Me, My Family, and Mathematics: Exploring Caregivers' Experiences of Doing Mathematics with Their Children

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Abstract

Caregivers influence how children experience mathematics (Maloney et al., 2015), yet caregivers' own relationships with mathematics remain underexamined. Mathematics education researchers have studied how families' Funds of Knowledge can contribute to classroom learning (e.g., Civil & Bernier, 2006), but less is known about how caregivers experience doing mathematics with their children and how these experiences relate to caregivers' mathematical identities. Researchers have also questioned if mathematical relationships between caregivers and their children are bi-directional (Li et al., 2021). Anderson (1997) describes caregivers as the "more proficient other," a role that is distinct from teacher or student. This distinction points to the need for research that explores caregivers' own unique experiences with mathematics. In my study, I employed a phenomenographic approach to examine the qualitatively different ways caregivers experienced doing mathematics with their children at home. I drew on Funds of Identity and Mathematical Identities as conceptual perspectives to examine the identity resources caregivers drew on and how caregivers understood themselves in relation to mathematics. Three caregivers from two families participated through semi-structured interviews, voice-note memoing, participant-generated artifacts, and a family mathematics task.

My analysis identified three categories of description. First, caregivers experienced mathematics as embedded within everyday family routines. Second, children's mathematical ideas became a source of insight through which caregivers learned more about their children and recognized aspects of themselves. Third, caregivers experienced mathematical competence as relational through who initiated mathematics in the household and anticipated expectations of how home mathematics might be taken up in other settings like school.

These findings show that doing mathematics with children can prompt caregivers to re-experience their own mathematical histories, emotions, and perceived competence. The findings also suggest that homework can be re-framed to support relationships between families and schools when it invites discussion, builds on caregivers' experiences and interests, and communicates a vision of mathematics that focuses on solving problems, making predictions, or experimenting. I argue that caregivers' relationships with mathematics matter in their own right, and doing mathematics with children can create opportunities for caregivers to develop more positive relationships with mathematics.

Dedication

This work is dedicated to the families who shared their stories with me over the years.

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Overture: The Beginning

I have been working with kids and families in some capacity since I started teaching dance at fifteen years old. I have a distinct memory of a mother standing outside a Saturday morning ballet class while I was teaching. She proudly held a yellow legal pad, taking detailed notes on her three-year-old's performance. The child always seemed stressed until I finally told the mom to just let her have fun. I also remember parents dropping kids off late with several others in tow, the grandparents who always picked them up, and younger siblings running around the lobby whom I would eventually teach.

The structure of the studio allowed me to know both students and their families. Pick-ups and drop-offs, studio fundraisers, extensive weekend rehearsals, and organizing costumes created ongoing opportunities to spend time with families and get to know them. Through my relationships with families, I learned which children had strong support at home, and which would benefit from me packing an extra snack on a long rehearsal day. As a result, my classes ran smoothly because families and I had the opportunity to become aligned with each other. Time spent with families made it clear to me that the children I taught existed within communities beyond my classroom that influenced what happened inside the classroom.

When I began working as a public school teacher, I noticed a different pattern. Relationships between families and teachers felt more distant than what I had experienced in the studio. In schools, most communication with families occurred through agendas, report cards, emails, or phone calls home. Conversations often focused on behaviour, homework completion, or academic concerns rather than ongoing relationship-building. Unlike the studio, there were fewer informal opportunities to spend time with families or learn about children's lives beyond

the classroom. None of the parents knew my preference for green tea over coffee, and I did not know who would be celebrating a big birthday this year. These differences made me more aware of how institutional structures, like school boards, shape relationships between teachers and families. Nonetheless, I could still see children's home lives entering the classroom in subtle but important ways. Some children approached homework with visible confidence, while others expressed anxiety about bringing mathematics home. Students frequently referenced family experiences during classroom discussions, including procedures they learned from parents or negative experiences they were having with mathematics at home. I listened to many stories from parents and students about being frustrated over a worksheet around the dinner table. These moments made it difficult to separate classroom mathematics from the experiences families described surrounding mathematics at home.

The research on families and education reflected some of the tensions I noticed in my own teaching experiences. Ippolito (2010) critiques approaches that frame home-school relationships primarily in terms of families orienting to schools or schools orienting to families. Instead, he argues for the importance of *middle spaces*, where educators and families can engage in more reciprocal forms of relationship-building. At the beginning of my doctoral work, I was drawn to Civil and Bernier's (2006) work on parental partnerships that challenged hierarchical relationships between homes and schools. Their work raised important questions for me about how caregivers experience relationships with schools and educators. These questions became especially important to me in mathematics education, where caregivers are often seen as homework helpers rather than collaborators in children's mathematical learning.

My interest in these questions was also shaped by my own relationship with mathematics. Growing up, I adamantly described myself as someone who hated mathematics. In my household, my brother was "the math person," while I was considered "good at writing." When I entered teacher education, I even asked if I could replace the required mathematics course with an additional drama course because I believed I would "never use it." At the time, I planned to teach dance in a high school, and mathematics felt irrelevant to my life. That has since become a running joke in my household.

After spending five years teaching high school dance abroad, I returned to Canada and unexpectedly found myself teaching Grade 7 mathematics. I accepted the assignment with gratitude because I needed the job. But behind closed doors, I was terrified. I felt completely unqualified for this role, and soon everyone would know it too. I sat in the back of Mr. De Grandis' Grade 7 mathematics class learning the lessons I would be teaching the following period. His view was that anyone can do mathematics, and I knew he really believed it because he thought I could too. During this year, through doing mathematics with children every day, my relationship with mathematics changed completely. The subject I once viewed as irrelevant to my career trajectory now became central to it. Seventeen-year-old me would not have believed that I would eventually complete a master's degree in mathematics education and pursue a doctorate in the field. Her plan was to be a backup dancer for Britney Spears. My experiences have since made it difficult for me to view mathematical identities as fixed. They also led me to wonder how doing mathematics with children might reshape caregivers' relationships with mathematics over time.

Researchers (e.g., McNeal, 2014; Matthes & Stoeger, 2018) have identified that parent-child discussions are an important part of how children learn, and parents' beliefs about learning can influence children through these interactions. Mathematics education researchers have also shown that caregivers' relationships with mathematics influence children's mathematical learning. For example, Maloney et al. (2015) found that when parents with high mathematics anxiety frequently help with homework, children's mathematics achievement tends to decrease. These findings suggest that caregivers' experiences with mathematics shape how mathematical activity unfolds in the home.

One parent in particular came to me for advice on supporting her daughter. Her husband was trying to help with mathematics at home, but it always ended in tears. Both the child and her father would leave upset, and her mother was deeply hurt watching all of this unfold. Watching this family struggle with mathematics homework made me recognize that caregivers' feelings in mathematical interactions matter too.

Despite the importance of these interactions, relatively little research has focused on caregivers' experiences of doing mathematics with their children. Anderson (1997) notes that parents occupy a role that differs from both teachers and students. Anderson's work inspired me to wonder more about how the parents I had built relationships with experienced the mathematics I sent home. I also began to wonder how caregivers felt while doing mathematics with their children.

My own experiences also made me more interested in how mathematical identities are formed and changed over time. Mathematics education researchers have shown that mathematical identities influence how people engage with mathematics. Researchers have

examined how experiences with mathematics shape confidence, emotional responses, participation, and willingness to engage in mathematical activity. Di Martino and Zan (2010), for example, describe mathematical attitudes as involving emotional disposition, perceived competence, and vision of mathematics. Similarly, Sfard and Prusak (2005) argue that identities are shaped through stories people tell about themselves and are told by others. Caregivers are also involved in mathematical interactions through homework, parent-child discussions, and everyday activity in the home. These interactions may shape how caregivers understand themselves in relation to mathematics. It also means there is potential to influence their relationships in a positive way.

Mathematics education research has examined the experiences of teachers and students in considerable depth. However, we know far less about how caregivers experience mathematics within their interactions with children at home. In my study, I focus on how caregivers experience doing mathematics with their children and how these experiences relate to caregivers' mathematical identities. I also examine how caregivers experience relationships between home and school mathematics. Existing research on parental involvement in mathematics education often focuses on how caregivers support children's achievement or attitudes toward mathematics. By focusing on caregivers' experiences, I shift attention away from viewing parents primarily as supporters of school mathematics. Instead, I examine how mathematics is experienced within family relationships and how caregivers come to understand themselves in relation to mathematics through interactions with children. This study contributes to research on parental involvement, mathematical identity, and home mathematics practices by foregrounding caregivers' experiences and perspectives.

The dramatic shift in my own relationship with mathematics has made me want to support others in learning to love the subject. Or at least not hate it. Many people are walking around with awful relationships with mathematics–tell someone seated next to you on an airplane that you teach math, and they will tell you a horror story of middle school mathematics. This happened on the plane while on my honeymoon–there and back. I think, as mathematics educators, we can do better for people. My study examines how relationships with mathematics may shift through interactions with children and points toward possible ways of supporting more positive mathematical experiences for caregivers and families.

My Research Questions

In my study, I ask:

- *How do adult caregivers experience mathematics in their home setting?*
- *How do adult caregivers' experiences of doing mathematics with their children influence their relationship with mathematics?*
- *How do caregivers experience relationships between home and school mathematics?*

Positionality

I should also note that I am not a parent. I am a middle school mathematics teacher. My own experiences from loathing to loving mathematics shed light on the possibility that relationships with mathematics can change. I came to this work to help others experience mathematics as something they can do and enjoy. I entered this research believing that relationships with mathematics can change over time and that experiences doing mathematics with children may play a role in those shifts.

My experiences teaching mathematics also shaped the kinds of things I paid attention to during interviews and analysis. I found myself especially interested in the emotional dimensions of mathematical interactions, including frustration, confidence, anxiety, and joy. Throughout the research process, I tried to remain attentive to how my own experiences and hopes for mathematics education influenced the interpretations I was making.

Organization of the Dissertation

This dissertation is organized into five chapters:

Chapter 1 reviews four bodies of literature relevant to caregivers and mathematics education. I begin with literature on parental involvement in education before examining research on caregiver involvement in mathematics education. I then review scholarship related to caregivers' relationships with mathematics, including work on mathematics anxiety, mathematical attitudes, and mathematical identity. The chapter concludes with literature on parental partnerships in mathematics education and identifies a gap in understanding how caregivers experience doing mathematics with their children.

Chapter 2 presents the conceptual framework for the study. I begin with an overview of Funds of Knowledge before introducing Funds of Identity as the primary conceptual lens. I then discuss mathematical identity and explain how these perspectives support an examination of caregivers' experiences of doing mathematics with their children.

Chapter 3 describes the study design and methodology. I discuss my positionality as a researcher, phenomenography as the methodological approach, participant recruitment, data collection procedures, and data analysis. The chapter also outlines the role of interviews, voice note memoing, and artifacts in the study.

Chapter 4 presents the findings. The findings are organized into three categories of description that represent qualitatively different ways caregivers experienced doing mathematics with their children. These categories examine caregivers' experiences of mathematics within everyday family life, experiencing children's mathematical ideas as a source of insight, and experiencing competence through family interactions.

Chapter 5 discusses the findings in relation to the research questions, conceptual framework, and existing literature. I examine four contributions arising from the findings: caregivers re-experiencing mathematics through their children, structuring parent-child discussions through mathematics, intergenerational support for caregivers, and homework as a bridge between home and school mathematics. Drawing on these discussions, I identify implications for mathematics education related to supporting caregivers' relationships with mathematics, supporting relationships through mathematical discussion, and fostering conditions for home-school relationships. The chapter concludes with a discussion of limitations, directions for future research, and concluding reflections.

Chapter 1: Literature Review

In this chapter, four bodies of literature that are relevant to families and mathematics education are examined. First, the literature around parental involvement in education is discussed more broadly to examine how researchers discuss relationships between families, schools, and learning. Then, there is an examination of the literature on caregiver involvement in mathematics education to examine the role of everyday mathematical interactions and mathematics homework within families. Next, the literature on caregivers' relationships with mathematics is explored as it appears in relation to mathematics anxiety, mathematical attitudes, and mathematical identities. Finally, scholarship in parental partnerships in mathematics education highlights research that explores how families' mathematical knowledge and experiences are taken up in school settings. Across these bodies of literature, caregivers are often discussed in relation to children's mathematical outcomes or school-defined forms of participation. Less attention has been given to how caregivers experience doing mathematics with their children. Examining these experiences can provide insight into how caregivers' relationships with mathematics are shaped through interactions with children.

Parental Involvement in Education

Families play an important role in children's academic achievement, and this relationship has been widely examined across education research. Many studies have found associations between certain forms of parental involvement and positive educational outcomes (Epstein, 1991; Hornby & Lafaele, 2011; Hornby & Blackwell, 2018; Senler & Sungur, 2009). Within this literature, parental involvement is conceptualized through interactions between parents and

children, relationships between families and schools, and connections among parents within educational communities (McNeal, 2014).

Three forms of parental involvement are identified in the literature: *parent-child*, *parent-school*, and *parent-parent*. Parent-child involvement consists of parent-child relationships, such as having conversations with children and parental monitoring (McNeal, 2014). Parent-school involvement typically refers to parents' relationship with their child's school, such as attending parent-teacher interviews or parent-teacher associations. Lastly, parent-parent interactions refer to relationships with other parents. Among these forms, parent-child discussion has been found to be the most effective form of parental involvement when it comes to a child's academic achievement (McNeal, 2014). Researchers have examined how parents interact with their children, including how parental beliefs influence the quality of parent-child interactions (Matthes & Stoeger, 2018).

McNeal (2014) defines parental involvement as "social relations that are imbued with norms of trust, obligation, or reciprocity" (p. 565). Using data from the National Educational Longitudinal Study data set (NELS:88), McNeal (2014) examined how different forms of parental involvement were associated with students' academic outcomes. The findings indicated that parent-child discussion consistently had the strongest association with education expectations, absenteeism, homework completion, and truancy. These findings suggest that conversations between parents and children play an important role in influencing students' attitudes towards learning. Although this literature focuses primarily on children's academic outcomes, it also suggests that parent-child discussion shapes how family members experience learning together.

Parental involvement programs around literacy often encourage parents to read with their children. For example, Kraft and Monti-Nussbaum (2017) examined a program that hoped to reduce summer learning loss. The program sent text messages to parents encouraging them to participate in reading activities with their children during the summer. The messages provided parents with resources, ideas for literacy activities, and reminders about the value of parental engagement. Their findings indicated that students whose parents participated improved their reading enough to make up for the reading skills students usually lose over the summer.

Studies of family literacy show that what parents do during reading interactions matters for children's learning. Saracho (2020) explains that reading with children is most effective when parents engage in discussion about the story rather than focusing only on reading the text itself. Conversations before, during, and after reading can help children pay attention to the structure and language of stories. Together, these studies suggest that parental participation depended on what parents did when they interacted with their children.

Parent-Child Discussions

Parent–child discussions are an important part of how children learn. Researchers (e.g., McNeal, 2014; Matthes & Stoeger, 2018) have also shown that parents' beliefs about learning can influence children through these interactions. However, little is known specifically about what constitutes quality parent-child discussions, especially as it pertains to mathematics in the home. Qualitative studies can offer deeper insight into how parents make sense of these interactions and how their experiences influence the ways they engage with their children's learning. Based on the existing literature, there is a need to shed further light on how caregivers

experience doing mathematics with their children and how these experiences influence interactions in the home.

Caregivers and homework

Homework interactions are one common way caregivers participate in children's learning. Researchers have identified different forms of caregiver involvement in homework interactions, including *autonomy support*, *controlling support*, *interference*, and *cognitive engagement* (Gonida & Cortina, 2014). Autonomy support typically involves caregivers offering support in response to children requesting help. This type of support communicates to the child that the parent trusts them and believes they are competent. In contrast, controlling forms of support involve caregivers monitoring or directing homework completion. Researchers have found that caregivers oriented toward mastery goals are more likely to engage in autonomy-supportive forms of homework involvement, and performance-oriented goals are associated with more controlling forms of involvement (Gonida & Cortina, 2014). These findings suggest that caregivers' beliefs about learning influence how homework interactions unfold within families.

Parents' beliefs about learning can influence how they interact with their children around homework. For example, Matthes and Stoeger (2018) investigated how the implicit beliefs of parents influence their children's achievement. Parents' implicit beliefs were described in terms of *entity theory,* the belief that ability is mostly fixed, and *incremental theory*, the belief that there are no limits to developing ability through practice and effort. Two possible mechanisms for parents to transfer incremental theory beliefs were examined in the study: (a) *from parents to children,* such as through parent-child discussion, and (b) *parents' incremental theory beliefs affecting parental learning-related behaviours* when parents participate in homework-related

conflict and employ controlling behaviour (Matthes & Stoeger, 2018). Matthes and Stoeger's (2018) findings showed that the more parents held the belief that their child can develop abilities over time with effort, the more their children also held the same belief about themselves. Parents who believed that their children's abilities could develop over time were also less likely to engage in controlling or conflict-driven behaviours during homework interactions. These findings suggest that parents' beliefs about learning influence how they engage with their children around schoolwork and, in turn, shape how homework interactions are experienced within families.

Epstein and Van Voorhis (2001) argue that homework can serve communicative purposes beyond academic practice. They identify parent-child relations and parent-teacher communication as two important purposes of homework. Homework can be designed to promote conversations between parents and children about what students are learning in school, while also keeping families informed about classroom topics and learning goals. Through interactive homework activities, parents gain insight into what their children are learning, and teachers create opportunities for families to engage with school learning in meaningful ways. In this sense, homework can function as a tool for communication between home and school.

Parental partnerships in education

The literature on parental partnerships in education differs from parental involvement because it focuses on examining parents as partners in their children's learning (Hornby, 2011). In this perspective, parents are seen as individuals with knowledge and experiences that can contribute to educational practices. In this section, I examine parental partnerships in education broadly. Parental partnerships in mathematics education are explored later in this chapter.

Research on family-school relationships has often been polarized between two views: a *school-centred view* and a *family-centred view*. In a school-centred view, parents are expected to align themselves with school norms and practices. In a family-centred view, schools are expected to adapt to the social realities of families (Eccles & Harold, 1993; Delpit, 1995; Pushor & Murphy, 2004). While these perspectives differ in where responsibility for change is located, both treat family-school relationships as a means of improving student achievement.

