / Project Type	Recherche de professeur / Professor's research project
Statut du projet / Project Status	Approuvé / Approved
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	16/01/2018
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	15/01/2019

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Erin MALONEY	École de psychologie / School of Psychology	Chercheur Principal / Principal Investigator
Bronwyn O'BRIEN	École de psychologie / School of Psychology	Assistant de recherche / Research Assistant
Maria FAKHOURI	École de psychologie / School of Psychology	Assistant de recherche / Research Assistant
Michela Gosselin DISTEFANO	École de psychologie / School of Psychology	Assistant de recherche / Research Assistant

Conditions spéciales ou commentaires / Special conditions or comments

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16/01/2018

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

Le Comité d'éthique de la recherche (CÉR) de l'Université d'Ottawa, opérant conformément à l'*Énoncé de politique des Trois conseils* (2014) et toutes autres lois et tous règlements applicables, a examiné et approuvé la demande d'éthique du projet de recherche ci-nommé.

L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout évènement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completedfour weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

Riana MARCOTTE
Responsable d'éthique en recherche / Protocol Officer
Pour/For **Daniel LAGAREC** Président(e) du/ Chair of the **Comité d'éthique de la recherche en sciences sociales et humanités / Social Sciences and Humanities Research Ethics Board**

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Project: ***Understanding the Homework environment***

Children often struggle with math and reading homework. We aim to create tools to help children better succeed in math and reading. However, before we can design effective tools to help, we must first understand what math and reading homework interactions look like in the homes of children in the junior grades.

Your participation today will help provide insights into parents' homework helping behaviours and the homework environments of their children. The purpose of this research is to examine how various factors relate to children's math and reading homework experiences. Your participation will consist of completing a 15-minute-long questionnaire, which can be completed on your own computer. Within this questionnaire, you will be asked to complete demographic questions, as well as questions about your attitudes and emotions towards your child's math and reading homework.

Your participation will help to enhance knowledge on the role that parents play in their child's education, and therefore to the literature on the different practices parents use when teaching their children math and reading.

Anonymity will be assured in the following manner. Your results will be coded and you will be assigned a participant ID that will be used to label your data. With your permission, the researchers would like to keep these data. Your data will be stored on a secure network that is password protected. The link between you and your participant ID will be kept private. If the researchers publish the results of this study, they will not use your name. Furthermore, all anonymized data may be posted on an open science framework repository to help facilitate the ongoing reproducibility effort within Psychological Science. Participation in this study is strictly voluntary. There are no known risks for your participation in this study.

You are free to withdraw from the project at any time (before or during participation), to refuse to participate, or to refuse to answer questions.

Compensation

To thank you for your contribution to the research project, you will be given the option to enter your name in a draw to win one of five $50.00 Amazon gift cards.
The draw is open to all research participants who enter their name in the draw, regardless of whether they decide to withdraw from further participating in the research project.
Upon completion of the study, five names will be randomly selected amongst those who have entered and the person whose name is drawn will be informed by email. To win the prize, the

person must correctly answer a skill testing question. If the person cannot be reached within 14 days from the date of the draw, the prize will be awarded to the next name that is randomly selected and so on until the prize has been awarded. The odds of winning a prize are will depend on the number of eligible entries received. The prize must be accepted as awarded or forfeited and cannot be redeemed for cash.

Your name and email address that you provide when you enter the draw is collected for the purposes of contacting you if your name is selected in the draw. Your name and the contact information you have provided will be kept confidential and then destroyed once the prizes have been awarded.

We reserve the right to cancel the draw or cancel the awarding of the prize if the integrity of the draw or the research or the confidentiality of participants is compromised. The draw is governed by the applicable laws of Canada.

Please note that should you choose not to provide your email address for the draw, you will not be able to withdraw your data after it has been submitted as data are collected anonymously. Any questions about your rights as a research participant may be addressed to Protocol Officer for Ethics in Research, 550 Cumberland Street, Room 154, 613-562-5387, ethics@uOttawa.ca.

If you wish to participate in this research, please indicate your agreement by checking off the "I agree" box. Please provide your email address if you wish to be included in the draw. If you have any questions about the conduct of the research project, you may contact the researchers.

☐ I agree to participate in this research

☐ I do not agree I do not agree to participate in this research

Email address (for inclusion in the draw): _____

We strongly encourage you to print or save a copy of this consent page for your records.

Researcher information:

Dr. Erin Maloney, University of Ottawa, Faculty of Social Sciences, School of Psychology; [personal information redacted]

Michela DiStefano, University of Ottawa, Faculty of Social Sciences, School of Psychology; [personal information redacted]

Project: ***Understanding the Homework environment***

Children often struggle with math and reading homework. We aim to create tools to help children better succeed in math and reading. However, before we can design effective tools to help, we must first understand what math and reading homework interaction look like in the homes of children in the junior grades.

Your participation today will help provide insights into parents' homework helping behaviours and the homework environments of their children.

All the information we collected in today's study will be confidential, and there will be no way of identifying your individual responses in the data archive. We are not interested in any one individual's responses; we want to look at the general patterns that emerge when the data are aggregated together. You are free to withdraw from the project at any time (during or after the session). Should you choose to withdraw from the study without providing your email address, you will not be able to withdraw your data after it has been submitted (as data are collected anonymously).

Your participation today is greatly appreciated! Any information about your rights as a research participant may be addressed to Protocol Officer for Ethics in Research, 550 Cumberland Street, Room 154, 613-562-5387, ethics@uOttawa.ca. If your participation in this study has caused you concerns, anxiety, or you have any questions, you are welcome to contact the principal investigator, Erin Maloney. Her information can be found at the top of this form.

Thank you for your participation!

15/01/2019

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number	H-10-18-1205
Titre du projet / Project Title	Learning About Homework Helping
Type de projet / Project Type	Recherche de professeur / Professor's research project
Statut du projet / Project Status	Approuvé / Approved
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	15/01/2019
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	14/01/2020

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Erin MALONEY	École de psychologie / School of Psychology	Chercheur Principal / Principal Investigator
Andie STOROZUK	École de psychologie / School of Psychology	Étudiant-chercheur / Student-researcher
Michela Gosselin DISTEFANO	École de psychologie / School of Psychology	Étudiant-chercheur / Student-researcher
Fraulein RETANAL	Département de biologie / Department of Biology	Assistant de recherche / Research Assistant

Conditions spéciales ou commentaires / Special conditions or comments

15/01/2019

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

Le Comité d'éthique de la recherche (CÉR) de l'Université d'Ottawa, opérant conformément à l'*Énoncé de politique des Trois conseils* (2014) et toutes autres lois et tous règlements applicables, a examiné et approuvé la demande d'éthique du projet de recherche ci-nommé.