Ippolito (2010) critiques this binary and proposes a *middle space*–an arena for collective learning and "mutually-specifying relationships" that moves beyond the family-centred versus school-centred dichotomy (p. 47). Middle spaces create opportunities to confront the tensions that exist between families, school staff, and researchers in an effort to develop non-hierarchical relationships. This perspective shifts attention away from caregivers supporting student achievement. Instead, it focuses on the quality of relationships among the adult stakeholders in education.

Ippolito (2018) develops this perspective in Ontario through a multi-year, parent-driven research initiative. One example of this work is the Gathering Model, which creates structured opportunities for dialogue among parents, educators, researchers, and community members (Leung et al., 2021). These events bring stakeholders together in informal settings where participants share a meal and engage in small-group discussions about issues affecting families' experiences of schooling. The agenda for these discussions is developed collaboratively with community members so that the concerns and perspectives of families shape the conversation. The initiative creates a middle space where participants can learn from one another and contribute to conversations about school practices and priorities. This is a unique way to engage

families in education by centring the relationships between the adults involved in schools. These perspectives frame dialogue and relationship-building among adult stakeholders as central to developing reciprocal relationships between families and schools.

Caregiver Involvement in Mathematics Education

The literature on caregivers in mathematics education examines how families participate in mathematical activity within homes and schools. This literature focuses on interactions such as homework support, everyday mathematical activity, and partnerships between families and schools around mathematics learning. In this section, I examine how mathematical activity unfolds within family interactions. Caregivers' relationships with mathematics are explored later in this chapter.

Caregivers and Everyday Mathematics

Children's perceptions of mathematics can be influenced by whom they see using mathematics in everyday life. Parents participate in many everyday activities where mathematics is used, and these interactions can make mathematics visible to children. However, some studies suggest that children often associate doing mathematics primarily with school. For example, Metzger et al. (2019) examined elementary children's conceptions about mathematics. Many participants identified teachers as people who do mathematics and school as the place where mathematics happens. Parents were mentioned less frequently, and when they were, children often described mathematics as something their parents did at work. These findings suggest that children may come to see mathematics primarily as a school-based activity. Metzger et al. (2019) also suggest that when children recognize that a wider range of people use mathematics in their lives, they are more likely to view mathematics as useful and relevant.

Research in mathematics education has emphasized the social nature of mathematical activity. Yackel and Cobb (1996) describe mathematical understanding as developing through classroom interactions in which ideas are proposed, interpreted, and negotiated. From this perspective, mathematical meaning emerges through participation in relationships with others. While much of this work has focused on classroom communities, mathematical activity also develops through interactions within families.

Mathematical ideas can emerge through everyday interactions between parents and children. Anderson (1997) describes these interactions as exchanges in which parents and children engage in shared activity, ask questions, and respond to one another's ideas. For example, Anderson (1997) documented interactions between parents and their young children as they engaged with materials such as blocks, storybooks, and mathematics worksheets in the home. During these activities, parents introduced mathematical ideas by asking questions, drawing attention to quantities or relationships, and prompting children to explain their ideas. Although parents knew that the study focused on mathematics in the home, they were free to engage with the materials in ways that felt natural to them. As a result, mathematics was not always the explicit focus of the interactions that unfolded. Still, mathematical ideas often appeared within play or conversation, such as asking children about what they noticed in the storybook. These interactions illustrate how mathematical ideas can emerge through everyday exchanges between parents and children.

Parents' own experiences with mathematics can also influence how they participate in their child's mathematics. Howker and Black (2025) explored parents' experiences with school mathematics and the role of everyday mathematical activity in family life. Their work shows that

many parents describe feeling alienated from school mathematics, which they experience as disconnected from the mathematics they interact with in their everyday lives. Parents in the study refer to this as "our kind of mathematics." At the same time, parents regularly participate in mathematics through activities such as managing household resources or navigating daily routines. Howker and Black argue that tensions between everyday mathematical activity and the expectations of school mathematics can influence how parents relate to their children's mathematics. Parents had a sense of wanting their children to learn mathematics that would be useful in their everyday lives, rather than mathematics that made them wonder when they would ever use it. The disconnect between home and school mathematics also meant that parents were less likely to engage with mathematics they did not understand. Parents did participate when mathematics felt relevant, such as giving their children play money to practise giving change when shopping. In this way, parents' past experiences with mathematics influenced the kinds of mathematical activities they participated in with their children.

What Counts as Mathematics

Research in mathematics education has examined how particular forms of mathematical activity come to be recognized as mathematical. Yackel and Cobb (1996) argue that sociomathematical norms establish classroom-specific expectations for what counts as an acceptable mathematical explanation, solution, or justification. These norms influence how students come to understand mathematical activity and what forms of participation are recognized as mathematically valid. Gerofsky (2010) questions the use of word problems and the *semi-realities* they create, arguing that school mathematics can become separated from the mathematical activity people engage in outside of school. Together, this work suggests that what

counts as mathematics is shaped by the norms and practices of communities rather than being universally agreed upon.

Caregivers and Mathematics Homework

Homework interactions are one common way caregivers participate in children's mathematics learning. Similar to the broader literature on homework help, research on mathematics homework help often examines different forms of caregiver involvement, including *autonomy-support*, *controlling-support*, and *content support* (Silinskas & Kikas, 2019; Xu et al., 2017). Autonomy-support behaviours involve caregivers encouraging children to explain their ideas, explore their strategies, and ask for help when needed. In these interactions, caregivers support children's mathematics without taking control of the task. Controlling forms of involvement, by contrast, involve directing children towards specific procedures, closely monitoring homework completion, or providing answers before children have a chance to solve problems on their own. Researchers have found that autonomy-supportive interactions are associated with greater persistence and engagement (Silinskas & Kikas, 2019). These findings suggest that how caregivers support homework influences how children experience mathematics.

Research on mathematics homework has also examined how caregivers' emotional relationships with mathematics influence homework interactions. Retanal et al. (2021) investigated the relationships between parents' mathematics anxiety, homework helping styles, and children's mathematics achievement. Their findings indicated that parents with higher mathematics anxiety were more likely to engage in controlling forms of homework support, which negatively influenced children's persistence and mathematics achievement. Similarly, Maloney et al. (2015) found that when parents with high mathematics anxiety frequently help

with homework, children's mathematics achievement tends to decrease, suggesting that parents' experiences with mathematics shape how mathematical activity unfolds in the home. Researchers have also suggested that relationships between caregiver and child mathematics anxiety may be bi-directional, meaning that children's homework interactions may also influence caregivers' emotional experiences with mathematics (Li et al., 2021; Szczygieł, 2020). This literature highlights that children's experiences of mathematics homework are deeply influenced by how caregivers feel about mathematics. These studies suggest that homework interactions may shape how caregivers and children develop relationships with mathematics within the home.

Studies on mathematics homework also identify tensions surrounding the role of homework in family life. Some parents describe mathematics homework as useful when children engage willingly with the task, while others describe homework as rote, stressful, and a source of conflict within the home (Erdogan et al., 2021). In some cases, family members beyond parents, such as siblings or extended family members, also participate in homework interactions when caregivers feel they lack time or mathematical knowledge. This suggests that mathematics homework often involves broader family dynamics rather than isolated parent-child interactions.

Researchers have also cautioned against viewing homework as the primary form of mathematical engagement within families. Focusing only on homework can overlook the ways caregivers and children engage in mathematical discussions and activities through everyday life (Erdogan et al., 2021). These studies suggest that homework may be more productive when it creates opportunities for mathematical discussion among family members.

Caregivers' Relationships with Mathematics

Caregivers' past experiences with mathematics influence how they see themselves in relation to the subject. Research in mathematics education has documented how individuals often draw on memories of their schooling when describing their relationships with mathematics. Studies using autobiographical and narrative approaches have examined the stories people tell about their experiences learning mathematics in school settings (Towers et al., 2017). Participants' accounts include describing significant moments in learning mathematics, feelings about mathematical ability, and interactions with others around the subject. These autobiographies illustrate how individuals construct identities in relation to mathematics through their experiences with the subject.

Early work on affect in mathematics education emphasized the role of emotions, beliefs, and attitudes in mathematical activity. McLeod (1989) described the affective domain as consisting of three related components: emotions, beliefs, and attitudes. Emotions refer to immediate feelings that arise during mathematical activity, while beliefs and attitudes are more stable orientations toward mathematics. This work challenged earlier views that mathematical problem solving was purely rational and highlighted how individuals' beliefs about themselves and about mathematics influence their mathematical behaviour.

Mathematics Anxiety

Research on mathematics anxiety has often examined caregivers primarily through their influence on children's relationships with mathematics. Much of this work focuses on homework interactions, where caregivers' beliefs and emotional responses to mathematics may influence how children experience the subject (Maloney et al., 2015; Soni & Kumari, 2015). Researchers

have found that when caregivers express negative beliefs about mathematical competence or emphasize that mathematics is difficult, children may adopt similar beliefs about themselves as mathematics learners (Furner & Gonzalez-DeHass, 2011; Ramirez et al., 2018). In addition to anxiety itself, researchers suggest that rigid beliefs about how mathematics should be solved may also contribute to children's negative experiences with mathematics (Ramirez et al., 2018). Across this literature, caregivers are often discussed as antecedents to children's mathematics anxiety and attitudes toward mathematics. Much of this research also relies on quantitative measures such as surveys and anxiety rating scales, which provide limited insight into how caregivers experience mathematics and make sense of interactions with children. As a result, less attention has been given to caregivers' own experiences of mathematics and how mathematical interactions with children may influence caregivers' emotional relationships with the subject.

Vanbinst et al. (2020) found associations between children's and parents' mathematics anxiety and argued that mathematics anxiety should be understood within a broader family context. Their study highlighted the importance of considering both mothers' and fathers' mathematics anxiety, as well as the potential role of genetic and environmental influences in the development of mathematics anxiety. These findings suggest that relationships with mathematics develop within family contexts and may be influenced by experiences that extend across generations.

Caregivers' past experiences with mathematics can also influence how they participate in mathematical interactions with children. Civil and Bernier (2006) describe how parents draw on their own experiences with mathematics when engaging in mathematical activity with their children. Parents who describe feeling confident in mathematics often participate more readily in

mathematical discussions, while those who recall negative experiences with mathematics sometimes describe themselves as less capable of supporting their children. Similarly, Gerbrandt and Culligan (2026) show how parents' conceptualizations of mathematics influence the ways they engage with children's mathematics learning in the home. Maloney et al. (2015) found that when parents with high mathematics anxiety frequently help with homework, children's mathematics achievement tends to decrease. These findings suggest that caregivers' experiences with mathematics shape how mathematical activity unfolds in the home. This literature suggests that caregivers' relationships with mathematics influence how they participate in mathematical interactions with children.

Mathematical Attitudes

Individuals' relationships with mathematics are often examined through the concept of mathematical attitudes. Di Martino and Zan (2010) describe mathematical attitudes as consisting of three interrelated dimensions: *vision of mathematics*, *emotional disposition*, and *perceived competence*. Vision of mathematics refers to how individuals describe what mathematics is. Emotional disposition refers to the feelings individuals associate with the subject. Perceived competence refers to how capable individuals believe themselves to be in mathematics. In other words, perceived competence is about whether someone thinks they can or cannot do mathematics. Their work highlights how past experiences with mathematics influence how individuals see themselves in relation to the subject. Studies drawing on this perspective examine how learners describe their feelings about mathematics, how capable they believe themselves to be, and what they understand mathematics to be. These experiences influence how individuals see themselves in relation to mathematical activity.

Di Martino and Zan's (2010) framework also emphasizes that mathematical attitudes are not fixed traits, but relationships that develop through experience and interaction. Their study showed that students often described changes in their relationships over time, particularly through experiences connected to teachers, perceptions of success and failure, and changing views of what mathematics is (Di Martino & Zan, 2010). Their work suggests that emotional disposition, perceived competence, and vision of mathematics are interconnected and may shift through mathematical interactions with others. This perspective is important because it raises questions about how mathematical interactions outside school settings may also influence individuals' relationships with mathematics.

Olivares (2012) examined the intergenerational transmission of mathematics attitudes and explored how students internalized, adopted, or rejected their parents' attitudes toward mathematics. Central to her study was the investigation of the explicit and implicit messages students received from parents regarding the ease and value of learning mathematics. Olivares argued that parents' own mathematical experiences and beliefs may be communicated to children through everyday interactions and stories about mathematics.

The literature on mathematical attitudes focuses primarily on students' experiences with mathematics in school. Studies have examined how students describe their feelings about mathematics, their sense of competence, and their views of the subject (Di Martino & Zan, 2010). Other research has examined how parents influence the development of children's attitudes toward mathematics (e.g., Finlayson, 2014; Furner & Gonzalez-DeHass, 2011). This work highlights the important role families play in shaping children's relationships with mathematics. Fewer studies have examined caregivers' own experiences when engaging with

their children's mathematical activity. As a result, little attention has been given to how mathematical interactions with children may influence caregivers' own relationships with mathematics. This is important because caregivers' relationships with mathematics can influence how children experience the subject.

Identities in Mathematics Education

Mathematics education researchers have used the concept of mathematical identity to examine how individuals understand themselves in relation to mathematics. Hall et al. (2018) describe mathematical identities as the narratives people create to explain themselves in relationship to mathematics. Similarly, Sfard and Prusak (2005) define identities as collections of stories about persons and argue that these stories are shaped through social interactions and collective narratives. Within mathematics education, these identity narratives often involve descriptions of who is perceived as mathematically capable and who participates in mathematics. Researchers also describe mathematical identities as fluid, negotiated, and shaped through interactions with others. This literature describes mathematical identity as socially constructed and connected to how individuals experience mathematics across different settings.

Mathematics identity research also examines how ideas about mathematical competence are produced through social interaction. Bishop (2012), for example, examined how middle school students enacted identities such as the "smart one" and the "dumb one" through everyday classroom interactions and discourse. Her work shows how repeated interactions shape who is recognized as mathematically capable, whose ideas are valued, and how individuals come to understand themselves in relation to mathematics. Similarly, researchers have argued that mathematical identities are shaped through participation, recognition, and interaction with others

(Sfard & Prusak, 2005; Hall et al., 2018). This literature highlights that mathematical identities are socially constructed. Much of this literature focuses on students in classroom settings. However, students also engage in mathematical interactions with family members in the home, where ideas about mathematical competence are also formed. Less attention has been given to how these interactions influence caregivers' own mathematical identities, even though caregivers are frequently identified as influencing children's mathematical attitudes and experiences.

Parental Partnerships in Mathematics Education

Parents and schools can work together in partnerships to support children's mathematics. Work drawing on the Funds of Knowledge (Moll et al., 1992) framework highlights household and community knowledge as resources for mathematics learning. For example, Civil and Bernier (2006) collaborated with parents, teachers, and researchers to develop *Math for Parents* workshops. In this project, parents first participated in and later facilitated mathematics workshops for other parents in the community. The parents were knowledge resources whose cultural and everyday practices helped connect school mathematics to situations that were familiar within their communities. Through workshops, parents adapted mathematical tasks in ways that reflected community experiences and everyday practices. This work highlights how dialogue and collaboration between parents, teachers, and researchers can challenge traditional images of parental participation in mathematics education. In these traditional images, parents are often used as supporters of school-defined activities such as helping children with homework. In these workshops, parents were knowledgeable participants who could draw on their own experiences and community knowledge to support learning mathematics.

Parental partnerships in mathematics education can help teachers recognize the mathematical knowledge within families. Stoehr, Salazar, and Civil (2022) examined how teachers learned from working with Latina mothers in a bilingual mathematics collaboration. In this collaboration, mothers and teachers worked on mathematics tasks and discussed their mathematical reasoning. When mothers expressed their ideas in Spanish, teachers gained insight into the mothers' mathematical knowledge. Teachers also learned more about their students' lives outside of school and recognized the contributions mothers made to their children's mathematics education. Through these interactions, teachers came to appreciate the different strategies mothers used to solve mathematical problems. Stoehr et al. (2022) show that collaborations between teachers and parents can support teachers in recognizing the mathematical knowledge within the family. Their work also shows that parents are intellectual resources that can support learning in mathematics.

Parental partnerships in mathematics education can also involve tensions when families' knowledge and school mathematics do not align. Civil and Bernier (2006) illustrate this tension in a Math for Parents session where a parent described π as 3.14. While 3.14 is a common approximation of π, this explanation does not invite consideration of π as the relationship between a circle's diameter and its circumference. This example shows the challenge of engaging families' knowledge while also supporting the development of mathematical ideas. It raises questions about how teachers can work with families' contributions while also drawing on the specialized knowledge required for teaching mathematics.

Parental partnerships in mathematics education can also depend on how schools recognize and value families' mathematical practices. Takeuchi (2017) illustrates this challenge

in a study from Japan where Filipino immigrant children learned finger multiplication strategies from their parents. The children hesitated to use these strategies at school because they understood which methods were considered legitimate by their teachers. In Japanese schools, the *kuku,* a recitation method used to memorize multiplication tables, is treated as the expected way to perform multiplication. Parents often shared finger multiplication as a secondary strategy when their children were struggling with memorizing multiplication tables. When children did draw on finger multiplication at school, they often hid it under their desks and did not share it with their teachers. Students did not bring family knowledge into the classroom, even though the strategy supported their work on mathematics tasks. Takeuchi's work demonstrates how students actively manage the boundary between home and school mathematics based on what they anticipate will be accepted by teachers.

Parental partnerships in mathematics education are also constrained by how school is organized. Moll et al. (1992) describe classrooms as often isolated from the social worlds of students and their families. While teachers are described as a link between families and classrooms, these connections require time, collaboration, and support from the school. Teachers in their study participated in after-school study groups and were provided with release time for household visits and collaborative planning. This combination of after-school study groups, release time, and collaborative planning shows that engaging with families' knowledge requires support that extends beyond typical classroom practice. The need for additional time and structured collaboration shows that parental partnerships require strong support from schools. Baker and Koedel (2025) show that maintaining time for collaboration, relationship-building, and sustained interaction with families has become increasingly difficult. Teachers in their study

report declining working conditions, particularly in areas involving interactions with students and their families. As a result, opportunities to build sustained partnerships between families and schools depend on support from school structures and policies.