L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout évènement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completedfour weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

Kim THOMPSON
Responsable d'éthique en recherche / Protocol Officer
Pour/For **Daniel LAGAREC** Président(e) du/ Chair of the **Comité d'éthique de la recherche en sciences sociales et humanités / Social Sciences and Humanities Research Ethics Board**

550, rue Cumberland, pièce 154 550 Cumberland Street, Room 154
Ottawa (Ontario) K1N 6N5 Canada Ottawa, Ontario K1N 6N5 Canada

613-562-5387 • 613-562-5338 • ethique@uOttawa.ca / ethics@uOttawa.ca

Informed Consent Sheet for Parents

Homework-Helping Behaviours: Exploring Parent and Child Interactions

Principal Investigator: Erin Maloney, Professor, School of Psychology, University of Ottawa
Project Funding: Social Sciences and Humanities Research Council of Canada
Phone Number: [redacted]
Email address: [redacted]

You and your child are invited to take part in our research study that is being conducted by researchers from the University of Ottawa.

Purpose of this study

Children often struggle with math and reading homework. We aim to create tools to help children better succeed in math and reading. However, before we can design effective tools to help, we must first understand what math and reading homework interactions look like in the homes of children in the junior grades. Hence, your participation in this current study will help provide insights into parents' homework helping behaviours and the homework environments of their children. The purpose of this research is to examine how various factors relate to children's math and reading homework experiences.

You are free to choose to participate or not participate in this study.

Procedures

For this study, you and your child will be asked to participate in 2 parts of the study, which will be done consecutively. Below you will find a detailed explanation of what you will be asked to do for each part.

Self-reported questionnaires

You will be contacted by telephone or email by a Research Assistant (RA) to book a convenient time for you and your child to come into the laboratory. You will be asked to complete a series of questionnaires. Within these, you will be asked to complete demographic questions, as well as questions about your attitudes and emotions towards your child's math and reading homework. With the help of an RA, your child will be asked to do the same. These tasks will take approximately 1 hour to complete.

Videotaped session

You and your child will be invited to complete a series of tasks together in a videotaped session. These tasks will include solving riddles, completing math and reading activities, talking about something you usually disagree on at home, and finally planning a fun vacation. This interaction and should take approximately 1 hour.

Please note that the above tasks are not presented the order that they will be administered.

Are there any risks to participating in the research?

You may feel uncomfortable completing math and reading questions with your child in front of a video camera. You may also feel uncomfortable answering some of the questions on the questionnaire. Finally, the conflict task may cause some tension between you and your child, however, a follow-up task is designed to lighten up the mood. If you and/or your child are too uncomfortable with any of the tasks or procedures that are a part of this study, you may choose not to complete the procedure(s) or withdraw from the study.

Are there any benefits to participating in this research?

You and your child may not directly benefit from this research. However, participants enjoy learning more about the research conducted in the Psychology Department at the University of Ottawa. In addition, coming into the laboratory to participate in our study will allow you and your child to spend time together while engaging in our research activities.

Compensation

To thank you for participating in this study, you will be provided a monetary compensation of $20. Additionally, your child will be able to choose a small toy from a selection of toys or receive a $5 Tim Hortons gift card.

Withdrawing from the study

If you decide not to take part in this study, that is alright. If you or your child decide to take part, but change your minds at any time, that is fine too. If you choose to withdraw, you still have the right to decide if the videos or questionnaire data (up to that point) may be used for the study. Please note that if you choose to withdraw from the study, you will still receive the compensation stated above.

Limits of confidentiality

You and your child's personal information will be kept strictly confidential. Written consent forms will be stored in a locked cabinet in a locked office. Written data will be conserved for 10 years following the study. Your results will be coded and you will be assigned a participant ID that will be used to label your data. Your data will be stored on a secure network that is password protected. The link between you and your participant ID will be kept private. Electronic data will be kept indefinitely.

If the researchers publish the results of this study, they will not use your name. Furthermore, all anonymized data may be posted on an open science framework repository to help facilitate the ongoing reproducibility effort within Psychological Science. Please note that video recordings will not be included.

If you wish, you can receive a summary of the study's results. You will be provided with this summary at the conclusion of the study.

Research Ethics

The Research Ethics Board is a group of people from scientific and non-scientific backgrounds who review research studies. Their goal is to ensure the protection of the rights and welfare of people involved in research. You may contact the Protocol Officer for Ethics in Research at the University of Ottawa for information regarding your rights in this research study or to make a complaint about the ethical conduct of this project. They can be reached at (613) 562-5387 or by email at ethics@uottawa.ca.

There are two (2) copies of this consent form, one that the researchers keep, and one for you to keep.

Please feel free to contact Erin Maloney at 613-562-5800 (ext. 4116) if you have any questions about this research study.

I, _____ consent to participate in the above research study by Erin Maloney of the School of Psychology in the faculty of Social Sciences at the University of Ottawa. I have received a copy of this consent form.

I have legal custody of my child and consent to allow my child to participate in this project.

_____

Participant's signature (as parent or guardian)

_____

Printed name (parent)

_____

Printed name (child)

_____

Date

_____

Signature of person obtaining consent

_____

Printed name of person obtaining consent

_____

Date

Child Assent

Homework-Helping Behaviours: Exploring Parent and Child Interactions

Principal Investigator: Erin Maloney, Professor, School of Psychology, University of Ottawa
Phone Number: [redacted]
Email address: [redacted]

You are invited to take part in a research study at the University of Ottawa.

Why do you want to talk with me?
I would like to ask you to take part in our research project.

What is the study about?
This study looks at many different things that relate to your math and reading homework experiences. We will look at the way you and your parent/guardian interact in our laboratory.

You are free to choose to participate or not to participate in this study.

What do I need to do?
For this study, you will be asked to participate in lots of tasks, which will be done one after the other.

First, with my help, you will be asked to complete a series of questions about how you feel about math and reading. Then, you and your parent/guardian will be invited to complete a series of tasks together. This will include solving riddles, completing math and reading activities, talking about something you disagree on, and finally planning a fun vacation! This will all be filmed, but only the researchers in this lab will have access to the video.

The whole visit will take about 2 hours to finish.

Will anyone know what or how I did in this study?
Only the people who are a part of the study will see the film of you and your parent/guardian doing the research activities.

Do I have to do this?
If you do not want to answer any questions or to be filmed while you are doing the activities with your parent, that is alright. You can tell your parent/guardian or us if you don't want to answer or to be filmed. You can stop your participation at any point during the visit. No one will be upset with you.

What if I am not sure?
You can tell your parent/guardian or us that you do not want to answer the questions or to be filmed. If you say yes now, you can change your mind later. You can still say no. No one will be upset with you.

Do you have any questions? You can ask questions at any time. You can ask now, or you can ask later.

What's in it for me?
To thank you for participating in our study, you will have the choice to either pick a small toy from our toy box or get a $5 Tim Horton's gift card.

IF YOU WANT TO BE IN THE STUDY, SIGN YOU NAME ON THE LINE BELOW:

_____ _____

Child's Name **Signature of child**

_____

Date

I confirm that the study has been explained to my child to the extent compatible with my child's understanding, and that my child has agreed to be in this study.