Research on parental partnerships in mathematics education shows both the possibilities and constraints of bringing family knowledge into classrooms. Studies drawing on the Funds of Knowledge framework highlight how parents can contribute to mathematics learning when their knowledge is recognized in educational settings. Research drawing on Funds of Knowledge also highlights that family practices and resources are shaped by broader social, cultural, linguistic, and socioeconomic contexts (Ortega & Oxford, 2025). Consequently, the forms of knowledge that are recognized and valued within educational settings are influenced by these broader conditions. At the same time, funds of knowledge research identifies tensions related to the development of mathematical ideas, the recognition of family practice, and the conditions under which teachers and families interact. While this research provides important insight into how partnerships can be built, less is known about how caregivers experience doing mathematics with their children in the home. In particular, limited attention has been given to how caregivers understand their own mathematical competence and how these experiences are affected by interactions with their children.

Chapter 2: Conceptual Framework

While extensive research has examined students' and teachers' mathematical experiences, parents' perspectives remain less visible. Parents and other adult caregivers are often framed through home-school partnerships (e.g., Civil & Bernier, 2006; Suh & Calabrese, 2025), yet their own mathematical experiences remain underexamined. This absence is important because caregivers play a significant role in how children experience mathematics within and beyond school settings. Caregivers influence how mathematics is discussed, supported, valued, and felt within families (e.g., Metzger et al., 2019; Silinskas & Kikas, 2019). The ways caregivers understand themselves in relation to mathematics can therefore shape children's mathematical experiences in the home (Maloney et al., 2015; Howker and Black, 2025). Understanding these perspectives requires theoretical frameworks that center identity and experience. Anderson (1997) identifies parents as the "more proficient other" in mathematics education–neither the child nor the teacher, but adults whose own mathematical histories and experiences influence how they engage with their children. To understand these underexplored perspectives, I draw on two theoretical frameworks: Funds of Identity (FoI) and Mathematical Identity.

Funds of Identity emerged from Funds of Knowledge research, so this chapter begins with an overview of Funds of Knowledge before turning to Funds of Identity. Both frameworks examine the knowledge, practices, and experiences present within people's lives and communities. However, Funds of Identity places greater emphasis on the identity resources individuals draw upon in everyday life. This distinction is important in my study because caregivers frequently drew on experiences connected to schooling, parenting, work, and family

relationships during mathematical interactions with their children. The chapter then turns to Mathematical Identity to examine how caregivers described themselves specifically in relation to mathematics.

Initially, I considered Funds of Knowledge as a possible framework because of its use within research on families in mathematics education (e.g., Civil, 2025; Howker & Black, 2025; Suh & Calabrese, 2025; Stoehr et al., 2022; Williams et al., 2020). Funds of Knowledge research examines the knowledge and practices present within households and communities, particularly the ways families' everyday experiences can support learning (Moll et al., 1992). However, as I analyzed caregivers' accounts, it became clear that caregivers were doing more than simply describing what they were doing with their children. Caregivers drew on identity resources connected to schooling, parenting, professional experience, and family relationships during mathematical interactions with their children. Because of this, Funds of Knowledge alone could not fully account for the identity work present in caregivers' accounts.

Funds of Identity (Esteban-Guitart & Moll, 2014) provided a stronger analytic fit because it focuses on the identity resources people draw on when understanding themselves. Mathematical Identity research examines how people understand themselves in relation to mathematics. Researchers describe mathematical identities as socially constructed, relational, and negotiated through interaction (Sfard & Prusak, 2005; Bishop, 2012; Hall et al., 2018). This literature examines how people come to see themselves as mathematically capable or incapable through recognition, discourse, and participation in mathematical activity.

FoI serves as the central theoretical lens in this study by highlighting how people's histories, practices, and relationships shape the identity resources they draw upon in everyday

life. Mathematical Identity complements this framework by providing a domain-specific way of understanding how caregivers describe themselves in relation to mathematics. FoI and Mathematical Identity allowed me to examine both the identity resources caregivers drew upon during mathematical interactions and how caregivers understood themselves mathematically.

Funds of Knowledge

Funds of Identity (FoI), the central framework for this study, emerged from Funds of Knowledge research. Hogg and Volman (2020) explain that all FoI are Funds of Knowledge, but not all Funds of Knowledge are FoI. Funds of Knowledge focuses primarily on what families know and do, and how this knowledge can be mobilized in classroom contexts. Although Funds of Knowledge provides an important foundation for understanding how everyday practices become educational resources, it is not used for this study's analytic focus. The focus of this study is on understanding how adult caregivers make sense of themselves in relation to mathematics. Because caregivers in my study spoke about doing mathematics with their children that related to their identities, FoI was the best framework to capture how they experienced these interactions. I outline the origins of Funds of Knowledge and its place within mathematics education to position my choice to use FoI as the central framework.

Origins and Purpose

The Funds of Knowledge framework (Moll et al., 1992) challenged the deficit view that working-class communities in Tucson, Arizona, lacked educational value by positioning family and community knowledge as assets that schools could draw from; Moll et al. reframed families as intellectual partners with schools. The framework captures the family and community knowledge that is historically accumulated and socially distributed. This means that the

knowledge is accumulated by engaging in everyday activities and shared with family or community members. For example, families that run businesses on the US-Mexico border may have to calculate exchange rates. They may develop knowledge about exchange rates that they share with members of their family and community who also perform these calculations. Through this reorientation, Moll et al. established a foundational principle for researchers–that families' everyday knowledge is educationally valuable.

By examining how families used these funds of knowledge to navigate social and economic circumstances, Moll et al. (1992) demonstrated that households function as adaptive systems of expertise. Their findings disrupted the idea that only school-sanctioned knowledge holds academic value. They illustrated how everyday practices such as running a family business required a sophisticated set of skills. Their reframing of families broadened what counted as knowledge and positioned homes as sites of knowledge.

Moll et al. (1992) further described household networks as *thick and multi-stranded* and contrasted them with student-teacher relationships, which they described as *thin and single-stranded.* They present two ways that household networks are thick and multi-stranded. First, family knowledge often spans generations: children, parents, and grandparents contribute distinct forms of cultural and historical knowledge that can be drawn upon. For example, children may act as translators for parents in school meetings or other non-school events. Secondly, when knowledge is not readily available within the home, families draw upon relationships beyond the home. For example, if a family were faced with a legal problem, they may call upon someone with legal experience in the community to help them. These examples show that family knowledge circulates through social networks to meet the needs of the family.

On the other hand, classroom practices are different. Moll et al. (1992) describe classroom interactions as thin and single-stranded. This means that teachers' relationships with their students are limited to classroom interactions. By recognizing this limitation, the Funds of Knowledge framework offered educators and researchers a way to build multi-stranded connections with students by drawing on the intellectual resources of their homes and communities. At the same time, the framework made visible school barriers—policies and time constraints—that restrict teachers' ability to engage with families' knowledge (Eccles & Harold, 1993; Moll et al., 1992).

Initially, I considered Funds of Knowledge as a potential framework for understanding how adult caregivers experience their mathematical lives. Caregivers in this study described their experiences of mathematics as relational, often drawing on connections with family and community members to support their children. Funds of Knowledge provides a valuable foundation for understanding families' intellectual resources, and it emphasizes what families do. However, as caregivers shared their stories, it became clear that they were not just describing what they did with their children but sharing how they saw themselves in relation to mathematics.

Funds of Knowledge in Mathematics Education

The Funds of Knowledge framework has been widely taken up in mathematics education to expand what counts as mathematical knowledge and who is recognized as mathematical. Early applications of the framework (Civil & Bernier, 2006) focused on repositioning parents as intellectual resources. In their *Math for Parents* courses, Civil and Bernier collaborated with teachers and families to design mathematics activities grounded in familiar cultural practices,

such as recipe scaling. Their work demonstrated that everyday activities within Latine households are sites of mathematical reasoning. Their early work laid the foundation for later studies to explore the mathematical knowledge already present in families, and eventually how family members come to see themselves as mathematical.

Civil's (2016) later work extended the Funds of Knowledge framework by recasting the hierarchical relationship between schools and families as a relational one. The hierarchies Civil wanted to challenge positioned school mathematics as superior to the mathematics found in homes and communities. In a relational view of home-school partnerships, the knowledge present in school mathematics and home- or community-based mathematics are complementary to each other. Civil positioned teaching and learning as shared practices between home and school, where teachers and parents co-constructed mathematical understanding and learned from each other's ideas. Civil demonstrated that when home-school partnerships are relational, the knowledge present in family mathematics becomes clear.

Civil used the Millroy Paradox (Millroy, 1991) to describe the tension parents, teachers, and researchers experienced when trying to find the mathematics in everyday activities. This paradox is defined as the difficulty of recognizing mathematical knowledge in forms that do not look like school mathematics, such as everyday mathematics. Civil explored this tension in two related ways. First, in her own reflection, she described experiencing this paradox when trying to see the mathematics embedded in everyday practices such as sewing. Even though she knew participants were drawing on mathematical reasoning, her own schooling in mathematics made it hard to perceive that reasoning. Secondly, she extended Millroy's insights to community members who viewed school mathematics as devaluing everyday mathematics, reinforcing

hierarchies between school and family knowledge. Civil drew upon Millroy's Paradox as an analytical tool for her argument on the *valorization of knowledge*–that is, what mathematical knowledge is viewed as legitimate. While Civil's use of the Millroy Paradox sits within a Funds of Knowledge perspective, it provides a foundation for my study by showing how questions of legitimacy influence how parents narrate and define themselves as mathematical and make sense of their child's ideas.

Stoehr, Salazar, and Civil (2022) advanced the Funds of Knowledge framework to explain how sharing mathematical ideas influenced how Latina mothers viewed themselves. This study examined removing language barriers between Latina mothers and teachers so that parental Funds of Knowledge could be made visible to teachers. When Latina mothers were able to express their mathematical reasoning in their own language, it created spaces for the mothers to see themselves as mathematically competent. Stoehr et al. (2022) sought out to examine how removing language barriers made Latina mothers' Funds of Knowledge visible to teachers. They also found that this shift touched upon the way mothers identified themselves in relation to mathematics. This evolution of Funds of Knowledge research demonstrates a shift from identifying what families know toward exploring how relationships, power, and language influence who is viewed as mathematically knowledgeable. Although Stoehr et. al began to touch on Funds of Identities through their attention to how mothers saw themselves as mathematical, their study remained primarily grounded in Funds of Knowledge. My study takes up this theoretical pivot more directly, focusing on how caregivers narrate and define their identities in relation to mathematics.

Limitations of Funds of Knowledge

While the Funds of Knowledge framework is influential in repositioning family knowledge, it also has limitations. One limitation involves how educators and researchers can co-opt the framework for school purposes. In these situations, family knowledge is valued when it serves schools' objectives and reinforces the hierarchies of school knowledge over home knowledge (Hogg & Volman, 2020). When this happens, families become resources for schools rather than partners. In mathematics education, Civil (2016) addresses the hierarchies that exist in school by repositioning the framework as relational. Her work challenged hierarchical models by focusing on building relationships between families and educators. She positioned teachers and parents as co-learners who construct mathematical understanding together. Through this relational reframing of partnerships, Civil's work highlights the importance of relationships between families and schools. My study extends this relational view to examine adult caregivers' experiences of doing mathematics with their children and how these experiences influence the way they narrate and define themselves in relation to mathematics.

Hogg and Volman (2020) offer another limitation of Funds of Knowledge, cautioning that efforts to identify community-based Funds of Knowledge can sometimes lead to narrow views of communities. For instance, if a researcher identifies sewing as an example of the community's mathematical knowledge, educators might assume that everyone from that community is skilled and interested in sewing. As a result, educators might focus activities around sewing without realizing there may be members of the community who have no interest in it. This limitation illustrates how Funds of Knowledge can overlook the diverse experiences of people within a community. FoI, however, attends to this limitation by focusing on how

individuals narrate and experience their identities. While these identities may draw on community membership, FoI allows space for personal experiences of community membership to emerge.

Because adult caregivers in this study drew on their histories, roles, and relationships when talking about their mathematical experiences, FoI (Esteban-Guitart & Moll, 2014) provided a better fit. FoI brings attention to how everyday practices, personal histories, and relationships serve as resources for identity construction. This shift is essential for exploring the caregiver as the "more proficient other" (Anderson, 1997) and for understanding how caregivers' memories, beliefs, and roles influence their participation in mathematical life. In this study, caregivers drew on their memories of doing math in school and at home, their current professional lives, and family narratives to position themselves in relation to mathematics. FoI allows me to investigate how these identity resources influence their engagement with their children and with mathematics.

Funds of Identity (FoI)

Esteban-Guitart and Moll (2014) introduced FoI as an extension of Funds of Knowledge. Whereas Funds of Knowledge emphasizes household resources that teachers might use in the classroom, FoI shifts the focus to the *identity resources* through which people describe their experiences. This distinction is important in my study because caregivers' relationships with mathematics influence how mathematics is discussed, supported, and experienced within families. Understanding these interactions requires attention to caregivers' mathematical identities and the identity resources they draw upon during mathematical interactions with their children. Esteban-Guitart and Moll (2014) define FoI as "the historically accumulated, culturally

developed, and socially distributed resources that are essential for a person's self-definition, self-expression, and self-understanding" (p. 31). In other words, FoI focuses on a variety of factors—culture, history, and relationships—which contribute to how people define themselves. For this study, FoI provides the framework needed to examine how adult caregivers define themselves in relation to mathematics. While Funds of Knowledge showcases what families do, FoI examines how caregivers describe themselves through mathematical experiences. This distinction makes FoI necessary for understanding the ways caregivers' histories, relationships, and roles influence their mathematical identities. FoI also draws attention to the different ways identities are experienced, allowing for an exploration of the variation in how caregivers describe their identities. The following section outlines key concepts within the FoI framework and explains how they inform my lens. It begins with the foundational categories of identity resources before examining invisible and dark FoI, all of which make this framework particularly well-suited to this study.

Esteban-Guitart and Moll (2014) identify five broad categories of FoI: significant people, cultural practices, material artifacts, institutional memberships, and geographical places. *Significant people* describe important people in a person's life, such as family and friends. *Cultural practices* encompass various aspects, including hobbies and everyday activities. *Material artifacts* refer to objects, technologies, and cultural products. *Institutional memberships* discuss religious, cultural, educational, and community affiliations. Lastly, *geographical places* discuss locations tied to belonging, such as one's place of birth or familial cultural origins. These categories provide a way of thinking about the different identity resources individuals may draw upon when describing themselves and their experiences. The categories helped inform my

understanding of how caregivers connected relationships, histories, and prior experiences with mathematics to the ways they understood themselves mathematically.

At the same time, the authors caution against treating FoI as fixed categories, noting the danger of reinforcing stereotypes. For example, a person might describe cooking as part of their identity, but if they belong to a culture recognized for its cuisine, the researcher may incorrectly attribute it to their cultural practice. FoI's flexibility matters for this study because it allows caregivers' own interpretations to guide how their identities are defined. Categories serve as starting points rather than boundaries. New categories may emerge from the ways participants describe their identities.

Hogg and Volman (2020) similarly caution against focusing on fitting the identity resources described by participants into static categories. For example, a person may identify herself as a mother at home and a teacher at work. Yet, these roles overlap: parenting experiences may influence teaching, and teaching experiences may influence parenting. In my study, adult caregivers drew on their professional knowledge when engaging in mathematics with their children. This emphasizes how FoI highlights the different ways identity resources are interconnected.

Hogg and Volman's (2020) synthesis of FoI research is significant to the field because they identified three primary purposes for FoI research: (i) identity-focused, attending to how individuals define themselves; (ii) equity-focused, challenging deficit discourses and foregrounding cultural wealth; and (iii) pedagogical-focused, seeking to integrate FoI into curriculum and classroom practice. This study takes on the first purpose, identity-focused, to understand how adult caregivers describe themselves in relation to mathematics. This framework

is beneficial because understanding how caregivers perceive themselves as mathematical is essential for building home-school partnerships. In my study, caregivers' memories of schooling, perceived competence, and professional experiences all influenced the mathematical interactions that unfold at home. FoI enables me to view these narratives as expressions of identity.

Extensions of FoI investigate identity resources that may be hidden even to participants themselves, such as tacit personal beliefs. Esteban-Guitart (2023) has advanced the concept of *invisible FoI,* which draws from Ortega y Gasset's (1940) distinction between ideas and beliefs. Ideas are things we consciously hold, and beliefs are the taken-for-granted assumptions that influence how we live.

Invisible FoI are identity resources that may not be immediately visible in classroom contexts but nonetheless influence individuals' lives. These include gender roles, cultural stereotypes, or messages from popular media. Recognizing these invisible identity resources is helpful for this study because caregivers' mathematical identities are influenced by unspoken beliefs about who is *good at math.* In this study, invisible FoI is evident in the way adult caregivers describe their perceived mathematical competence and how they position others within the household. For example, when caregivers defer math homework help to the perceived *math person* in the family, they show how these tacit beliefs influence their engagement with mathematics.

Esteban-Guitart (2023) further extended FoI to include dark FoI–identity resources grounded in painful or marginalizing experiences such as poverty, racism, or bullying (Zipin, 2009; Subero et al., 2017). Recognizing these "dark" elements matters because they show how negative schooling experiences or deficit discourses can stay with individuals, shaping how they

continue to describe themselves in relation to mathematics. This dimension of FoI is useful for my study because many adult caregivers carry memories of doing mathematics that involve comparison or stress that continue to influence how they define themselves. By attending to invisible and dark FoI, this framework reveals how unspoken beliefs influence caregivers' sense of mathematical competence and their interactions around mathematics at home.

This framing clarifies how caregivers' mathematical identities are influenced by both their past experiences of mathematics and their present experiences of doing mathematics with their children at home. These ideas make FoI the most appropriate framework for this study, as it allows for both the visible and invisible experiences that influence how caregivers talk about themselves in relation to mathematics.

FoI provides the conceptual grounding needed to explore how adult caregivers' mathematical identities are influenced by their histories, relationships, and everyday experiences. It extends the Funds of Knowledge framework by attending to the ways people describe themselves through both visible and invisible identity resources. This framework aligns with the goals of this study because it captures the complexity of how caregivers experience and make sense of mathematical activities with their children. By drawing on FoI, my study focuses on understanding how caregivers experience mathematics at home.