_____ _____

Parent's Name **Signature of parent**

_____

Date

I confirm that I have explained the study to the participant to the extent compatible with the participant's understanding, and that the participant has agreed to be in the study.

_____ _____

Printed name of person obtaining assent **Signature of person obtaining assent**

_____

Date

Debriefing Form

Homework-Helping Behaviours: Exploring Parent and Child Interactions

Dear participant,

Thank you for taking part in our study. Your participation will help us to better understand parents' homework helping behaviours and the homework environment they provide their children. Additionally, this study will allow us to understand the bond and support between parents and their children and the impact it will have on the child's academic performance. It is important to gain an understanding about this issue because, thus far, there is very little research examining the practices that parents use when teaching their children math. This study aimed to investigate a variety of emotional factors, such as enjoyment of mathematics and anxiety of mathematics. This research will also shed light on how these factors differ as a function of the parent's math anxiety (i.e., the adverse emotional reaction to the prospect of doing math).

All the information we collected in today's study will be confidential, and there will be no way of identifying your individual responses in the data archive. We are not interested in any one individual's responses; we want to look at the general patterns that emerge when the data are aggregated together. You are free to withdraw from the project at any time (during or after the session).

Given that some students struggle with mathematics, we wanted to tell you about the following resources for your child:

Homework Help

Homework Help is free, real-time math tutoring by certified Ontario teachers available to students in grades 7 to 10 in all English-language school boards. Students have access to live, interactive online math help funded by the Ministry of Education. This program is password protected and not available to the general public.

TVOKids Homework Zone

Homework Zone is a TVO segment that invites students to call or email questions to a teacher who provides answers, solutions and tips on air. The focus of the segment is on literacy, math and science, and an archive of the videos is made available online for students, parents and educators.

SOS Devoirs

SOS Devoirs, which is operated by TFO, provides tutoring services and educational resources such as dictionaries and multimedia learning objects to French-language students from grades 1 to 12. Students can get help in any subject matter from specialized teachers via chat, by phone and by e-mail. SOS Devoirs' tutoring services are available Monday to Thursday, from 3:30 p.m. to 9 p.m., during the school year.

Additionally, we understand that some activities that you and your child participated in today may increase general distress in your child. For this reason, we wanted to tell you about the following resources:

Kids Help Phone

24-hour anonymous telephone counseling, referral and internet counseling service for children and youth. Phone: 1-800-668-6868. Email: www.kidshelpphone.ca.

Crossroads Children's Mental Health Centre

Mental health agency for children under the age of 12 with major behavioural, emotional, and social challenges. Services offered: school-based day treatment program with a capacity of 60 children; family-support program; individual therapy; family therapy; group therapy; in-home treatment; walk-in clinic. Administrative hours: Mon-Fri 8am-4pm. Walk-in clinic: Wednesdays 9am-12pm and Thursdays 12pm-8pm. Email: info@crossroadschildren.ca. Website: www.crossroadschildren.ca.

Youth Services Bureau of Ottawa

Mental health walk-in clinic and ongoing counseling services available with counselors who specialize in working with youth and their families. Mental health walk-in clinic located at 2301 Carling Avenue (Tuesdays & Thursdays 12pm-8pm). Phone: 613-562-3004 or after hours 613-260-2360 or 1-877-377-775. Website: www.ysb.on.ca.

Your participation today is greatly appreciated! Any information about your rights as a research participant may be addressed to Protocol Officer for Ethics in Research, 550 Cumberland Street, Room 154, 613-562-5387, ethics@uOttawa.ca. If your participation in this study has caused you concerns, anxiety, or you have any questions, you are welcome to contact the principal investigator, Erin Maloney. Her information can be found at the top of this form.

Thank you,

Dr. Erin Maloney
Cognition and Emotion Laboratory
University of Ottawa
[personal information redacted]

Debriefing Form (CHILD)

Homework-Helping Behaviours: Exploring Parent and Child Interactions

Dear participant,

Thank you for taking part in our study. You were told that the purpose of this study is to look at many different things that relate to your math and reading homework experiences, and how you and your parent/guardian interact in our laboratory. More specifically, your participation today has helped us to better understand how parents help their kids with homework and how kids respond to that help. This study is also going to help us understand the way that the bond and support between you and you parent help your success at school. It's important to learn more about this because, so far, there aren't a lot of researchers looking at what parents do when they help their kids with math. This study looked at many different emotional factors, like how much you like math or how much you are anxious about math. This research will also help us understand how all these factors may change depending on your parent's anxiety about math. Math anxiety is a bad feeling you get whenever you're presented with a math task.

All of the information we collected in today's study will be confidential. This means that only the people in this lab will have access to all of this information. We are not interested in any one individual's responses; we want to look at the general patterns that come up looking at the data as a whole. You are free to withdraw from the project at any time (during or after the session).

Your participation today is greatly appreciated! Any information about your rights as a research participant may be addressed to Protocol Officer for Ethics in Research, 550 Cumberland Street, Room 154, 613-562-5387, ethics@uOttawa.ca. If your participation in this study has caused you concerns, anxiety, or you have any questions, you are welcome to contact the principal investigator, Erin Maloney. Her information can be found at the top of this form.

Thank you,

Dr. Erin Maloney
Cognition and Emotion Laboratory
University of Ottawa
[personal information redacted]

Follow-up Consent

Homework-Helping Behaviours: Exploring Parent and Child Interactions

After having completed this study, do you continue to consent to the research team keeping the video recordings for research purposes?

□ Yes, I consent
□ No, I do not consent

_____
Participant's signature (as parent or guardian)

_____
Date

_____
Signature of person obtaining consent

_____
Date

Grade 5 ID# ___

1. **Mrs. Smyte records the number of people in the school gym every hour during a school day. The data she collects show a maximum of 100 people. Which of the following is an approriate scale for the graph?**

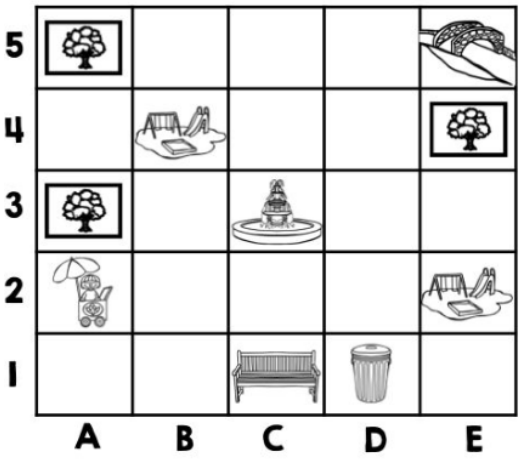
    a. Increasing by 1 (0,1,2,3,4,...)
    b. Increasing by 2's (0,2,4,6...)
    c. Increasing by 10's (0, 10,20, 30...)