Mathematical Identities

While FoI provides a broad framework for understanding how people describe themselves, the concept of *mathematical identity* offers a discipline-specific way to view this in relation to mathematics. This perspective deepens the theoretical framing of this study by attending to how people make sense of themselves through participating in mathematics,

discourse, and experience. In this section, I outline key contributions to mathematical identity research that inform this study. I begin with Sfard and Prusak's (2005) conceptualization of identity as narrative, followed by Hall, Towers, and Martin's (2018) work on the fluid and contradictory nature of mathematical identities, and conclude with Lutovac and Kaasila's (2014) notion of identity work and *possible selves*. Together, these ideas provide a framework for understanding how adult caregivers talk about themselves in relation to mathematics.

Mathematics education researchers have increasingly drawn on the concept of identity to understand how individuals come to see themselves in relation to mathematics. Identity research shifts attention beyond mathematical achievement alone to questions of participation, recognition, belonging, and perceived competence in mathematics. Mathematical identity research is useful because it helps explain how individuals come to see themselves as mathematically capable or incapable, and how these understandings influence participation in mathematics, perceptions of mathematical competence, and emotional relationships with mathematics. Sfard and Prusak (2005) conceptualize identity as "a set of reifying, significant, and endorsable stories about a person" (p. 16). In this view, identities are constructed through stories individuals tell about themselves and stories others tell about them. Because these stories must be socially recognizable and endorsable, identity is inherently relational. Sfard and Prusak further argue that identities are products of "collective storytelling" (p. 14), shaped through interaction with significant others and broader cultural expectations about mathematics. This perspective is useful in my study because it highlights how caregivers' understandings of their mathematical competence develop through interaction with others.

Building on this perspective, Hall, Towers, and Martin (2018) define mathematical identity as the narratives people construct about themselves in relation to mathematics. They emphasize that identities are fluid, dialogical, and context-dependent. This perspective is important in my study because it helps explain why caregivers' relationships with mathematics were often contradictory and unstable rather than straightforward or fixed. Their work demonstrates how individuals can simultaneously hold contradictory positions—for example, identifying both as *not a math person* and as someone who perseveres with mathematical challenges. These contradictions illustrate the complexity of an individual's relationship with mathematics. Similarly, caregivers often hold conflicting positions in their accounts–seeing themselves as *not a math person* while holding external markers of success in mathematics, like receiving a mathematics award.

Lutovac and Kaasila (2014) similarly conceptualize mathematical identity through the narratives pre-service teachers talk about their past, present, and anticipated futures in mathematics. They emphasize the notion of *identity work*, showing how people actively construct, reconstruct, and negotiate their identities as mathematics learners and teachers. In particular, they draw on the concept of *possible selves* (Markus & Nurius, 1986) to argue that mathematical identities are not only about past experiences but also about how individuals imagine their future selves in relation to mathematics. The concept of possible selves is useful in my study because it helps understand how caregivers' interactions with their children may reshape how they see themselves mathematically. For example, some caregivers recognize their own ways of reasoning in their children's mathematical ideas. These moments create opportunities for caregivers to imagine themselves as more mathematically capable than they had

previously believed. In this way, children's mathematical success becomes a resource through which caregivers can envision new mathematical possibilities for themselves.

This body of work highlights that mathematical identities are dynamic, negotiated, and situated in personal histories. Caregivers' descriptions show how they see themselves as mathematics learners–their mathematical histories and present experiences–all of which influence how they engage with their children and mathematics. Conceptualizing these accounts as *mathematical identities* underscores that they are evolving narratives influenced by experiences, relationships, and contexts. This framing highlights that identity in mathematics is relational. Caregivers in my study described their relationships with mathematics as experiences shaped through interactions with children, family members, and school mathematics.

In my study, understanding caregivers' relationships with mathematics requires attention to both the identity resources caregivers drew on and the ways they understand themselves in relation to mathematics. Mathematical identity research focuses on how people understand themselves in relation to mathematics. FoI (Esteban-Guitart & Moll, 2014) focuses on the identity resources people draw on when developing these understandings. FoI provokes me to consider how these resources influence caregivers' experiences of doing mathematics at home. Mathematical identity research provides a lens to consider how caregivers understand themselves in relation to mathematics. This includes how caregivers may describe their relationships with mathematics, including their mathematical competence, views of mathematics, and emotional experiences of mathematics. These perspectives reflect an asset-based approach that focuses on the knowledge, experiences, competencies, and identity resources caregivers bring to

mathematical interactions with their children. Together, these perspectives construct the lens through which I understand caregivers' experiences of doing mathematics with their children.

How I am Implicated in my Research

Creswell (2007) indicates that in qualitative research, the inquirer is implicated in the research they pursue. He indicates the importance of reflecting upon how "their role in the study and their personal background, culture, and experiences hold potential for shaping their interpretations" (p. 236). This may include the themes that emerge and what meanings researchers ascribe to the data. He emphasizes that this is more than just advancing the researcher's biases and values; it is about considering how the researcher's background may shape the direction of the study.

Scholars have discussed that personal justifications for exploring a research puzzle, biases, and other influences may be at play in qualitative research (Kim, 2016). For example, a researcher may collect contradicting stories of the same event from different participants, or even the same participant over an extended period of time. In other cases, a new reading of the same account by the same researcher after a period of reflection may produce a new understanding. Kim (2016) also points out that the length of time spent building rapport with participants may influence the findings.

I acknowledge that what I bring to this research is everything that I have experienced, my own thinking, my education, and my current role as a middle school mathematics teacher. My interest in this study was informed by both personal and professional experiences. Before becoming a middle school mathematics teacher, I viewed myself as someone who was not particularly competent in mathematics. Through teaching mathematics, I began to reconsider this

understanding and became increasingly interested in how people come to see themselves in relation to mathematics. At the same time, my work with families highlighted the important role caregivers play in children's educational experiences. Conversations with caregivers, particularly during the COVID-19 pandemic when many families were supporting mathematics learning at home, led me to wonder how caregivers themselves experience doing mathematics with their children. These experiences influenced both my interest in the topic and the perspectives I brought to the research. Throughout the study, I remained attentive to how these experiences influenced my engagement with participants and my interpretations of their accounts.

These experiences also influenced how I engaged with participants throughout the research process, particularly those who were teacher-caregivers. We shared a familiarity with the routines, language, and expectations of schooling, which supported rapport and conversations that drew upon common experiences working in education. This shared understanding allowed participants to refer to educational practices and scenarios without extensive explanations. For example, Barbara described her work as a mathematics facilitator without needing to explain the responsibilities of the role because I had also completed a short contract as a mathematics facilitator in my school board. This shared understanding meant our conversations focused on how that role influenced her experiences of mathematics in the home. At the same time, I remained attentive to how these shared experiences influenced the questions I asked and the interpretations I developed. Shared professional knowledge helped me understand the educational situations participants described, but I was careful not to assume that we experienced those situations in the same ways. My interpretations remained grounded in participants' descriptions of their experiences.

Chapter 3: Study Design

In chapter three, I offer an examination of the research design employed in this study, exploring the philosophical underpinnings and specific methods chosen to investigate the research questions:

- *How do adult caregivers experience mathematics in their home setting?*
- *How do adult caregivers' experiences of doing mathematics with their children influence their relationship with mathematics?*
- *How do caregivers experience relationships between home and school mathematics?*

Qualitative Methodologies

I situate this study within qualitative research because I am interested in understanding how caregivers experience doing mathematics with their children and how they make sense of those experiences within family life. Creswell (2007) explains that qualitative research focuses on understanding participants' perspectives, experiences, and meanings within natural settings. Qualitative research also seeks to develop a complex and holistic understanding of a phenomenon by attending to the multiple realities participants describe (Creswell, 2007). Creswell (2007) further explains that qualitative research is interpretive, meaning researchers seek to make sense of the meanings participants attribute to their experiences. In contrast, quantitative research is an approach for testing objective theories using established instruments to analyze numbers and statistics (Creswell, 2007). It intends to produce results that are

replicable and generalizable. I am not interested in evaluating my participants through numerical measures. I am, however, interested in the variation of experiences that caregivers have while doing mathematics with their children. Caregivers' relationships with mathematics are an emerging area of study; therefore, qualitative methods would be most appropriate.

Creswell (2015) describes qualitative research as emergent, iterative, and responsive to the unfolding research process. He explains that qualitative research cannot be "tightly prescribed" because research questions, forms of data collection, and interpretations may shift as researchers engage with participants and data. Therefore, my study unfolded in response to participants and their requests. As I continued to build relationships with participants and learn more about their experiences, the research process evolved alongside those interactions.

Reflexivity

Notably, reflexivity is encouraged within all relational methodologies (Clandinin, 2013; Cole & Knowles, 2001; Creswell, 2007). More pointedly, reflexivity is used as a way for researchers to *sharpen their kaleidoscope* (Kim, 2016), identify bumping-up points (Clandinin, 2013), and be responsive within the relationships they cultivate within the space of the research (Cole & Knowles, 2001). Reflexivity is clearly an important aspect of qualitative inquiry (Creswell, 2007) to help bring the researchers' subjectivity to the foreground so that the researcher can then respond to their participants and build mutuality within the research space.

Reflexivity emphasizes the importance of seeing ways of knowing from multiple different vantage points (Kim, 2016, chapter 8, p.6). Korsgaard's (2019) metaphor of 'pearl diving' is a helpful way to consider unearthing experiences of our own and participants' pasts. 'Pearl diving' is a way of thinking about reconstructing experiences from the past where

memories are considered a ‘pearl’ that can be viewed from a multitude of vantage points (Korsgaard, 2019). The pearl diving metaphor positions experiences in terms of which pearls ‘speak to us’ (Korsgaard, 2019). When we are reflexive, we consider the meaning of each ‘pearl’ (idea, experience, artifact) that we are working to uncover in the research. Furthermore, reflexivity allows us to account for the variety of different ways by which we can see each pearl (Korsgaard, 2019), while knowing that it is almost impossible to see each pearl from all possible vantage points.

Phenomenography

I have chosen to situate my work in qualitative methods, using analytic methods inspired by phenomenography. This will allow me to analyze the different ways adult caregivers experience doing mathematics with their children. Phenomenography (Marton, 1981) examines qualitatively different ways people experience the same phenomenon. Its central focus is variation—the different conceptions people have of the same phenomenon. Through analysis, these variations are articulated as categories of description (Marton & Pong, 2005). These categories represent different conceptions, or ways of making sense, of the phenomenon within a group of people. In my study, categories of description will be used to represent various ways caregivers experience mathematical interactions with children across the data set. Phenomenography is used as an analytic tool in this study. Researchers have used phenomenography with smaller samples when participants provide detail-rich accounts that are closely connected to phenomena under investigation (e.g., Barnard et al., 1999; Dasborough et al., 2015). In my study, phenomenography is used as an analytic tool to identify variation in caregivers’ experiences rather than as a complete methodological framework. This approach

allows me to examine qualitatively different ways caregivers experience doing mathematics with their children while also paying attention to the relational and contextual aspects of their experiences.

My conceptual perspective, Funds of Identities (Esteban-Guitart & Moll, 2014), and mathematical identities also focus on the variations in the ways identities are constructed. In fact, Funds of Identities and mathematical identities are heavily influenced by a variety of factors, including social circumstances that impact the wide range of ways identities are experienced. Perspectives of mathematical identity conceptualize identities as fluid, relational, and context-dependent (Hall et al., 2018); for example, when a caregiver feels comfortable helping with mathematics in the younger grades but not the older grades. These perspectives attend to the different ways individuals experience and describe themselves in relation to mathematics. Therefore, phenomenography is an excellent fit to examine Funds of Identity and mathematical identities.

I also considered narrative inquiry as a method because caregivers frequently made sense of their current mathematical interactions with children by drawing on stories from their own experiences of schooling, parenting, teaching, and family life. These accounts often connected past experiences with present mathematical interactions and revealed how caregivers understood themselves in relation to mathematics over time. Narrative inquiry is useful for examining how individuals construct meaning through lived experience and storytelling (Clandinin & Connelly, 2004). However, my study does not seek to construct individual life histories or analyze the structure of participants' narratives. Instead, I use participants' accounts to examine the different ways caregivers experience doing mathematics with children. This focus allows me to explore

variation in caregivers' experiences while also identifying the identity resources they draw upon during mathematical interactions. Because my interest is in understanding the different ways caregivers experience mathematics and how those experiences relate to their relationships with mathematics, phenomenography provided a stronger methodological fit.

In this study, the distinction between phenomenography and phenomenology lies in their analytic aims. Scholars (e.g., Stolz, 2020; Cibangu & Hepworth, 2016) explain that both approaches share an interest in understanding experience. Phenomenology seeks to understand the meaning or essence of lived experience, while phenomenography seeks to describe the qualitatively different ways people experience the same phenomenon (Marton, 1981). Phenomenography has been widely used in educational research. Although both approaches attend to experience, phenomenography is particularly concerned with variation across participants' experiences and the categories of description that represent this variation. I use phenomenography as an analytic approach for examining variation in how caregivers experience doing mathematics with their children. This distinction is important in my study because Funds of Identity and perspectives of mathematical identity both emphasize that identities are shaped through varied social experiences, relationships, and interactions.

In phenomenology, a *first-order perspective* is used to describe *the essence* of the lived experience of a phenomenon. According to Marton (1981), essence refers to the common intersubjective meaning of an aspect of the experience. Phenomenology asks what my participants experience. It studies the experience itself.

Phenomenography, on the other hand, adopts a *second-order perspective* that focuses on how individuals experience and make sense of a phenomenon (Marton, 1981; Marton & Booth,

1997). This perspective aligns closely with perspectives of mathematical identity that conceptualize identities as relational, negotiated, and shaped through experience (Hall et al., 2018; Lutovac & Kaasila, 2014). Phenomenography asks: How did my participants experience this? It studies the various ways people experience a phenomenon. A second-order phenomenographic perspective therefore supports an examination of how caregivers understand themselves in relation to mathematics while engaging in mathematical interactions with their children. I am not interested in the essence of caregivers' experiences of mathematics at home; instead, I want to learn about the variations in how they experienced it.

In phenomenography, attention is given to what aspects of a phenomenon come into focus for participants and what remains in the background of their awareness. This analytic lens, referred to as the *structure of awareness* (Marton, 1981), helps illustrate how individuals attend to different features of the same experience. Attention to *foreground* and *background* aligns closely with Funds of Identity because Funds of Identity focuses on how individuals draw upon different identity resources through lived experiences, relationships, and social interactions (Esteban-Guitart & Moll, 2014). In this study, attention to foreground and background will support an examination of the aspects of mathematical interactions caregivers bring into their awareness, such as emotions, perceptions of competence, relationships with mathematics, or children's mathematical ideas. This analytic approach will also support an exploration of the different identity resources caregivers draw upon while experiencing mathematical interactions with their children. Attention to foreground and background will therefore support the construction of categories of description by helping surface variation in how caregivers experience the same mathematical interactions.

In the field of mathematics education, researchers (e.g., Stott & Voutsina, 2024; Cudjoe et al., 2025) use phenomenography as a methodological approach to investigate experiences of doing mathematics. These studies show how phenomenography can make variation in experience visible, attend to what participants notice, and articulate these differences through categories of description. For example, Stott and Voutsina (2024) used phenomenography to identify different conceptions of children's experiences with written numerals in everyday environments. Their study highlights how phenomenography can illustrate variation in children's experiences with what they know about numbers. Similarly, Cudjoe et al. (2025) used phenomenography to explore how eighth-grade students experienced algebra through a task rooted in a real-life situation. Their analysis identified a variety of conceptions that eighth-grade students held about algebra, demonstrating phenomenography's use in mathematics education to examine variation in experience. These studies demonstrate phenomenography's usefulness for examining variation in mathematical experience. In my study, I use phenomenography to examine the different ways caregivers experienced doing mathematics with children at home, including how these interactions became experiences of connection, pressure, and competence.

I use phenomenography because it allows for an examination of how caregivers experience doing mathematics with their children in qualitatively different ways. It also supports an examination of how caregivers experience relationships between home and school mathematics. As described above, my conceptual perspectives describe identities as fluid, relational and context-dependent (Hall et al. 2018). This means that there are many aspects to identities influenced by social situations and other identity resources. Identities can therefore be experienced in a variety of ways across participants. Phenomenography supports an examination

of caregivers' histories, relationships, perceptions of competence, and prior experiences with mathematics. It allows me to investigate the ways mathematical interactions within families influence how caregivers understand themselves in relation to mathematics.

The Study

This section begins with a description of the participants and the study setting. I then provide an overview of the data sources and data collection procedures used to generate accounts of caregivers' experiences. Following this, I explain the analytical processes used. The section concludes with a discussion of ethical considerations and strategies used to support integrity throughout the research process.

Participants

Three adult caregivers participated in this study. Participants are presented in two family groups to describe the family relationships relevant to the study. Children were not participants in this study. Children's mathematical ideas appear in the data only through caregivers' descriptions of shared interactions. Pseudonyms are used throughout.

Family 1. *Madison* is the mother of an eight-year-old son, Connor. She lives with her parents and son in the small town she grew up in. Living in an intergenerational household meant that Connor regularly interacted with multiple adults who participated in everyday care for him, which included engaging with his learning. *Barbara* is Madison's mother and Connor's grandmother. She has extensive professional experience in teaching mathematics, including roles as a classroom teacher, school board mathematics facilitator, and school principal. She holds a degree in mathematics and was also Madison's Grade 8 teacher. Madison and Barbara live in a small Northern Ontario community where many residents know one another. Through her decades of work in education, Barbara has taught many members of the community, including adults who continue to play important roles in Connor's life, such as his hockey coach.