2. **A student collects apples over a 5-day period.**

Day	Apples
1	5
2	6
3	4
4	3
5	7

What is the median number of apples that the student collected?

3. **Use the map and key below to complete the grid and answer the questions.**



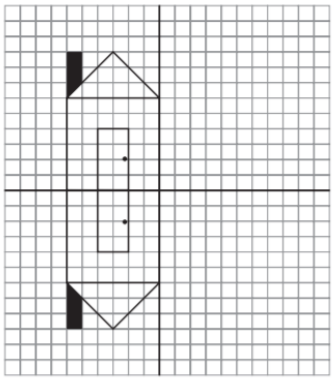
a. Name the location of each item on the map.

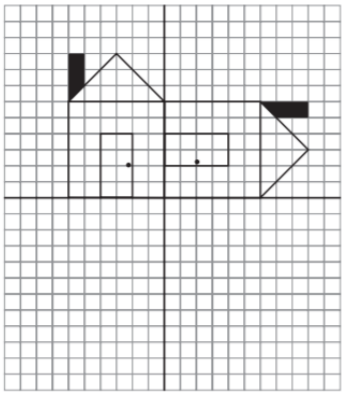
play area: B4, E2	ice cream:
trash can:	fountain:
park bench:	tree:

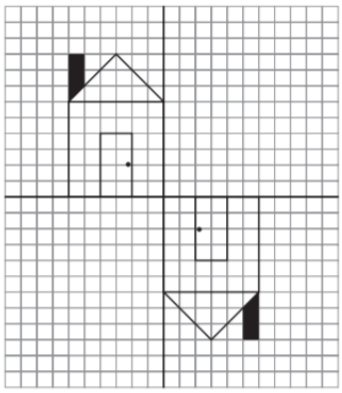
b. Add the following items to the map key by drawing a picture and labeling them. Draw the items anywhere on the map and name the location.

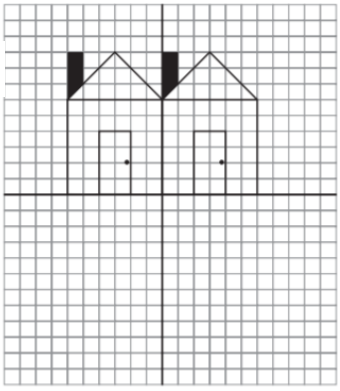
restroom:	**bike trail:**
cotton candy:	**balloons:**

4. Which image demonstrates a reflection?

a. 

c. 

b. 

d 

5. Which is the most appropriate unit of measurement to describe the area of the floor of a gym?

a. km^2
b. cm^3
c. m^2
d. m^3

6. Build a rectangle with a length of 9 cm and a width of 1 cm and record the area.

Now, build a rectangle that has a side length of one less cm and a side width of one more cm.

What do you notice about the area?

7. How many minutes are in 5 hours?

a. 65 minutes
b. 120 minutes
c. 300 minutes
d. 240 minutes

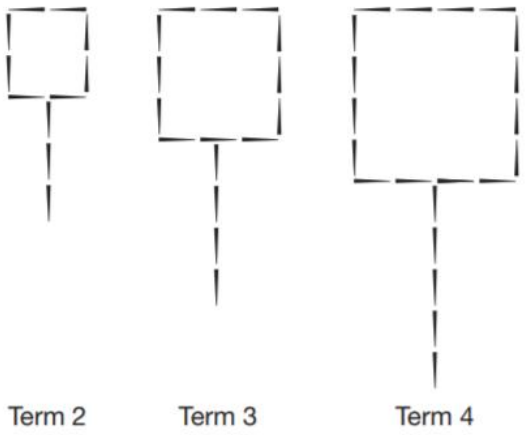
8. Look at the numbers below:

$$\frac{1}{5} \; or \; \frac{1}{4}$$

Which fraction is the largest?

a. $\frac{1}{5}$ b. $\frac{1}{4}$

9. The terms of a pattern are made using toothpicks. Term 1 and Term 5 are not shown.



a. How many toothpicks are used to build the first term?

b. How many tooth picks are used to build the 5^{th} term?

Grade 6 ID# ___

1. **Mrs. Smyte records the number of people in the school auditorium every hour during a school day. The data she collects show a maximum of 325 people in the auditorium. Which of the following is an appropriate scale for the vertical axis of the line graph for these data?**

    a. 7 increments with each increment representing 40 people
    b. 10 increments with each increment representing 35 people
    c. 15 increments with each increment representing 20 people
    d. 20 increments with each increment representing 12 people

2. **A student collects apples over a 5-day period.**

Day	Apples
1	5
2	6
3	4
4	3
5	7

What is the mean number of apples that the student collected?

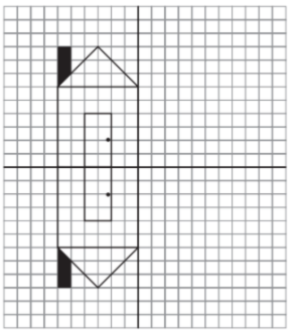
3. **Using a protractor and a ruler, build a triangle with an interior angle of 45° and a side length of 5 cm.**

Show your work.

4. Which shows a transformation that matches its title?

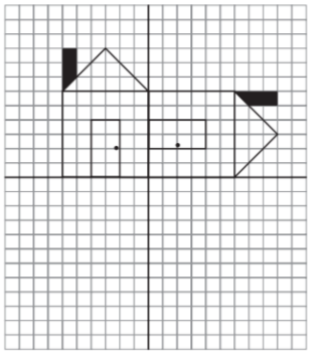
a.

Translation



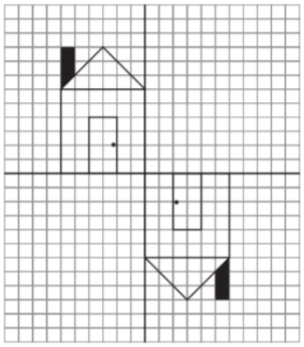
c.

Translation



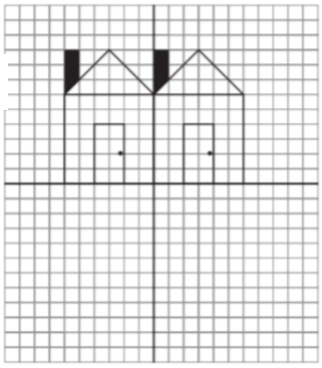
b.

Rotation



d

Reflection

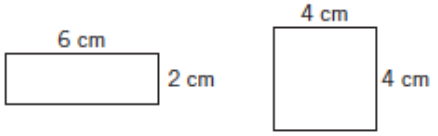


5. Ms. Vanstone asks her students to draw a rectangle and a square with the areas and perimeters given below.

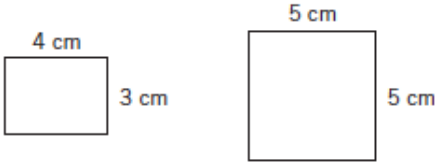
	Rectangle	Square
Area	12 cm^2	25 cm^2
Perimeter	16 cm	20 cm

Which shows two correct drawings?