Family 2. *Emilie* is a teacher and the mother of three children: Sylvie, Liam, and Jackson. At the time of data collection, Sylvie was in Grade 4, Liam in Grade 2, and Jackson in kindergarten. Emilie has taught mathematics at both the primary and middle school levels. Emilie's three children participated in multiple competitive sports, and much of the family's weekly routine revolved around practices and games. These activities frequently created one-on-one time with individual children while siblings participated in their own activities. At times, grandparents cared for the children who were not attending practices, providing additional opportunities for family members to spend time together. These shared caregiving arrangements created regular opportunities for children to engage with multiple adults in their everyday lives. Emilie's husband, Alfie, appears in her accounts but was not interviewed or a participant in the study. Alfie has a background in finance and works in real estate. Their family lives in a rural area just outside a large suburb where her children attend school.

Participants occupied different family, professional, educational, and social positions. At the same time, they also shared several important characteristics that influenced how they experienced mathematics in the home with their children. Both families had direct access to insider knowledge about schools because they had teachers within the family. Their professional experiences provided opportunities to develop familiarity with drawing mathematics out of everyday situations and posing questions that encouraged children to share their mathematical ideas. All participants were fluent in English, which was the dominant language used in their children's schools. Both families also had multiple adults who participated in the children's care and learning, creating regular opportunities for family members to engage with children's mathematical ideas. These intersectional family, professional, educational, and social positions

afforded participants particular opportunities to do mathematics in the home. The experiences described in this dissertation should therefore be understood in relation to these intersectional positions.

Study Setting and Recruitment Conditions

I received university ethics approval on September 19th, 2023. I distributed a flyer/advertisement via a community library's website and email communication to families already connected to the library. Eleven participants signed up for the study; however, only two family groups attended the meetings. Most individuals who initially expressed interest did not respond to follow-up communications or attend scheduled meetings. As a result, the study proceeded with two family groups and three adult caregivers. While the participant group was smaller than originally anticipated, the data generated through interviews and mathematical tasks provided rich descriptions of caregivers' experiences.

This section outlines the data sources and data collection methods that I used to examine caregivers' experiences of mathematics in the home setting, their experiences of doing mathematics with children, and their experiences of relationships between home and school mathematics.

Data Collection

Semi-structured Interviews

Madison and Barbara participated in three one-hour interviews. I conducted the first interview jointly and focused on learning about their family and co-designing a mathematical activity involving Connor. In the subsequent weeks, I conducted one individual interview with

Madison and one with Barbara, allowing each participant to reflect independently on their experiences. All three interviews were conducted via Zoom.

Emilie was enthusiastic about the study, but she knew that she was unable to meet for three one-hour interviews. To accommodate her schedule, Emilie participated through a series of shorter interviews that we scheduled around her availability. Each of our meetings typically lasted approximately twenty minutes in person.

Semi-structured interviews are commonly used in phenomenographic research to invite participants to discuss phenomena in their own terms (e.g., Bruce, 1999). I used semi-structured interviews to support open responses while keeping discussions connected to the research questions. The flexibility of semi-structured interviewing also allowed me to ask follow-up questions that encouraged participants to elaborate on relationships, interactions, and prior experiences connected to mathematics in the home. This approach aligned with my use of phenomenography because it supported an examination of the different ways caregivers experienced doing mathematics with children at home.

My own experiences as a middle school mathematics teacher also influenced how I responded during interviews. When participants referred to familiar educational practices or used language connected to teaching, I was often able to ask follow-up questions that built on this shared professional understanding. For example, when Emilie shared how she felt about the teacher's assessment of her daughter's question, I was already familiar with language used within the *Ontario Mathematics Curriculum* (Ontario Ministry of Education, 2020) and *Growing Success* (Ontario Ministry of Education, 2010), which guides teachers' assessment practices. This shared professional understanding meant that Emilie could discuss the feedback from her

perspective as a teacher-caregiver without first explaining the policies or terminology that informed her interpretation. Although I used a common interview guide, the follow-up questions differed across interviews because they were responsive to participants' accounts. My background as a teacher and a scholar also helped me recognize moments that invited further explanation. For example, when Madison remarked that Connor's strategy "would be so confusing to anybody else," I asked additional questions to understand whom she meant by "anybody else." Similarly, I asked follow-up questions to better understand Barbara's reasons for encouraging Madison to focus on listening to Connor's strategies. At the same time, I was careful not to assume that shared professional knowledge reflected shared experiences or interpretation of that knowledge. Instead, I invited participants to explain what these experiences meant to them and how they understood them within their own families. This approach aligned with phenomenographic principles by keeping the focus on participants' experiences.

Interviews were flexible and responsive, allowing participants to describe their experiences while remaining focused on the study's objective. I used open-ended prompts to guide conversations about caregivers' experiences of mathematics in the home, their relationships with mathematics, and their experiences of home and school mathematics.

The interview prompts invited participants to describe their own experiences of doing mathematics with their children and how they perceived their children's experiences. My interviews also provided participants with opportunities to reflect on their prior experiences with mathematics and how they saw themselves in relation to it.

The following are examples of prompts used during interviews:

- Can you describe how a recent mathematical activity with your child unfolded and what stood out to you?
- What were you thinking or feeling before beginning the activity, and how did those feelings shift as it progressed?
- How did you perceive your child's engagement and responses during this moment?
- How did you respond in the moment, and what influenced that response?
- Did this experience prompt you to think differently about yourself, your child, or mathematics moving forward?
- Can you tell me about how you remember doing mathematics as a child?

Voice Note Memoing

Voice note memoing, sometimes referred to as audio diaries, is a qualitative longitudinal research method in which spoken reflections are recorded over time. Audio diaries are used to capture participants' lived experiences, thoughts, emotions, and reactions as they occur within everyday contexts. Verma (2021) explains that audio diaries allow participants to "talk through their experiences and engage in a reflective dialogue related to their lived experiences." Unlike traditional interviews, audio diaries can capture reflections in real time and provide insight into how participants' experiences and understandings shift over the course of a study. Researchers have used audio diaries to explore identity formation, reflective practice, and professional experiences because the method allows participants to speak naturally and conversationally about their experiences. Verma also notes that audio diaries may be particularly useful for participants who are less inclined to communicate through written responses.

Voice note memoing was not originally planned as part of my study. Instead, the method emerged out of necessity because one participant, Emilie, preferred communicating through voice notes rather than written responses. As the study progressed, voice note memoing became an important methodological approach within the research. The participant used voice notes to share reflections, experiences, and reactions connected to doing mathematics with children in the context of everyday family life. Using voice notes allowed the participant to communicate in a way that felt more natural and accessible to them. These recordings became part of the broader qualitative dataset alongside interviews and researcher reflections. In this way, voice note memoing emerged responsively within the study rather than as a pre-planned data collection method.

Emilie shared additional information that she felt was relevant to her experience through voice notes and text-based exchanges (voice-note memoing). This flexible format supported Emilie's participation within the constraints of her children's busy after-school schedules. It also allowed her to capture her family doing mathematics as it unfolded.

Artifacts

The term *artifacts* is used to describe materials that adult caregivers and I created or selected because they marked moments where mathematics became visible in everyday family life. An artifact is an object of study, commonly used in qualitative studies. They are constructed by humans, making them symbolic and purposeful. Artifacts are dynamic, fluid, ever-changing, and sometimes ambiguous. They are shaped by our perceptions of them and our communication about them. They are more commonly described as texts,

Researchers employing qualitative inquiry methods collect artifacts as part of their process. The artifacts collected can be categorized broadly and informally to help understand their utility: a) artifacts that are primarily information or data about a life; b) artifacts that are primarily representations of a life; c) artifacts that are related to the context within which a participant's life is situated (Cole & Knowles, 2001, p.84). During interviews, the researcher and participant can inquire about the meaning of artifacts by asking the participant to share its importance or the circumstances surrounding the artifact. For example, the researcher could ask "What else was going on in your life at this time?" (Cole & Knowles, p.86) or "How did this report card make you feel at the time? How does it make you feel revisiting it now?" Artifacts are a way of helping participants share their stories, evoke memories, or explore their stories more deeply if they are comfortable doing so. Essentially, artifacts are another way of coming to know the stories of participants beyond words. An artifact may unlock a memory or provoke a new understanding of a story when it is examined through a different lens (e.g., coming back to an artifact at a different time, or in a different space).

Participant-Generated Artifacts

In this study, participant-generated artifacts were also collected. Artifacts included photographs of children's work, short written notes, and audio recordings. In line with phenomenography, I used these artifacts alongside semi-structured interviews to direct attention to what participants noticed as mathematical (Marton & Booth, 1997). Emilie shared seven artifacts during the data collection period, often shortly after the interaction occurred. I discussed these artifacts with her in subsequent conversations, which supported reflection on how

mathematics was experienced by her family in daily life. Barbara and Madison shared one artifact – handwritten notes—documenting Connor's responses.

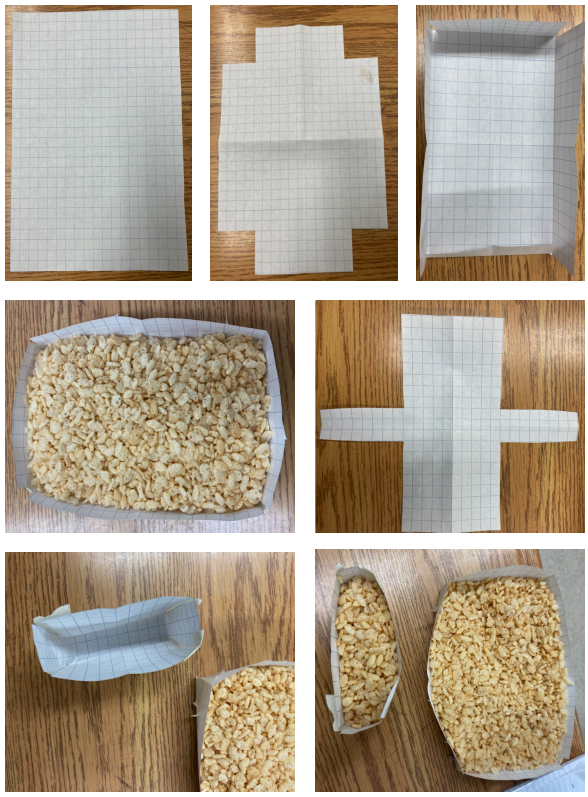
Family Mathematics Task: The Popcorn Problem

I shared the popcorn problem with Madison and Barbara because they requested a mathematical task related to volume. I selected this task because it supported open-ended mathematical discussions between caregivers and children. The popcorn problem prompted families to discuss their predictions, describe their calculation strategies, and examine their results. I explicitly asked Barbara and Madison to focus on listening to Connor's ideas and encouraging him to test them out before confirming whether his answers were correct. The task also supported my phenomenographic approach because it generated opportunities for caregivers to discuss how they experienced mathematical interactions with their children. Unlike typical homework worksheets, this task encouraged discussion and experimentation. Madison, Barbara, and Connor engaged in the popcorn problem at home without me present.

The task is a version of the open-top box problem developed by Mamolo et al. (2015). It asks participants to compare the volumes of boxes formed by cutting equal squares from the corners of a sheet of paper and folding the sides upward. The task begins with a sheet of grid paper, typically 20 x 20. Equal squares are removed from each corner to create an open-top box. The volume of each box is determined by multiplying the area of its base by its height. By varying the size of the corner cuts, multiple boxes can be constructed and compared. Boxes were compared by filling them with cereal and pouring the contents between boxes. See Figure 3.1 for an example.

Figure 3.1

Stages of the Popcorn Problem task, including net construction, box assembly, and volume comparison.



Timing and Scope of Data Collection

Data collection occurred over a three-month period. This time frame allowed for multiple interactions with participants while remaining manageable within caregivers' family schedules. Data collection concluded for all participants at the end of three months.

Analytic Process

To transcribe the interviews, I used a program (Turboscribe) to convert the audio files to text. Then, I listened to the interviews while reading the transcripts to check for accuracy. I revised the transcripts to more accurately reflect the conversations documented. Upon transcribing all the interviews, I began analysis by reading the data multiple times to become familiar with caregivers' accounts. Because my focus was on identifying the qualitatively different ways participants experienced doing mathematics in the home setting and their relationships with mathematics, I paid close attention to how caregivers described their thoughts, feelings, and interactions. Analysis unfolded through: 1) the construction of a *pool of meaning*, 2) iterative comparison of excerpts, and 3) the development and refinement of categories of description (Marton & Booth, 1997).

Data from both families were considered together as a pool of meaning (Marton & Booth, 1997). This pool of meaning consisted of excerpts from across the data set that addressed my research questions. These excerpts included descriptions of interactions with children and caregivers' relationships with mathematics. I moved repeatedly between interview transcripts, artifacts, and excerpts while comparing the different ways participants described their experiences. This process was not linear (Creswell, 2007). As categories began to emerge, I repeatedly returned to earlier excerpts to reconsider how participants' experiences responded to

my research questions. Analysis allowed differences in participants' experiences to emerge. For example, many caregivers drew upon their identity resources from their professional lives when doing homework with their children. Through this iterative process, I began identifying qualitatively different ways caregivers experienced doing mathematics within family interactions. Excerpts were grouped together when they reflected a similar way of experiencing doing mathematics in the home. For example, within the subcategory of *"Oh my god. That's me,"* excerpts were grouped together when participants described their children's mathematics as a reflection of themselves. Throughout analysis, I moved between individual excerpts and the broader pool of meaning to consider how participants' accounts related to emerging categories of description.

Early analytic groupings focused on conceptions of experience that appeared across participants' accounts. For example, I paid attention to how caregivers described their feelings during mathematical interactions, using descriptions like *surprised*, *joy*, or *stressed,* and sorted these into the category of *affect*. As my analysis progressed, I realized that caregivers' affect overlapped with other dimensions of experience such as what they were doing at the time and who was present. I realized that describing participants' emotions was not enough. As a result, I rewrote categories to capture the ways different interactions influenced how caregivers felt.

Figure 3.2 (below) illustrates an example of early analytic groupings developed during the construction of the pool of meaning. Excerpts were compared and grouped according to similarities and differences in how caregivers described experiences of doing mathematics with children. These early groupings were refined iteratively throughout analysis as categories of description emerged.

Figure 3.2

Early analytic groupings developed during data analysis.



As categories emerged, I also paid attention to the boundaries between categories of description. Some excerpts reflected multiple dimensions of experience simultaneously. For example, experiences of competence were often connected to family relationships, prior school experiences, or caregivers' emotional responses during mathematical interactions. Rather than treating categories as isolated themes, I examined how categories represented different ways caregivers experienced mathematics within family life.

In phenomenography, analysis focuses on the aspects of a phenomenon that participants pay attention to and how those aspects are understood (Marton & Booth, 1997; Bruce, 1999). To support this stance, I paid attention to my assumptions by grounding analytical decisions in participants' descriptions. For example, the category *Experiencing mathematics as embedded within everyday routines* emerged because participants described everyday activities as mathematical. Participants referred to mathematics as emerging through everyday conversations or during routine activities. The category was constructed by paying attention to participants' language and the aspects of experience they brought into awareness.

Through ongoing comparison, I developed and refined categories of description. As categories began to emerge, I met with a committee member to discuss my initial interpretations. These conversations also influenced how I interpreted participants' experiences. Early in analysis, I initially drew on Funds of Knowledge because caregivers frequently described the knowledge and experiences they brought to doing mathematics with their children. However, as I revisited the data and discussed emerging interpretations with my committee, I recognized that Funds of Knowledge did not fully capture what participants were describing. During a discussion, a committee member observed the "different hats" caregivers seemed to describe

wearing, such as being grandparents, teachers, parents, and professionals. This prompted me to return to the literature and consider whether another conceptual lens better reflected these experiences. When I returned to the Funds of Knowledge literature, I encountered Funds of Identity, an extension of this work that more closely aligned with what I was seeing in the data. As I revisited the data, I realized participants were describing the identity resources connected to being parents, grandparents, teachers, and professionals. This shifted my attention from what knowledge caregivers were bringing into mathematical interactions to how caregivers understood themselves while doing mathematics with their children. As a result, I incorporated Funds of Identity as a conceptual category instead of Funds of Knowledge because it better reflected what participants were describing.

As I continued to build the categories of description, the committee member also noticed that there was still some overlap within categories. For example, as I examined caregivers' aspects of affect, my committee member asked me to think further about how personal histories influenced affect. This feedback prompted me to examine the ways caregivers described their relationship with mathematics overlapped with affect. With this new insight, I refined early categorizations. I also met with colleagues to talk through the data and explain how I was interpreting caregivers' experiences. My colleagues challenged me to consider whether the categories I had set out adequately described the excerpts grouped within them. These conversations helped me refine the categories as I worked toward coherence across the range of variation in the data set. Through this process, the analysis moved from identification of broad categories toward the articulation of qualitatively different ways adult caregivers experienced doing mathematics with their children. The analysis resulted in three categories of description,

which are presented in the Findings chapter, with illustrative excerpts from participants' accounts.

As a mathematics teacher, and through my own reflexivity, I was aware that my own experiences and relationships with mathematics influenced how I approached the data. Throughout the analysis, I returned to participants' language and descriptions to ground interpretations in caregivers' accounts. Discussions with committee members and colleagues also supported this process by prompting me to reconsider early interpretations and category boundaries. This reflexive process was particularly important when participants described educational practices that aligned closely with my own views as a mathematics teacher and doctoral student. For example, I found myself strongly connecting with participants' descriptions of listening to children while they explained their mathematical ideas. Recognizing these moments of connection prompted me to return to participants' accounts to ensure my interpretations remained grounded in their descriptions instead of my professional experiences.

Chapter 4: Findings

This chapter presents the different ways adult caregivers experienced mathematics within family life. Caregivers described experiencing mathematics through interactions with children, reflections on their own mathematical histories, and negotiations surrounding competence within family relationships. Mathematics emerged through play, conversation, problem solving, and everyday interactions with children. Across these accounts, the range of ways that mathematics was experienced as relational, emotional, or embedded within ordinary family life.

The findings are organized into three categories. The first category, "*Math is Everywhere, and it's all the time*," examines how caregivers experienced mathematics as embedded within everyday family life. Caregivers described mathematics emerging through everyday routines, play, games, conversations, and workplace experiences that became part of family mathematical interactions.

The second category, *Adults Gaining Insight from their Children's Mathematics*, examines how children's mathematical ideas became a source of learning about children and themselves. Five subcategories are identified within this category: i) learning about children through their responses to mathematical challenges, ii) knowing children through preferences, iii) experiencing differences between children in relation to mathematics, iv) "Oh my god. That's me.", and v) re-experiencing mathematics emotionally through children's ideas.

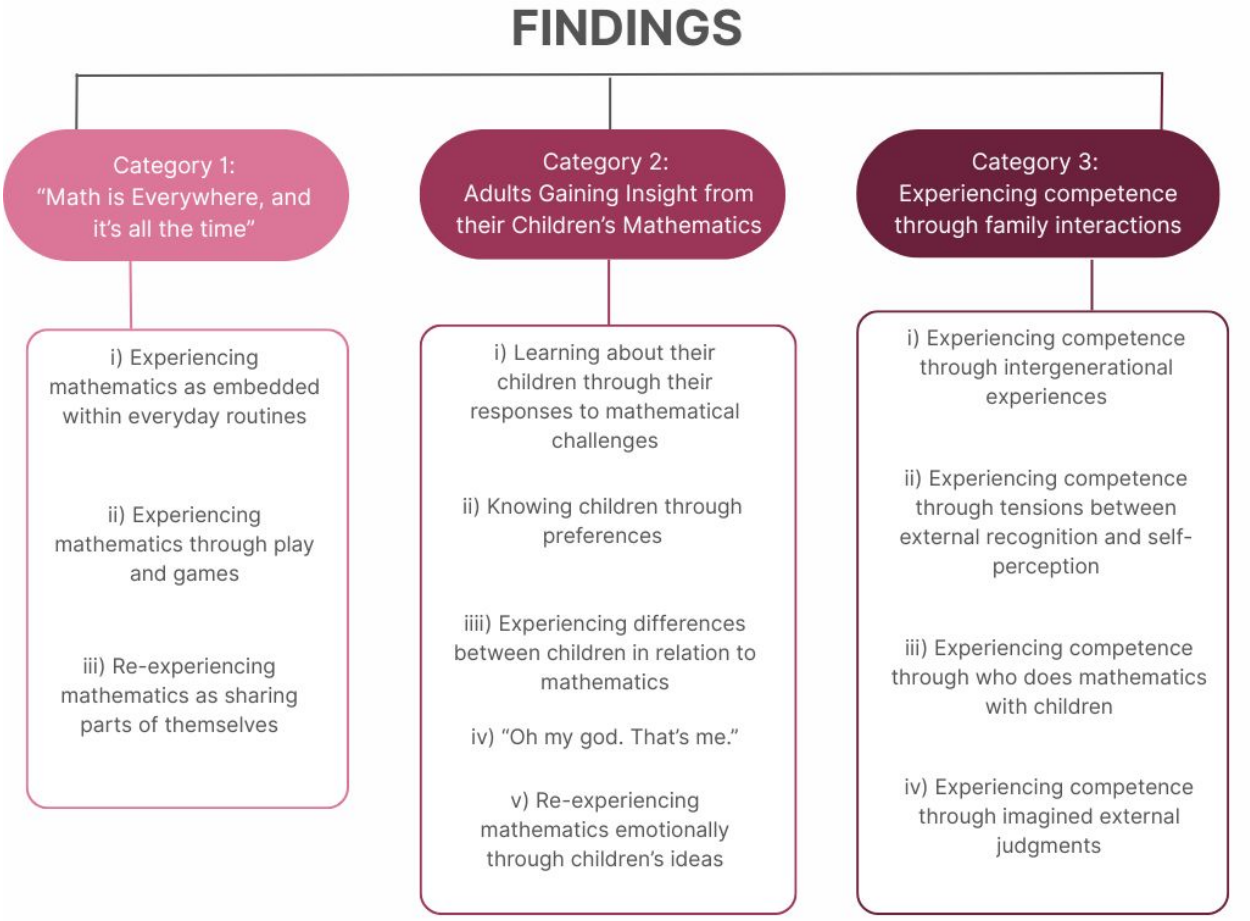
The third category, *Experiencing Competence Through Family Interactions*, examines how caregivers experienced mathematical competence through family relationships. Four subcategories are identified within this category: i) experiencing competence through intergenerational experiences, ii) experiencing competence through tensions between external

recognition and self-perception, iii) experiencing competence through who does mathematics with children, and iv) experiencing competence through imagined external judgments.

Together, these categories illustrate the varied ways caregivers experienced mathematics within family life.

Figure 4.1

Overview of the categories and subcategories identified in the findings.



Category 1: "Math is Everywhere, and it's all the time"

This category captures the ways caregivers experience mathematics as embedded within ordinary family life. As Barbara explains, "to me, math is everywhere, and it's all the time." This category focuses on caregivers experiencing mathematics as naturally emerging through everyday interactions, routines, and activities. Within this category, caregivers describe mathematics occurring through conversation, play, sharing, and daily family experiences rather than only through school-directed tasks or formal instruction. Across these accounts, mathematics becomes part of the fabric of everyday family life. Variation within this category is related to the complexity of the mathematics caregivers experienced within everyday family life. Some comments simply described mathematical experiences involving counting, sharing, and basic operations during everyday activities. Other comments described more elaborate mathematical experiences that involved discussing concepts such as profit, comparing quantities, and reasoning about mathematical situations together. Caregivers experienced these interactions as part of everyday life rather than planned opportunities to teach mathematics.

Some caregivers described mathematics as "something that just happens" and emerging naturally through everyday routines. For example, Barbara described mathematics occurring while "climbing stairs with a toddler" and "counting the stairs as you go up and down." Barbara experienced these interactions as examples of mathematics arising naturally through daily routines. Barbara also described mathematical conversations emerging while sharing food with children, explaining, "We have so many candies, and there are 4 of us. So how many does each person get?" In addition, she recalled moments during car rides involving food sharing and division, explaining, "Those little Ritz cracker minis were for a car ride…there were 3 of us, and

we have so many left. So how many does each person get?" These comments show how Barbara experienced everyday routines and interactions as naturally mathematical.

Another way caregivers experienced mathematics through everyday experiences was within play and games. Emilie described games such as Go Fish and Briscola as common family activities that created opportunities for spontaneous mathematical conversations. Reflecting on a conversation after a game of Go Fish, Emilie asked her son questions like, "You counted your cards. How many did you have?" Then she followed with "How do you know I won?" and prompted a discussion about subtraction by asking, "Tell me how you know it's a bigger number." During another interaction, Emilie said to her son, "I had thirty-two, you had nineteen," prompting him to compare their scores. Emilie identified these activities as opportunities to pose mathematical questions and engage her son in conversations about mathematics during card games.

In another example involving play, Barbara described her granddaughter playing at a trampoline park. Her two-year-old granddaughter asked for "10 more jumps" before later holding up two fingers on each hand and saying, "22 more jumps." Barbara experienced these interactions as examples of children sharing what they understood about numbers. These comments show how caregivers experienced mathematics as emerging through playful activities.

A more elaborate and involved way caregivers experienced mathematics in everyday life was by drawing on workplace experiences during mathematical conversations with children. For example, Emilie described how her husband, Alfie, often introduced mathematical conversations connected to his experiences working in business. Conversations about "profit" emerged while discussing the cost of Gatorade for a school fundraiser. He posed questions about the Gatorade,

like “How much are you selling them for?” Emilie recalled Alfie drawing on his experiences to describe profit as “when companies have to buy something and then resell it, they are looking to make a profit.” This conversation resurfaced later in the week during a dinner out where he began a conversation with his children about how restaurants make a profit. He asked his children questions like “Is the chef getting that money? Is the owner getting that money? What about the waiters? What money are they getting?” Through these conversations, children learned more about how Alfie understood profit through his work experiences. These comments show how caregivers experienced mathematics as emerging through conversations connected to everyday work experiences.

Across the category of “Math is Everywhere, and it’s all the time,” caregivers experienced mathematics as embedded within ordinary family life. Mathematics emerged through everyday routines, play, games, conversation, sharing, and other family activities rather than only through formal school-related tasks. Across these variations, caregivers described mathematics as something that naturally occurred within family interactions. These experiences show how caregivers experienced mathematics as part of the fabric of everyday family life.

Category 2: Adults Gaining Insight from their Children’s Mathematics

This category illustrates how adult caregivers experienced their children's mathematical ideas as a source of insight. This category describes how children’s ideas served as a springboard for adults to gain insight into their children or themselves. Children’s mathematical ideas sparked surprise, admiration, curiosity, and reflection for caregivers. This category can be distinguished from the first category because it focuses on adults growing their understanding through their children’s mathematics.

In this category, caregivers experienced mathematics in family life as: i) Learning about their children through their responses to mathematical challenges, ii) Knowing children through preferences, iii) Differences between children in relation to mathematics, iv) “Oh my god. That’s me.” and v) Re-experiencing mathematics emotionally through children’s ideas. Collectively, these accounts show how children’s mathematical ideas became a source for caregivers to gain new insights into themselves and their children.

Learning About their Children Through their Responses to Mathematical Challenges

This subcategory focuses on caregivers' understanding of their children’s responses to mathematical challenges. Like the other subcategories, caregivers gained insight through doing mathematics with their children. This subcategory is distinct because it focused on caregivers gaining insight about their children through how they made predictions and persisted when faced with mathematical challenges. Caregivers described paying close attention to how children justified predictions, responded to unexpected results, and remained interested while solving problems. Variation within this subcategory related to what caregivers paid attention to through these interactions. Some caregivers focused on children’s communication preferences while others focused on children’s mathematical strategies and visualizations.

One way that caregivers experienced insight into children’s mathematical ideas with regards to persistence was through learning about their communication preferences. For example, Emilie described gaining insight into Jackson’s preferences for only sharing his ideas once. After Jackson had explained his solution to 32 - 19 to Emilie, she was excited to record it as a voice memo and share it. When she went to record it, Jackson argued: “ummm… video, turn it off!” Emilie responded with “It’s not a video” and prompted him to share, “How do you know

it's a bigger number?" She also encouraged him by saying, "That's a really good observation." Finally, Jackson became frustrated with the interaction and said, "It's done!" This helped Emilie recognize that Jackson was happy to share his ideas with her in their regular family discussions but did not want to repeat it for a voice memo.

Another way caregivers experienced insight into children's mathematical ideas involved children making unexpected predictions while solving mathematical problems. Caregivers experienced this insight through children's mathematical strategies and visualization. For instance, when working on the popcorn problem, Madison expected Connor to choose the 1x1 cut because it produced the largest base. Instead, Connor immediately rejected that option because it did not create enough height to maximize the volume. Madison recalled feeling "shocked that he just knew it." Connor's prediction drew Madison's attention to how he visualized relationships between height and the area of the base while solving a problem about volume. Barbara explained that Connor "kept predicting," convinced that increasingly larger cuts would continue increasing the volume because of the additional height. Barbara interpreted his repeated testing and revising as evidence that he was actively exploring relationships between dimensions and volume. Connor continued testing different cut sizes because, as he explained, "I need to see where it stops." At another point, Connor exclaimed, "If this fits, my mind will be blown." These comments show how caregivers experienced children's persistence through insight into their strategies and visualization.

Children's persistence also provided caregivers with insight into children's mathematical ideas. Barbara focused less on whether Connor immediately arrived at a correct answer and more on his persistence while solving the task. Reflecting on the interaction, Barbara explained that

Connor “had been working so hard” before relaying that Connor eventually admitted, “My brain hurts. I can’t do any more.” Madison similarly interpreted Connor’s continued testing and revising as evidence that he remained invested in the outcome of the problem. These comments show how caregivers interpreted persistence not simply as perseverance, but as evidence of curiosity, engagement, and commitment toward mathematical activity.

Collectively, statements within this subcategory show how caregivers used children’s predictions, experimentation, and persistence to gain insight into children’s mathematical ideas. This subcategory focused specifically on caregivers learning about their children. Caregivers learned about how children visualized relationships, responded to challenges, and remained invested while solving problems.

Knowing Children Through Preferences

Caregivers experienced their child’s preferred mathematical solution strategies as a way of knowing children through mathematics. This subcategory is distinct because it focuses on children's mathematical preferences in solution strategies as a way for caregivers to gain insight about their child. Statements within this subcategory focused on caregivers describing recurring ways their children liked to work with numbers that became familiar features of their child’s preferences. Caregivers’ curiosity around children’s preferred strategies became a way for caregivers to continue learning about children through mathematical interactions.

For example, Emilie experienced Liam’s recurring use of tens as a familiar and recognizable feature of how he approached arithmetic. Emilie described that Liam “always seems to use his 10’s,” referring to his repeated tendency to reorganize quantities around tens while solving problems. While solving 28×2, Liam quickly provided the correct answer of 56.

He explained that he thought about the question as 20 + 8 and 20 + 8. First, he "added 20 plus 20" to give him an answer of 40. Then, to complete the remaining calculation of 8 + 8, he "took two away from one of the leftover eights, made it a 10" to give him a total of 50. Finally, he "had six left over," which he added to the 50, providing a final answer of 56. She noted that he preferred numbers that "end in a 0." These recurring approaches became recognizable patterns that Emilie associated with how Liam approached mathematical activity. Emilie reflected on her son Liam, "I always think of his brain, like how the wheels must be turning." Emilie's reflections showed how listening to Liam's mathematical preferences became a way for her to continue learning about him.

Across these accounts, caregivers demonstrated an understanding of their children's mathematical preferences. For caregivers, learning more about their children's preferences was a way they came to know their children, similar to the way they would know what foods their child prefers.

Experiencing Differences Between Children in Relation to Mathematics

Caregivers experienced differences between children which shaped how they supported children's emotional relationships with mathematics. This subcategory is distinct from the previous categories because it focuses on caregivers identifying and responding to the differences between their children as a way of learning about them. Statements within this subcategory focused on differences in children's speed, confidence, pacing, and comfort with mathematics. Caregivers described becoming increasingly aware of differences between children in how they approached mathematics and how these differences shaped the ways caregivers posed questions, responded to children, and created space for participation. Recognizing

differences between children became an insight into how caregivers could support children's emotional experiences with mathematics and adjust mathematical interactions in response to children's individual needs.

For instance, Emilie experienced differences between Liam and Sylvie in ways that shaped how she engaged mathematically with each child. She described Liam as "quick" when solving mental math problems and associated his speed with his comfort and confidence with numbers. Recalling a time when she asked her children to estimate the total number of chip bags in four boxes of 54 bags, Emilie noted that "10 seconds max and Liam came back with the answer." Emilie experienced Liam's speed as one of the differences between her children while doing mathematics together.

In contrast, Emilie experienced Sylvie as needing more time to work through mathematical problems. Reflecting on the same discussion, Emilie explained that Sylvie "had a tough time adding [four groups of 54]" and needed additional time to think. Emilie attributed this to Sylvie's developing fluency with "multiplication facts" and described her as less confident with mathematics than Liam. Differences between Liam and Sylvie shaped how Emilie interacted mathematically with each child. Emilie explained that she made "an effort [to] not [ask] them the same question," instead tailoring questions in ways that allowed each child to participate without feeling compared or pressured. Emilie emphasized that she did not want Sylvie to "feel rushed," particularly when it came to "not calculating as fast as him." These experiences show how differences between children shaped the ways Emilie adjusted mathematical interactions while doing mathematics together.

Across this subcategory, experiencing differences between children became a source of insight for how caregivers could support children's emotional experiences with mathematics. Caregivers were aware of differences in confidence, pacing, and comfort with mathematics. Caregivers used these understandings to shape how they engaged mathematically with children, including how they posed questions and created space for children to explore ideas at their own pace.

"Oh my god. That's me."

Caregivers experienced children's mathematical ideas as reflections of themselves. This subcategory is different from previous categories because it focused specifically on caregivers seeing themselves in their child. Statements within this subcategory focused on how caregivers recognized themselves in their children's mathematical ideas. This category shares similarities with other subcategories in that it discusses children's preferred strategies. However, this category focuses on the caregiver's experiences of recognizing themselves in their child's mathematics. Children's mathematical ideas resurfaced caregivers' own mathematical histories and created opportunities for caregivers to recognize aspects of themselves through mathematics. Variation within this subcategory related to the different ways caregivers experienced themselves through children's mathematical ideas. One example of caregivers seeing themselves in their children is through a shared preference. For example, Emilie described a connection she noticed with her son, Liam. She said, "He likes tens. I like tens." For Emilie, this was a way that she recognized herself in Liam's mathematics.

A more elaborate example of caregivers seeing themselves in their children's mathematics surfaced for Madison while she was listening to Connor explain his multiplication

strategy for 170 x 13. Connor decomposed 17 x 13 into 17 x 10 plus "three more seventeens." He calculated 17 x 10 to get 170, then used repeated addition to add three seventeens to get 51. Connor continued to find out how many were left "to get to 200" from 170, which was 30. Lastly, Connor subtracted 30 from 51 to get 21, and added 21 to his 200, for a final solution of 221. Madison reflected, "I remember doing math that way when I was a kid." She described this strategy as "how many can I take away from the little [number] to get to a... big number?" Madison laughed and explained, "He just did it. And I was like, oh my god. That's me." She smiled and said, "Me and my son learn the same way." These comments illustrate how children's mathematical ideas became opportunities for caregivers to recognize aspects of themselves in the mathematics. Madison's own memories and experiences were resurfaced through Connor's multiplication strategies.

The comments in this subcategory describe the ways caregivers experienced children's mathematical strategies as reflections of themselves. Across these accounts, children's strategies resurfaced caregivers' own mathematical histories and ways of doing mathematics. For caregivers, this was a way to connect with their children through mathematics.

Re-experiencing Mathematics Emotionally Through Children's Ideas

This subcategory focuses on how caregivers re-experienced mathematics through the emotions that came up while doing mathematics with their children. This is distinct from previous subcategories because it focuses on the emotions caregivers felt while doing mathematics with their child rather than learning about their children. Statements within this subcategory focused on caregivers' descriptions of emotional experiences connected to children's mathematics. These emotions reflected new ways of experiencing mathematics for

caregivers. Some caregivers re-experienced mathematics as stressful when they felt responsible for explaining mathematical ideas to children. Other caregivers re-experienced mathematics as enjoyable and emotionally rewarding through listening to children's ideas and discussing mathematics together.