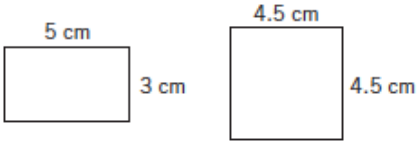
a



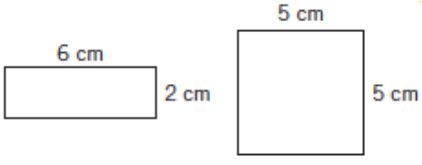
b



c



d



6. Which is the most appropriate unit of measurement to describe the area of the floor of a gym?

a. km^2
b. cm^3
c. m^2
d. m^3

7. How many minutes are in a day?

a. 1 440 minutes
b. 84 minutes
c. 7 20 minutes
d. 3 600 minutes

8. Look at the numbers below.

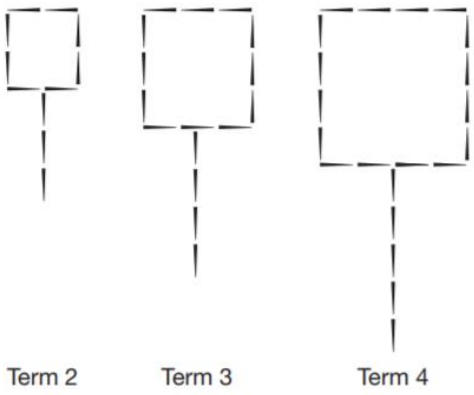
$$\frac{12}{8}, \frac{5}{8}, \frac{18}{8}, 1\frac{7}{8}$$

Which list shows these numbers order from smallest to greatest?

b. $\frac{5}{8}, \frac{12}{8}, 1\frac{7}{8}, \frac{18}{8}$
c. $\frac{5}{8}, \frac{12}{8}, \frac{18}{8}, 1\frac{7}{8}$
d. $\frac{12}{8}, \frac{5}{8}, 1\frac{7}{8}, \frac{18}{8}$
e. $\frac{12}{8}, \frac{18}{8}, \frac{5}{8}, 1\frac{7}{8}$

(turn to the following page...)

9. The terms of a pattern are made using toothpicks. Term 1 and Term 5 are not shown.



a. *How many toohtpicks are used to build the first term?*

b. *How many tooth picks are used to build the 5^{th} term?*

c. *How many toothpicks are used to build the 10^{th} term?*

Grade 7 ID# ___

1. The heights of the 5 starting players on a basketball team are shown in the table below:

Starting Players' Heights
164 cm
168 cm
178 cm
180 cm
180 cm

What is the mean height of the five starting players?

a. 138 cm
b. 174 cm
c. 178 cm
d. 180 cm

2. Mrs. Smyte records the number of people in the school auditorium every hour during a school day. The data she collects show a maximum of 325 people in the auditorium. Which of the following is an appropriate scale for the vertical axis of the line graph for these data?

a. 7 increments with each increment representing 40 people
b. 10 increments with each increment representing 35 people
c. 15 increments with each increment representing 20 people
d. 20 increments with each increment representing 12 people

3. Using a protractor and a ruler, construct a parallelogram with an angle measure of 115° and sides with lengths of 7 cm and 6 cm. Mark on the parallelogram the length of each side and the measure of all.

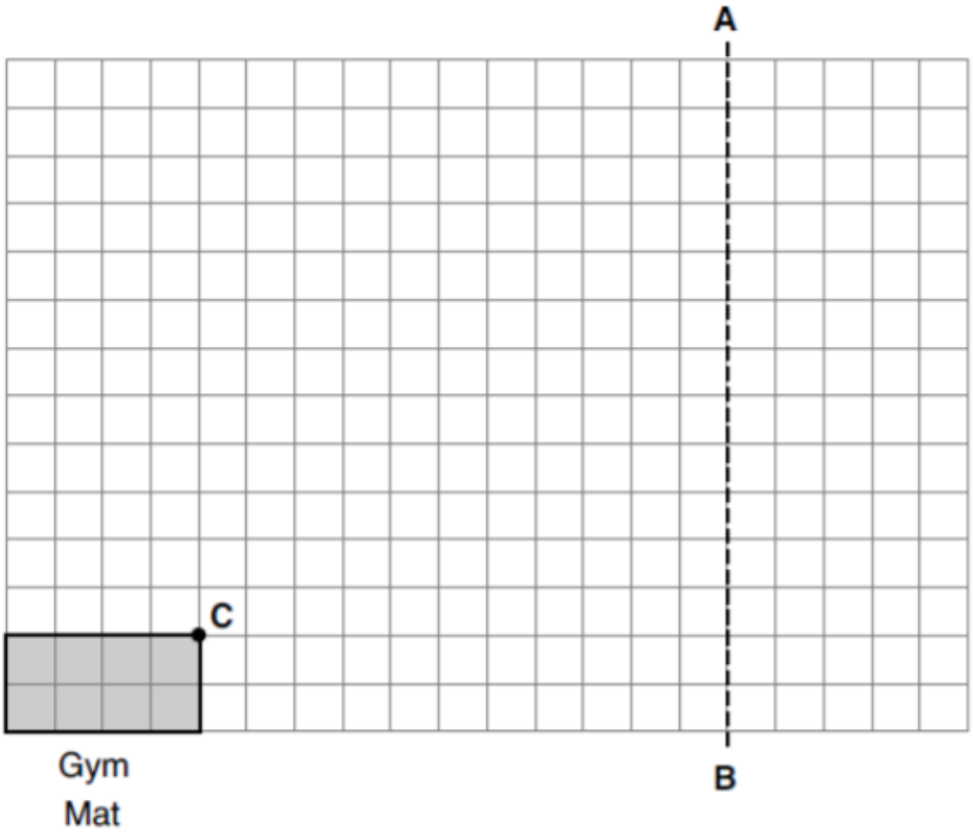
Show your work.

4. Mr. Lee moves a gym mat using the following four transformations.

i. Rotate the gym mat 90° clockwise about Point C.
ii. Translate the gym mat 8 units to the right.
iii. Translate the gym mat 6 units up.
iv. Reflect the gym mat over line AB.

On the grid below, show the new location of the gym mat after Mr. Lee makes the four transformations.

Show all your work.

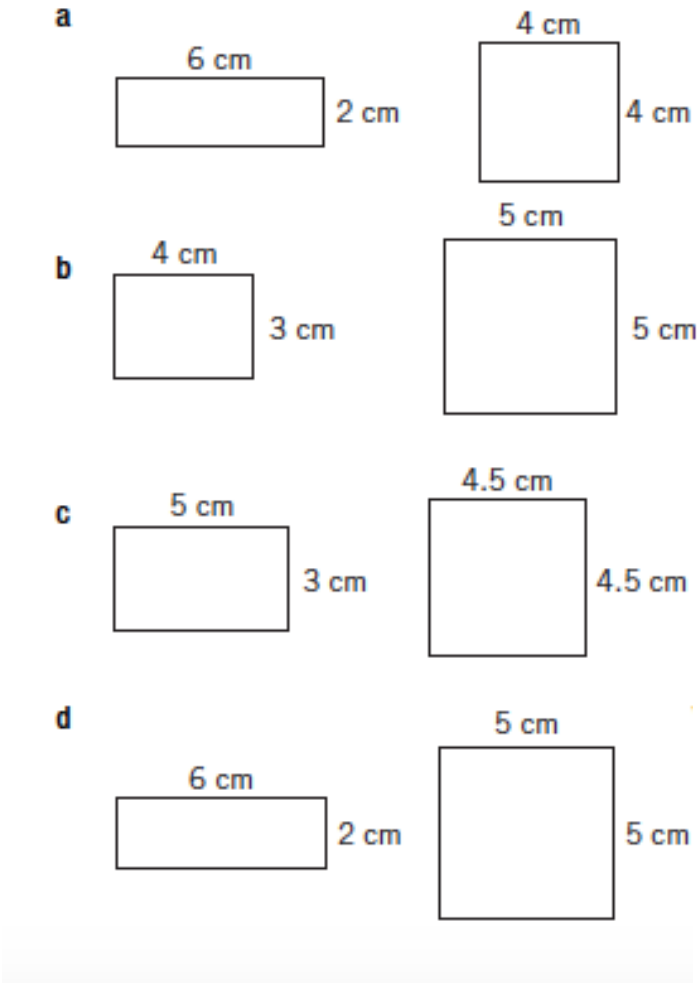


5. Ms. Vanstone asks her students to draw a rectangle and a square with the areas and perimeters given below.

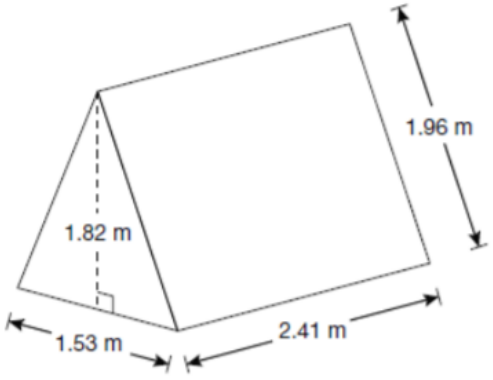
	Rectangle	Square

Area	12 cm^2	25 cm^2
Perimeter	16 cm	20 cm

Which shows two correct drawings?



6. Cynthia purchases a tent for her camping trip, as show below. During one night of the camping trip, it rains. The floor of the tent is the only part that stays dry.



What is the area of the part of Cynthia's tent that gets wet?

a. 10.84 m^2
b. 12.23 m^2
c. 15.01 m^2
d. 16.96 m^2

7. How many minutes are in 365 days?

a. 8760 minutes
b. 21 900 minutes
c. 262 800 minutes
d. 525 600 minutes

8. Look at the numbers below.

$\frac{3}{2}, \frac{5}{8}, \frac{9}{4}, 1\frac{7}{8}$

Which list shows these numbers ordered from smallest to largest?

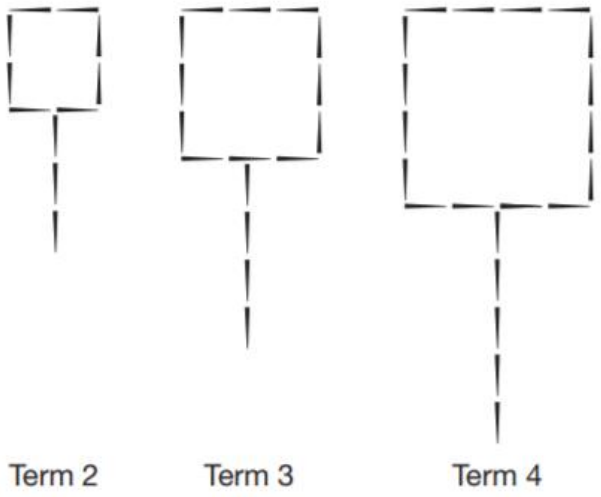
a. $\frac{5}{8}, \frac{3}{2}, 1\frac{7}{8}, \frac{9}{4}$

b. $\frac{5}{8}, \frac{3}{2}, \frac{9}{4}, 1\frac{7}{8}$

c. $\frac{3}{2}, \frac{5}{8}, 1\frac{7}{8}, \frac{9}{4}$

d. $\frac{3}{2}, \frac{9}{4}, \frac{5}{8}, 1\frac{7}{8}$

9. The terms of a pattern are made using toothpicks. Term 1 and Term 5 are not shown.



a. *How many toohtpicks are used to build the first term?*

b. *How many tooth picks are used to build the 5^{th} term?*

c. *How many toothpicks are used to build the 25^{th} term?*

Appendix B

Supplemental Tables and Figures for Study 1

Figure B1

Scree Plot for Study 1a

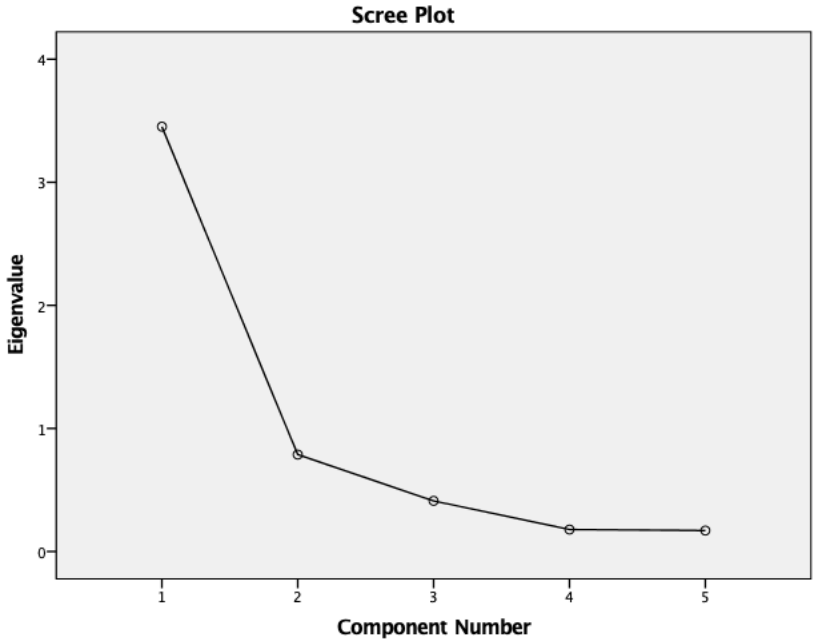


Table B1

Component Matrix for Study 1a

Variable	Component 1
Frustration	.924
Stress	.911
Conflict	.867
Emotionality	.815
Confidence	.595

Note. Extraction Method: Principal Component Analysis; 1 components extracted.