Some caregivers re-experienced mathematics as stressful when they felt responsible for explaining mathematical ideas to children. Madison explained that mathematics "stressed [her] out." She elaborated that when she does mathematics with Connor, she "get[s] it in [her] head," but feels "a bit stressed" when she needs to explain it to him. These comments show how responsibility for explaining mathematics became connected to stress while doing mathematics with children.

Other caregivers re-experienced mathematics as enjoyable and emotionally rewarding through listening to children's ideas. Madison expected to explain the relationship between height and volume to Connor but was "surprised" when Connor already understood this relationship. Barbara encouraged Madison to shift her focus from explaining the mathematics to listening to Connor's ideas. Through listening to Connor's ideas, Madison began to experience mathematics differently. She re-experienced mathematics as "pretty cool" and was "impressed" with the way Connor thought about volume. Barbara also described doing mathematics with Connor as "great" and explained, "I love seeing him think." For Barbara, enjoyment emerged through listening to Connor's ideas and watching him try to "figure things out."

More involved re-experiences of mathematics included the emotional state of closeness. For instance, while reflecting, Barbara explained, "I think the whole thing was a really good experience for us because…we got to talk, Madison and I, about how to best help him with

[mathematics], which normally I'm not a part of." For Barbara, conversations about Connor's mathematics created feelings of closeness and connection with Madison. Through these interactions, mathematics became connected to enjoyment, shared family experiences, and feelings of closeness with both her grandson and daughter.

Across these accounts, caregivers re-experienced mathematics emotionally through children's ideas. Mathematics was re-experienced through feelings of stress, surprise, enjoyment, and closeness that emerged while listening to children's ideas and discussing children's mathematics with family members.

Across the category of Adults Gaining Insight from their Children's Mathematics, caregivers learned about children through listening to their mathematical ideas. Children's predictions, persistence, preferences, and differences became sources of insight to learn more about their children. Caregivers also gained insights into themselves by seeing themselves in their child's mathematical ideas. Lastly, caregivers experienced mathematics as an opportunity to re-experience it through the emotions that came up while doing mathematics with their children. These experiences show how children's ideas became a source of insight for caregivers.

Category 3: Experiencing Competence Through Family Interactions

This category focuses on how caregivers experienced mathematical competence through family interactions. Even though statements in this category may be connected to emotions or computations like previous categories, this category is distinct from the previous categories because it focuses on how competence itself was experienced within family relationships. Caregivers experienced mathematical competence as relational rather than fixed. This category comprises four subcategories. Caregivers experienced math in their home setting as competence

through: i) intergenerational experiences, ii) tensions between external recognition and self-perception, iii) negotiating responsibility for mathematics, and iv) imagined external judgments.

Experiencing Competence Through Intergenerational Experiences

Caregivers experienced mathematical competence through intergenerational experiences with their family. This included how families identified what counted as being good at mathematics. While all the subcategories focus on experiences of mathematical competence, this subcategory is distinct because the focus is on how intergenerational family experiences influenced what caregivers understood as mathematical competence. Statements within this subcategory focused on the kinds of mathematical behaviours and skills caregivers came to associate with competence through interactions with their families. Variation within this subcategory related to the different ways mathematical competence was recognized within family interactions. Some caregivers experienced competence through the ability to answer mathematical questions quickly and correctly. Other caregivers experienced mathematical competence as being able to explain mathematics.

Some caregivers experienced mathematical competence through the ability to explain mathematical ideas clearly enough for others to understand. For example, Madison explained, “I find that I’m not very good at explaining certain things” and “I don’t know what words to use.” Madison remembered her mother as her “translator…especially for math” during moments when she struggled mathematically. Madison described these interactions as comforting and supportive while learning mathematics. Through these intergenerational experiences, mathematical competence, for Madison, was conceptualized as the ability to explain the mathematics through words. This understanding resurfaced while Madison was doing mathematics with Connor.

When Connor struggled to follow her explanation, Madison looked to Barbara to "explain it in a better way" because she "knew what words to use." Madison also described how "it was nice that my mom was able to kinda step in" during the interaction. These comments show how explanation became an important feature of how caregivers experienced competence through intergenerational family interactions.

Some caregivers experienced mathematical competence through speed and fluency during family mathematical interactions with other generations. For example, Emilie described mathematics feeling easy when she was young because her parents "didn't put any stress or pressure on it." When she was older, Emilie recalled family math drills led by an uncle she and her cousins "adored." She explained that she "really despised these times" because of the pressure they carried. She also described her father becoming "easily frustrated" if she or her siblings did not answer mathematical questions quickly enough. These comments show how speed and fluency became important features of how caregivers experienced competence through intergenerational family interactions.

These comments show how caregivers experienced mathematical competence through intergenerational family interactions. Mathematical competence became connected to explanation, speed, fluency, and helping others understand mathematical ideas during intergenerational family interactions. These understandings remained connected to how caregivers later experienced competence while doing mathematics with children.

Experiencing Competence Through Tensions Between External Recognition and Self-perception

Caregivers experienced mathematical competence through conflicts between external recognition and how they perceived themselves mathematically. This subcategory is a distinct way of experiencing mathematical competence because it focuses on how recognition of mathematical competence outside the home was interpreted within the family. Statements within this subcategory focused on how caregivers described themselves in relation to mathematics and experiences that identified them as competent. External recognition did not always align with how caregivers experienced their own mathematical competence. Some caregivers experienced tension between academic achievement and how they perceived themselves mathematically. Other caregivers experienced tension between teacher recognition and their family's perceptions of their mathematical competence.

Statements in this category pointed to the tension between academic achievement and how caregivers perceived themselves mathematically. For example, Barbara commented on Madison's view of herself, saying, "She won the Grade 11 math award. She should have more confidence than she does." Madison confirmed her mom's statement when she described herself as "not a math wiz." When asked about how she sees herself as a doer of mathematics, she responded, "Doer of the mathematics? I don't know." Madison also confirms her mother's statements about high school by saying she was "good at math in high school"; she immediately followed it up with "but nowhere near my mom." Despite identifying herself as successful in mathematics, Madison did not necessarily experience herself as mathematically competent.

These comments show how external recognition did not necessarily change how caregivers experienced their mathematical competence.

There were even more elaborated statements in this category that were rooted in longstanding family understandings of mathematical ability. For example, Emilie described her Grade 9 teacher recommending her for the International Baccalaureate (IB) program, an experience she remembered as "eye-opening." Reflecting on the recommendation, Emilie explained, "I didn't think I was performing at that level." Despite receiving recognition from her teacher, Emilie continued to experience herself as "kind of average" in mathematics. Emilie also described both herself and her family as being "kind of shocked" by the recommendation. Teacher recognition did not necessarily change how Emilie experienced her own mathematical competence or how her family perceived her as mathematically competent. Emilie later explained that "in grade 11, I failed high school math, and I never took it again." These experiences show how teacher recognition remained in tension with longstanding family understandings about mathematical competence.

Across these accounts, caregivers experienced mathematical competence through tensions between external recognition and self-perception. Academic achievement, teacher recognition, and recognition from schools did not necessarily align with how caregivers experienced their own mathematical competence. Instead, external recognition remained in tension with longstanding understandings about mathematical competence that had developed through family experiences and previous encounters with mathematics.

Experiencing Competence Through Who Does Mathematics with Children

Caregivers experienced mathematical competence through which caregivers were/would be doing mathematics with children. Within families, helping children with mathematics was often associated with being mathematically competent. This subcategory is a distinct way of experiencing mathematical competence because it focuses on two components: i) competence and ii) who is or will be doing math with children. It differs from competence through intergenerational experiences, even when comments include multiple generations, because the focus is on who is doing or will be doing mathematics with children. This category does not focus on how intergenerational family experiences influenced what caregivers understood as mathematical competence. Statements within this subcategory focused on how family members negotiated responsibility for helping with mathematics, leading mathematical interactions, and supporting mathematics homework.

Some statements simply discussed competence through supporting children in specific mathematical content they felt familiar and comfortable helping with. For instance, Emilie described feeling "confident in the math" while teaching and supporting primary-level mathematics. At the same time, she explained, "So if my kids were older, I don't know if I'd be as confident and as secure in [mathematics]." Emilie did not experience herself as globally competent or incompetent in mathematics. Instead, competence became connected to familiarity with specific Grade levels, concepts, and mathematical content. These experiences show how mathematical competence was experienced in relation to the kinds of mathematical support caregivers felt responsible and comfortable providing within family interactions.

Other more complex statements in this subcategory involved competence and who does mathematics with children involved shifting who was/would be/could be responsible for doing

math with children. Caregivers also experienced mathematical competence through negotiating responsibility for mathematical interactions within family relationships. Barbara described wanting Madison to feel more competent by becoming "comfortable… in getting in the habit of doing [math] with [Connor]." Barbara explained that Madison often "automatically just passes [math homework] on to me," suggesting that responsibility for mathematics had become assigned to the person in the home who describes mathematics as "the subject I love." She supported Madison in developing a perception of herself as mathematically competent by encouraging her to take the lead during mathematical interactions. During the Popcorn Problem, Barbara described feeling the instinct to intervene and tell Madison to "Just let [Connor] think." However, she did not. She recalled thinking, "No. I can't step in and tell her how to parent." Barbara experienced negotiating responsibility for mathematics by trying to guide Madison to focus on listening to Connor while also leaving space to allow Madison to lead the interaction. She also reflected on tensions surrounding this responsibility, explaining, "when you're a mother-daughter dynamic, and she's looking at me like, mom, stop micromanaging me." These comments demonstrate how competence was negotiated through Barbara's efforts to support Madison's growth of perceived competence by feeling comfortable doing mathematics with Connor.

Across these accounts, caregivers experienced mathematical competence through who did mathematics with children. Mathematical competence became connected to familiarity with mathematical content and negotiating responsibility for mathematical interactions. These experiences show how caregivers experienced mathematical competence through supporting

others mathematically and deciding when to lead, step in, or step back during family mathematical interactions.

Experiencing Competence Through Imagined External Judgments

This category focuses on the different ways caregivers experienced competence through concerns about external judgments of children's mathematical ideas. Unlike the previous subcategories, this category focuses on how caregivers imagined their children's mathematical ideas would be evaluated by others outside the home as a judgment of competence. Specifically, caregivers' concerns focused on whether children's mathematical ideas and strategies would be recognized as legitimate mathematics by others outside of the home. Other caregivers experienced competence through concerns about whether children's lived experiences and interests would be recognized as acceptable contexts for school mathematics.

One way that caregivers experienced competence through imagined external judgments involved concerns about whether children's strategies would be recognized as legitimate mathematics by others. While doing mathematics with her son, Madison explained that Connor was "figuring it out beautifully on his own." Madison also described herself as "following along" and understanding Connor's strategy "perfectly." However, Madison worried about how others might view Connor as competent by interpreting Connor's use of repeated addition when solving a multiplication question. Reflecting on the interaction, Madison explained, "I was like, this sounds so confusing to anybody else," emphasizing that "there's a lot of steps" in his strategy. Although Madison understood Connor's ideas, she felt pressure to redirect him toward "a faster way" by stacking the numbers vertically and using the North American Standard Algorithm for

multiplication. These comments show how Madison experienced competence through concerns about whether Connor's strategy would be understood by others beyond their home.

Caregivers also experienced competence through concerns about whether children's lived experiences and interests would be recognized as acceptable contexts for school mathematics. Emilie described a Grade 3 activity where Sylvie created a mathematics problem involving Pokémon cards, reflecting experiences from everyday family life. Emilie emphasized that Sylvie solved the problem correctly and communicated her ideas clearly. However, Sylvie's teacher responded, "Great job on solving this, but can you think of something more realistic?" Emilie experienced this response as disheartening because Sylvie's lived experiences were treated as unrealistic within school mathematics. Reflecting on the interaction, Emilie explained that "[Sylvie] used something that she was passionate about at that time in her life." These comments show how Emilie experienced competence through concerns about whether children's lived experiences and interests would be recognized as legitimate mathematics within school contexts.

Across these accounts, caregivers experienced tension between recognizing children's ideas as mathematical and imagining how those ideas would be evaluated by others. These experiences show how caregivers experienced mathematical competence through imagined external judgments about whether children's mathematical ideas would be recognized as legitimate mathematics within family and school interactions.

Across the category of *Experiencing Competence Through Family Interactions*, caregivers' accounts showed the varied ways they experienced mathematical competence within their families. Mathematical competence became connected to family experiences, relationships, responsibilities, and judgments surrounding mathematics. Caregivers experienced competence

through family experiences, external recognition, shared responsibility for mathematics, and concerns about how mathematical ideas would be judged by others. Across these variations, competence did not emerge as a fixed characteristic that caregivers simply possessed or lacked. Instead, caregivers experienced mathematical competence as relational, developing through interactions with others within family life.

This chapter presented the different ways adult caregivers experienced mathematics within family life. Caregivers experienced children's mathematical ideas as a source of insight into children's ideas, preferences, and emotional relationships with mathematics. Caregivers also re-experienced their own mathematical histories, emotions, and identities through mathematical interactions with children. Finally, caregivers experienced mathematical competence through family relationships, comparisons, support roles, and concerns about what counted as legitimate mathematics.

Chapter 5: Discussion

Chapter 5 discusses the findings in relation to the research questions, conceptual framework, and existing literature. This study explored: (1) how adult caregivers experience mathematics in their home setting; (2) how caregivers' experiences of doing mathematics with their children influence their relationships with mathematics; and (3) how caregivers experience relationships between home and school mathematics. My findings add to existing conversations about parental involvement in mathematics by considering: 1) Caregivers Re-Experiencing Mathematics Through Their Children; 2) Structuring Parent-Child Discussions: Re-Visioning Homework; 3) Intergenerational Support for Caregivers; and 4) Learning from Teacher-Caregivers: Homework as a Bridge Between Home and School. My findings also point to concrete strategies educators may use to support more positive mathematical relationships within families, which are included here.

Across the three categories of description, Funds of Identity and Mathematical Identities served different analytic functions. In the first category, caregivers drew on identity resources while emphasizing the mathematics existing within daily family life. For example, professional identity resources influenced what mathematics caregivers paid attention to while engaging with their children and the types of discussions they initiated. In the second category, caregivers discovered identity resources through mathematical interactions with their children. Shared mathematical preferences and strategies allowed caregivers to recognize aspects of themselves in their children and created opportunities to imagine themselves as mathematically capable. In the third category, caregivers' mathematical identities were constructed and reconstructed through relational experiences of perceived competence. Responsibility for doing mathematics with

children, recognition from others, and anticipated judgements about mathematical legitimacy influenced how caregivers saw themselves and others as mathematically competent. Across the three categories, identities and identity resources influenced what caregivers paid attention to, how they interpreted mathematical interactions, and how they saw themselves or others in relation to mathematical competence.

Caregivers Re-Experiencing Mathematics Through Their Children

My findings extend the literature on mathematical attitudes by specifically considering caregivers. In particular, caregivers doing mathematics with their own children may create unique (and not previously discussed in the existing literature) opportunities for caregivers to develop more positive relationships with mathematics. Di Martino and Zan (2010) describe mathematical attitudes as consisting of three interconnected dimensions: perceived competence, vision of mathematics, and emotional disposition. Caregivers described mathematical interactions that attended to these dimensions and thus can support them in growing positive relationships with mathematics themselves. This should be of great importance because existing literature often discusses how caregivers may pass negative mathematical attitudes onto children during homework interactions (Maloney et al., 2015). This means that mathematical interactions at home have the potential to shape caregivers' relationships with mathematics, which can in turn influence children's relationships with mathematics.

Caregivers sometimes re-experienced perceptions of mathematical competence through seeing connections with themselves and their child, whom they view as highly competent. These interactions created opportunities for caregivers to experience mathematical competence vicariously through their children. For example, Madison described observing Connor use a

multiplication strategy that reminded her of strategies she had used as a child. Recognizing this similarity created an opportunity for Madison to draw on identity resources connected to her own childhood experiences of mathematics. In doing so, she saw aspects of herself reflected in his mathematical strategies, which created an opportunity to reconsider her own mathematical identity. My findings suggest that the relationship between caregivers' and children's attitudes toward mathematics may be bidirectional. Previous research has shown that parents influence children's attitudes toward mathematics. In my study, caregivers also described ways their children's mathematical activity influenced how they understood their own relationship with mathematics.

Another way caregivers can re-experience visions of mathematics is by experiencing stronger connections between home and school when both approach mathematics as problem solving and sense making. Recall that Di Martino and Zan (2010) describe a vision of mathematics as beliefs about what mathematics is and what it means to do mathematics. For example, in this dissertation, Emilie experienced this connection when a “Math Talk” handout came home from school. The handout communicated that the teacher valued discussion and strategy sharing (i.e., the teacher’s vision of mathematics). Emilie drew on identity resources connected to both her teaching and parenting experiences to value these same ideas in her interactions with her children. My findings suggest that teachers can communicate a conceptual vision of mathematics before families begin working on homework. Small changes to framing homework may support stronger connections between home and school and a positive attitude toward mathematics. Teachers might include short preambles that explain the purpose of the task. These preambles might encourage families to focus on prediction, discussion, strategy

sharing, and listening to one another's ideas rather than speed and correct answers. This would be a way to promote a vision of mathematics that is associated with favourable attitudes towards mathematics. For example, a teacher might write their preferred vision of math to be supported at home: "We are interested in hearing different strategies and discussing your ideas together." These prompts support mathematical discussions focused on sense-making and associate math with communication. See Appendix A for examples of prompts that can be sent home for families.

Caregivers can re-experience mathematics as an enjoyable experience, which can influence the emotional disposition dimension of mathematics attitudes. Caregivers in my dissertation described positive emotional experiences while doing mathematics with their children. Notably, this extends to caregivers who have previously had negative relationships with mathematics or do not see themselves as doers of mathematics. For example, Madison, who was hesitant to describe herself as a doer of mathematics, expressed joy while discussing Connor's work on the Popcorn Problem. Therefore, my findings suggest that discussion-based mathematical tasks can create opportunities for caregivers to experience positive emotions while doing mathematics with their children. This is particularly significant because previous research (e.g., Di Martino & Zan, 2010) has identified emotional disposition as an important dimension of attitudes toward mathematics. When parents experience positive emotions while engaging in mathematics with their children, they may begin to re-experience mathematics in the home in more meaningful and enjoyable ways, potentially fostering more positive attitudes in caregivers toward mathematics over time. These findings suggest that doing mathematics with children may

create opportunities for caregivers to renegotiate their mathematical identities through positive emotional experiences.