Table B2

Summary of Multiple Regression Analyses Predicting for Individual Items Related to Parents' Emotional Experience Surrounding the Math Homework Environment in Study 1a

Variable	*B*	SE_B	*β*

Confidence			
Constant	.55	.75	
Parent Gender	.35	.43	.12
Child Gender	.14	.20	.05
Child Grade	.18	.15	.17
Parental Math Knowledge	-1.24	.57	-.16*
Parental Math Anxiety	.58	.13	.31**
Frustration			
Constant	1.67	.90	
Parent Gender	.25	.52	.07
Child Gender	-.04	.24	-.01
Child Grade	.22	.18	.18
Parental Math Knowledge	-1.29	.69	-.14t
Parental Math Anxiety	.56	.16	.26**
Conflict			
Constant	2.09	.90	
Parent Gender	-.08	.51	-.02
Child Gender	-.14	.24	-.04
Child Grade	.32	.18	.27t
Parental Math Knowledge	-.94	.68	-.11
Parental Math Anxiety	.31	.16	.15t
Stress			
Constant	2.34	.92	
Parent Gender	.08	.53	.02
Child Gender	-.24	.25	-.07
Child Grade	.30	.18	.24
Parental Math Knowledge	-1.68	.71	-.18*
Parental Math Anxiety	.48	.17	.22**
Emotionality			
Constant	.77	.82	
Parent Gender	.24	.27	.08
Child Gender	-.16	.22	-0.5
Child Grade	.09	.16	.08
Parental Math Knowledge	.56	.62	.07
Parental Math Anxiety	.44	.15	.24**

Note. t $p < .10$; * $p < .05$; ** $p < .01$; *M* = mean; *SD* = standard deviation. Note that the confidence variable was reverse-coded, wherein a higher score indicates lower confidence.

Figure B2

Scree Plot for Study 1b

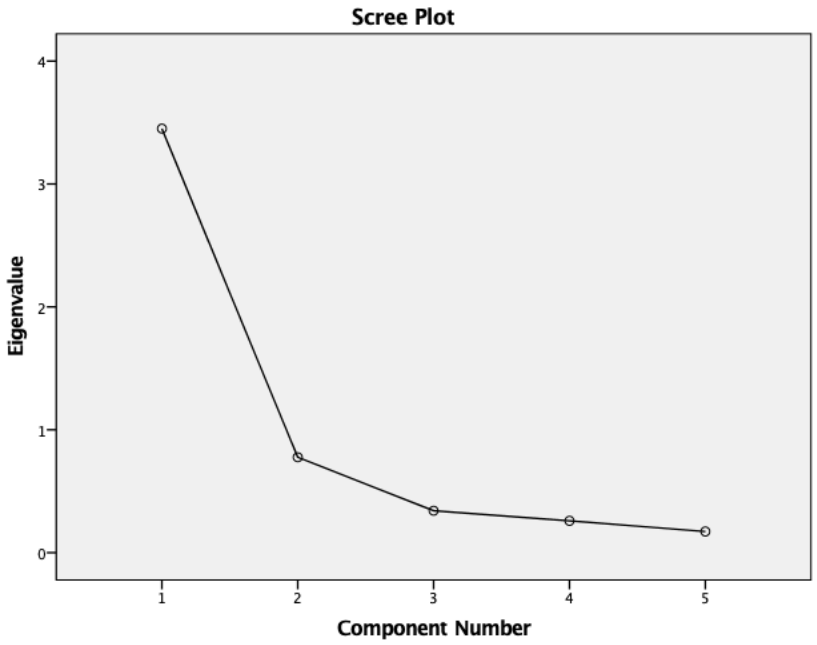


Table B3

Component Matrix for Study 1b

Variable	Component 1
Frustration	.917
Stress	.892
Conflict	.871
Emotionality	.863
Confidence	.558

Note. Extraction Method: Principal Component Analysis; 1 components extracted.

Table B4

Summary of Multiple Regression Analyses Predicting for Individual Items Related to Parents' Emotional Experience Surrounding the Math Homework Environment in Study 1b, Controlling for Parents' General Anxiety

Variable	*B*	SE_B	*β*
Confidence			
Constant	1.46	.62	
Parent Gender	.13	.18	.07
Child Gender	.09	.18	.03
Child Grade	.07	.05	.09
Parental Generalized Anxiety	.52	.20	.20*

Parental Math Knowledge	-1.56	.45	-.25**
Parental Math Anxiety	.15	.12	.11
Frustration			
Constant	.96	.68	
Parent Gender	-.06	.20	-.02
Child Gender	-.47	.20	-.13*
Child Grade	.07	.06	.07
Parental Generalized Anxiety	.44	.22	.13t
Parental Math Knowledge	-.37	.50	-.05
Parental Math Anxiety	.94	.13	.52***
Conflict			
Constant	1.46	.64	
Parent Gender	-.15	.19	-.04
Child Gender	-.33	.19	-.10t
Child Grade	.03	.05	.03
Parental Generalized Anxiety	.16	.21	.05
Parental Math Knowledge	-.66	.47	-.09
Parental Math Anxiety	.97	.12	.58***
Stress			
Constant	.29	.64	
Parent Gender	.11	.19	.03
Child Gender	-.32	.19	-.09t
Child Grade	.08	.05	.08
Parental Generalized Anxiety	.45	.21	.14*
Parental Math Knowledge	-.34	.46	-.04
Parental Math Anxiety	.96	.12	.55***
Emotionality			
Constant	1.36	.64	
Parent Gender	-.30	.17	-.09
Child Gender	-.10	.19	-.03
Child Grade	-.00	.05	-.00
Parental Generalized Anxiety	.59	.21	.19**
Parental Math Knowledge	-.77	.47	-.11
Parental Math Anxiety	.67	.12	.42***

Note. t $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$; *M* = mean; *SD* = standard deviation. Note that the confidence variable was reverse-coded, wherein a higher score indicates lower confidence.

Appendix C

Supplemental Tables for Study 2

Table C1

Spearman's Rho Correlations between Parent-Child Behaviours and Math Anxiety, Without Controlling for General Anxiety

Subscales	Parent Math Anxiety	Child Math Anxiety
Parental Behaviour		
Parental Sensitivity	-0.02	-0.41**
Respect for Child's Rhythm	-0.23	-0.47**
Parental Effort	-0.09	-0.18
Dyadic Interactions		
Relaxation	-0.11	-0.52***
Neutrality-Joy	-0.23	-0.52***
Intimacy	-0.03	-0.33*
Coordination	-0.24	-0.51***
Appropriate Roles	-0.23	-0.41**
Synchronized Emotions	-0.10	-0.33*
Attention Centred on Task	-0.11	-0.02

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table C2

Spearman's Rho Correlations between Parent-Child Affective Language and Math Anxiety, Without Controlling for General Anxiety

Affective Language	Parent Math Anxiety	Child Math Anxiety
Positive Word Count (Parents)[a]	-0.13	-0.38*
Negative Word Count (Parents)[a]	-0.09	0.19
Positive Word Count (Children)[a]	0.11	-0.07
Negative Word Count (Children)[a]	0.16	0.03

Note. [a]percentages; * $p < 0.05$.

Appendix D

Originally Planned Analyses for Study 3

Hypothesis D1.1: Influence of Parent Math Anxiety, Insecure Attachment, and Homework Interaction on Child Math Anxiety

The index of moderated mediation was statistically significant, b = -.22, 95% percentile CI [-.56, -.03], providing evidence for a moderated mediation.

For the a-path from parent math anxiety (IV) to the quality of the math homework-helping interaction (MED) there was a statistically significant interaction between parent math anxiety (IV) and the insecure attachment relationship (MOD), b = .35, p = .01, ΔR^2 = .18. The conditional effect from parent math anxiety (IV) on the quality of the math homework-helping interaction (MED) was the strongest for low values (- 1 *SD*) of the insecure attachment relationship (MOD), b = -.33, p = .01. It was not statistically significant for medium values (*M*) of the insecure attachment relationship (MOD), b = -.09, p = .20 and for high values (+ 1 *SD*) of the insecure attachment relationship (MOD), b = .15, p = .13. For the full regression results see Table D1.

The b-path from the quality of the math homework-helping interaction (MED) to child math anxiety (DV) was significant, b = -.63, p = .02. The direct effect (c'-path) from parent math anxiety to child math anxiety was also significant, b = .33, p = .01. For the full regression results see Table D1.

Table D1

Regression results for the a-path from IV to MED and for the b-path from MED to DV

Variable	Model a-path			Model b/c'-path		
	b	*SE*	*p*	*b*	*SE*	*p*
IV	-.09	.07	.20	.33	.13	.01
MOD	-.18	.10	.08			

IV x MOD	.35	.12	.01			
MED				-.63	.26	.02

Note. n = 38. Model for the a-path R^2 = .31, $F(3, 34) = 5.15$, $p < .01$, Model for b-path and c'-path R^2 = .29, $F(2, 35) = 7.11$, $p < .01$.

Hypothesis D1.2: Influence of Parent Math Anxiety, Secure Attachment, and Homework Interaction on Child Math Anxiety

The index of moderated mediation was not statistically significant, b = .04, 95% percentile CI [-.02, .12], providing no evidence for a moderated mediation.

For the a-path from parent math anxiety (IV) to the quality of the math homework-helping interaction (MED) there was no statistically significant interaction between parent math anxiety (IV) and the secure attachment relationship (MOD), b = -.06, p = .16, ΔR^2 = .05. For the full regression results see Table D2.

The b-path from the quality of the math homework-helping interaction (MED) to child math anxiety (DV) was significant, b = -.63, p = .02. The direct effect (c'-path) from parent math anxiety to child math anxiety was also significant, b = .33, p = .01. For the full regression results see Table D2.

Table D2

Regression results for the a-path from IV to MED and for the b-path from MED to DV

Variable	Model a-path			Model b/c'-path		
	b	*SE*	*p*	*b*	*SE*	*p*
IV	-.09	.08	.30	.33	.13	.01
MOD	.06	.04	.12			
IV x MOD	-.06	.04	.16			
MED				-.63	.26	.02

Note. n = 38. Model for the a-path R^2 = .16, $F(3, 34) = 2.12$, p = .12, Model for b-path and c'-path R^2 = .29, $F(2, 35) = 7.11$, $p < .01$.

Hypothesis D2.1: Influence of Parent Math Anxiety, Insecure Attachment, and Homework Interaction on Child Math Achievement

The index of moderated mediation was not statistically significant, $b = 1.88$, 95% percentile CI [-3.07, 8.39], providing no evidence for a moderated mediation.

For the a-path from parent math anxiety (IV) to the quality of the math homework-helping interaction (MED) there was a statistically significant interaction between parent math anxiety (IV) and the insecure attachment relationship (MOD), $b = .35$, $p = .01$, $\Delta R^2 = .18$. The conditional effect from parent math anxiety (IV) on the quality of the math homework-helping interaction (MED) was the strongest for low values (- 1 *SD*) of the insecure attachment relationship (MOD), $b = -.44$, $p = .01$. It was not statistically significant for medium values (*M*) of the insecure attachment relationship (MOD), $b = -.05$, $p = .45$ and for high values (+ 1 *SD*) of the insecure attachment relationship (MOD), $b = .11$, $p = .22$. For the full regression results see Table D3.

The b-path from the quality of the math homework-helping interaction (MED) to child math achievement (DV) was not statistically significant, $b = 5.43$, $p = .38$, nor was the direct effect (c'-path) from parent math anxiety to child math achievement, $b = -3.01$, $p = .33$. For the full regression results see Table D3.

Table D3

Regression results for the a-path from IV to MED and for the b-path from MED to DV

Variable	Model a-path			Model b/c'-path		
	b	*SE*	*p*	*b*	*SE*	*p*
IV	-1.05	.35	< .01	-3.01	3.03	.33
MOD	-.98	.27	< .01			
IV x MOD	.35	.12	.01			
MED				5.43	6.15	.38

Note. $n = 38$. Model for the a-path $R^2 = .31$, $F(3, 34) = 5.15$, $p < .01$, Model for b-path and c'-path $R^2 = .05$, $F(2, 35) = 1.00$, $p = .38$.

Hypothesis D2.2: Influence of Parent Math Anxiety, Secure Attachment, and Homework Interaction on Child Math Achievement

The index of moderated mediation was not statistically significant, b = -.34, 95% percentile CI [-1.66, .62], providing no evidence for a moderated mediation.

For the a-path from parent math anxiety (IV) to the quality of the math homework-helping interaction (MED) there was not statistically significant interaction between parent math anxiety (IV) and the secure attachment relationship (MOD), b = -.06, p = .16, ΔR^2 = .05. For the full regression results see Table D4.

The b-path from the quality of the math homework-helping interaction (MED) to child math achievement (DV) was not statistically significant, b = 5.43, p = .38, nor was the direct effect (c'-path) from parent math anxiety to child math achievement, b = -3.01, p = .33. For the full regression results see Table D4.

Table D4

Regression results for the a-path from IV to MED and for the b-path from MED to DV

Variable	Model a-path			Model b/c'-path		
	b	*SE*	*p*	*b*	*SE*	*p*
IV	.12	.14	.40	-3.01	3.03	.33
MOD	.21	.10	.05			
IV x MOD	-.06	.04	.16			
MED				5.43	6.15	.38

Note. n = 38. Model for the a-path R^2 = .16, $F(3, 34)$ = 2.12, p = .12, Model for b-path and c'-path R^2 = .05, $F(2, 35)$ = 1.00, p = .38.