Structuring Parent-Child Discussions: Re-Visioning Homework

My findings extend the existing literature on parent-child discussion in education by suggesting conditions for homework that encourage families to have meaningful discussions about mathematics. This has the potential to build stronger relationships between families and educators by positioning homework as a space where school mathematics and families' mathematical experiences can come into conversation. Three conditions for provoking positive emotions emerged in the data: a) drawing on caregivers' interests and experiences at work; b) tasks involving experimentation and prediction; c) identifying mathematics in children's everyday experiences. Research on parental involvement consistently identifies parent-child discussion as one of the most influential forms of parental involvement connected to student achievement (McNeal, 2014). This literature also suggests that these discussions should be positive experiences (Silinskas & Kikas, 2019; Maloney et al., 2015). However, there is little direction in the literature regarding the conditions that provoke positive emotions like excitement and enjoyment during these discussions. My findings offer some insight into the conditions that provoke positive emotions during mathematical discussions within families.

One condition associated with excitement in my findings was discussions connected to caregivers' interests and experiences at work. For example, discussions surrounding profit allowed Alfie to draw on knowledge connected to his work and everyday life. His children remained engaged with the idea and returned to it later that week during a family dinner at a restaurant. The children demonstrated curiosity about the topic as they asked questions about

how much profit the restaurant would make and speculated about the operating costs. Emilie described positive feelings around Alfie sharing his work life with his children and seeing them engage in these conversations with their father. These discussions emerged from experiences that already mattered to Alfie. My findings suggest that caregivers can draw on identity resources connected to work and everyday experiences to provoke exciting mathematical discussion. Teachers might also create interview-style homework prompts where children ask caregivers questions such as, "Where do you use mathematics in your work?" or "Where do you see the mathematics we learn in school in your daily life?" These kinds of tasks create opportunities for mathematical discussions that connect school mathematics to the experiences and interests of caregivers. Structuring discussions in this way also legitimizes caregivers' mathematical experiences within schooling, and this may contribute to stronger connections between home and school.

A second condition associated with excitement and enjoyment in my data was tasks that encouraged prediction and experimentation. When Madison, Barbara, and Connor worked on the Popcorn Problem together, the focus was on making predictions about which size box would hold the most popcorn. Both caregivers participated with Connor in what they called a "math experiment." Madison noted that it was an enjoyable experience for the family because they were able to share predictions and test out ideas together. Tasks that encouraged prediction and experimentation shifted the focus of homework toward exploring ideas collaboratively. In these interactions, mathematics is experienced as prediction, discussion, and shared sense-making. Teachers can explicitly communicate this vision of mathematics when sending tasks that promote collaboration and experimentation home to families. In doing so, homework becomes a

way of communicating what mathematics children are doing at school with caregivers and what teachers value beyond fast, correct answers. Viewed in this way, homework as a communication tool serves as fertile ground to build "mutually-specifying relationships" (Ippolito, 2010) between caregivers and educators. Homework may then be understood as a middle space where school mathematics and families' mathematical experiences are brought into conversation, allowing caregivers' identity resources to be recognized as important contributions. Recognizing caregivers' identity resources in this way may strengthen relationships between home and school.

A third condition associated with enjoyment was mathematical discussions that emerged from children's everyday activity. Caregivers who were teachers demonstrated an awareness of how to identify mathematical ideas within their children's everyday lives and use these moments to spark discussion. For example, Barbara used a box of Goldfish crackers to prompt a conversation about division with Connor while on a long car trip. She asked him how many crackers were left in the box and how they could be shared among the people in the car. This prompted a discussion about fair sharing and who in the family might want a few extra crackers. Barbara explained how much she enjoyed listening to his ideas in these interactions. Barbara knew to prompt these discussions because teachers are often encouraged to build on mathematical ideas that emerge in children's everyday situations. For caregivers in this study with a teaching background, this was an identity resource they drew upon in their home lives. Homework that invites caregivers to identify mathematics in children's everyday lives creates opportunities for families to contribute their own mathematical experiences to school mathematics. Teachers can translate this into homework by sending tasks that encourage

caregivers to identify moments in children's lives where they are being mathematical. Children and caregivers could generate two questions connected to the mathematical moment they identified and choose one question to discuss together as a family. These kinds of tasks create opportunities for mathematical discussions that connect school mathematics to the experiences of children's everyday lives.

My study is unique because it focuses on how caregivers feel when doing mathematics. These findings are particularly important because they identify ways of leveraging parent-child discussions to build more positive relationships with mathematics. Existing literature (e.g., Retanal et al., 2021; Silinskas & Kikas, 2019; Soni & Kumari, 2015; Maloney et al., 2015) often focuses on the role parents play in children's negative relationships with mathematics, but there is far less discussion about how caregivers themselves might develop more positive relationships with mathematics. In contrast, my study shows how parent-child discussions can support more positive caregiver relationships with mathematics. These findings also suggest that homework can function as a bridge between home and school when it invites caregivers to draw on their identity resources, including professional experiences, everyday experiences, and personal interests, as important contributions to school mathematics.

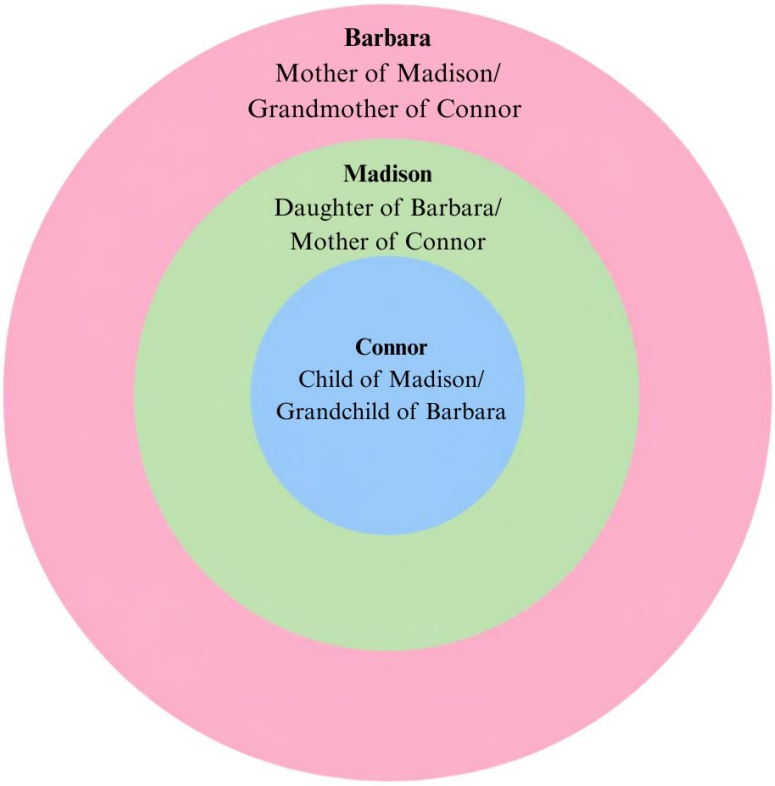
Intergenerational Relationships with Mathematics

My findings extend the existing literature on parental involvement in mathematics by showing that intergenerational family relationships may serve as mathematical resources to support caregivers in building positive relationships with mathematics. In my study, intergenerational relationships demonstrated how caregivers who are highly competent in mathematics can create opportunities for other adults to do mathematics with children. Existing

literature on parental involvement has largely focused on interactions between caregivers and children (Maloney et al., 2015; Olivares, 2012; Vanbinst et al., 2020). However, there is little focus on how caregivers experience mathematics with each other. My findings suggest that interactions among caregivers may also play an important role in shaping family mathematics experiences. Specifically, my findings suggest that intergenerational family relationships may create opportunities for caregivers to support one another's relationships with mathematics, which may in turn support children's mathematical experiences. The identities caregivers held within these intergenerational relationships, such as mothers, also served as identity resources caregivers drew upon as they did mathematics with children. Figure 5.1 represents the way support worked within Barbara, Madison, and Connor.

Figure 5.1

Nested Nature of Intergenerational Mathematical Support Within Barbara, Madison, and Connor's Family



Note: The figure illustrates how support was nested across generations, with Barbara's support enabling Madison's participation, which in turn supported Connor's mathematical experiences.

Madison explained that she felt more comfortable participating in mathematical interactions when her mother was present because Barbara knew how to explain mathematical ideas in ways Connor would understand. Barbara's presence reduced the pressure on Madison to immediately know how to respond to Connor's ideas or explain the mathematics clearly herself. While doing mathematics with Madison and Connor, Barbara's focus was on Madison learning to be "comfortable and confident" doing mathematics with Connor. She encouraged Madison to listen to Connor's ideas instead of expecting to explain procedures to him. In these moments, Barbara drew simultaneously on her identities as Connor's grandmother, Madison's mother, and an experienced teacher. These identity resources enabled her to support Madison by encouraging

her to participate in mathematical interactions where she did not feel fully confident on her own while remaining close enough to provide support if needed. Barbara explained that she drew on her experiences as a teacher to explain to Madison that Connor needed to "think and struggle," because "that's where the learning happens." She highlighted to Madison that mistakes are "part of [Connor]'s learning experience." Madison drew on her identity resources as Barbara's daughter and as Connor's mother, allowing her to simultaneously receive support from Barbara and provide support to Connor. She identified that having her mother nearby was a comfort because she knew that if she could not explain something to Connor, her mother could jump in to help. These findings suggest that parental support in mathematics may extend beyond childhood and continue to influence their mathematical experiences as caregivers. Intergenerational mathematical support may remain available throughout adulthood and become a resource that caregivers draw upon when supporting their own children.

My findings suggest that mathematically confident caregivers can support another adult's participation in mathematics by creating opportunities for that caregiver to take the lead during mathematical interactions with children. Mathematically confident caregivers can remain present while encouraging the other caregiver to ask questions, listen to children's ideas, and make sense of children's strategies. Barbara demonstrated this approach by encouraging Madison to focus on Connor's ideas rather than feeling responsible for explaining procedures or providing correct answers. This approach reduces pressure on less confident caregivers and positions mathematical interactions as opportunities to listen, wonder, and learn alongside children. Caregivers do not need to know the mathematics in advance to participate meaningfully. Instead, participation can begin with curiosity about children's ideas and a willingness to explore those ideas together. This

calls for further study of how caregivers' relationships with one another influence family mathematics experiences. Existing research has primarily focused on caregiver-child interactions, yet my findings suggest that relationships among caregivers may also play an important role in shaping participation in family mathematics. These intergenerational relationships can become identity resources that influence how caregivers experience doing mathematics with children.

Using Homework as a Connection Between Home and School

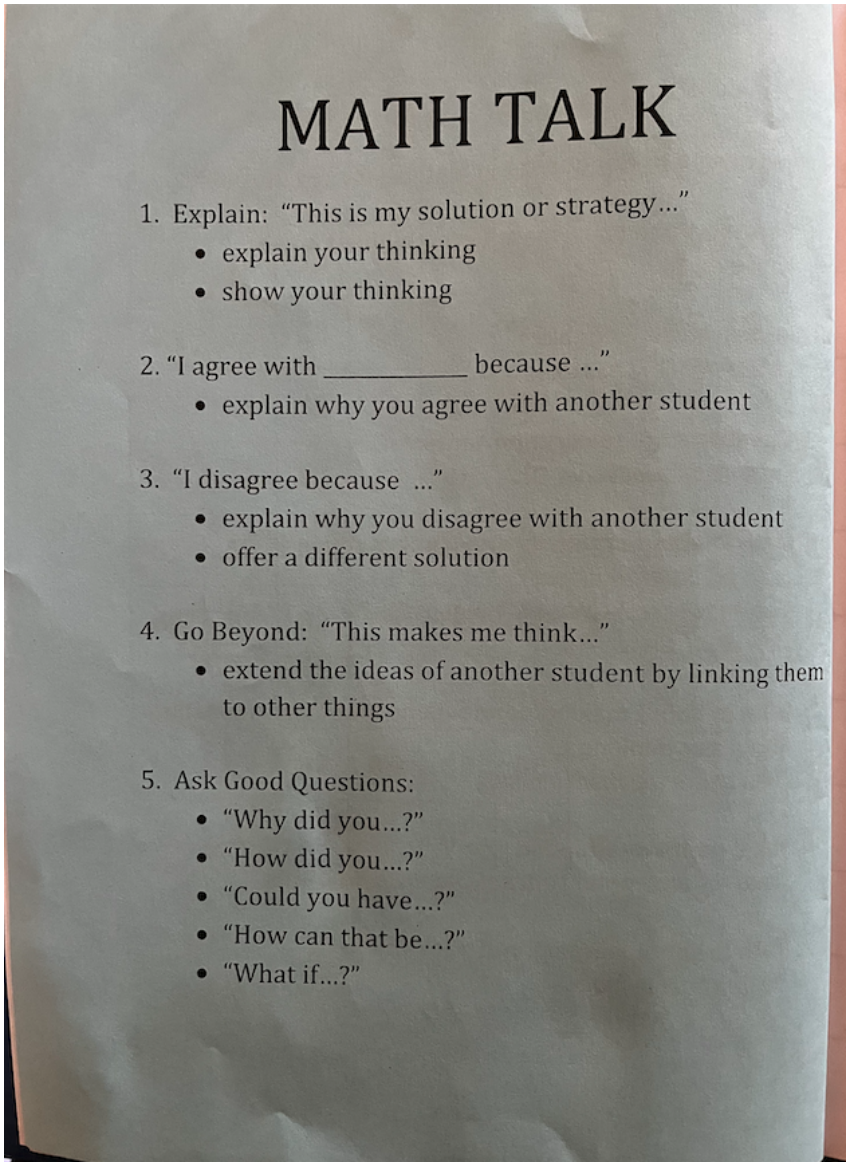
My findings extend the existing discussion around homework in mathematics education by showing how homework may be used to build relationships between families and schools. Teacher-caregivers in my study were particularly sensitive to how homework communicated their vision of mathematics and validated family mathematical identity resources. Teacher-caregivers drew upon professional identity resources developed through their work in schools to interpret what came home from school differently. They also drew on their identity resources as a parent to identify tensions when homework dismissed or misunderstood family experiences. Equally, teacher-caregivers described excitement when homework reflected a vision of mathematics that aligned with their views. Existing literature often presents homework as either a source of family tension (Gonida & Cortina, 2014; Matthes & Stoeger, 2018) or a way of connecting families to classroom learning (Epstein & Van Voorhis, 2001). However, there are few concrete suggestions for teachers on how to build relationships with families through homework. My findings offer insight into how teachers could use homework to build these relationships.

Teacher-caregivers in my study experienced tensions when teacher feedback on homework involving family identity resources dismissed their family's lived experiences. Emilie described feeling frustrated when a mathematical question Sylvie created around the family's practice of collecting Pokémon cards was dismissed by the classroom teacher as unrealistic. For Emilie, the question represented an authentic mathematical interaction grounded in Sylvie's everyday experiences and the family's shared interests. Emilie recognized the tension between the teacher attempting to connect mathematics to children's interests while simultaneously failing to understand "Sylvie's world." Emilie's interpretation of the interaction was informed by her experiences as a caregiver, her professional knowledge of teaching mathematics, and her own educational history. These identity resources heightened her awareness of how teacher feedback can recognize or dismiss the mathematical legitimacy of children's family experiences. An important observation Emilie made was that the teacher's feedback focused on whether the scenario was realistic rather than whether the mathematics was accurate. My findings suggest that homework tension may also emerge when family experiences brought into mathematics are treated as illegitimate or unrealistic. Existing literature often characterizes homework tension through time pressures, compliance, or homework being misaligned to families (Howker & Black, 2025; Epstein & Van Voorhis, 2001; Maloney et al., 2015). My findings suggest another source of tension: teacher feedback that evaluates the legitimacy of family experiences brought into mathematics. These findings highlight the importance of shifting homework feedback away from evaluating whether family experiences are realistic and toward discussing the mathematical ideas within those experiences.

Teacher-caregivers in my study also identified moments when school mathematics created meaningful connections between families and classroom learning. Emilie described feeling excited when a "Math Talk" handout came home in her child's mathematics duotang. Drawing on identity resources connected to her experiences as a teacher, Emilie recognized the handout as reflecting a vision of mathematics centred on discussion, questioning, and children's ideas. Drawing on her professional identity resources, Emilie interpreted the Math Talk handout as communicating a vision of mathematics in a way that may not be visible to a caregiver without the same insider knowledge of teaching. For Emilie, the handout communicated that her child's teacher's values aligned with her own. The handout also reflected the ways mathematics was discussed within her own family interactions. See Figure 5.2 for the handout Liam brought home.

Figure 5.2

Math Talk Handout Brought Home by Liam



MATH TALK

1. Explain: "This is my solution or strategy..."
   - explain your thinking
   - show your thinking

2. "I agree with _____ because ..."
   - explain why you agree with another student

3. "I disagree because ..."
   - explain why you disagree with another student
   - offer a different solution

4. Go Beyond: "This makes me think..."
   - extend the ideas of another student by linking them to other things

5. Ask Good Questions:
   - "Why did you...?"
   - "How did you...?"
   - "Could you have...?"
   - "How can that be...?"
   - "What if...?"

Note: Emilie described this handout, which her son Liam brought home from school, as reflecting a vision of mathematics centred on discussion, explanation, questioning, and children's ideas. She recognized these practices as aligning with the ways mathematics was discussed within her family.

Rather than eliminating homework entirely, my findings suggest that homework may be used as a tool for building relationships between schools and families. Homework can

communicate a vision of mathematics centred on discussion, sense-making, and children's ideas while creating opportunities for caregivers to participate in mathematical conversations. Early in the school year, teachers might communicate that homework is intended to support discussion and exploration rather than the reproduction of procedures. As the year progresses, teachers can send home prompts that encourage families to identify mathematics in everyday experiences, discuss different strategies, and make connections between home and school mathematics. For example, families might discuss questions such as, “Can you find my idea in yours?” or “How are our strategies connected?” Structuring homework in this way creates opportunities for schools to recognize families’ mathematical experiences while also communicating that mathematics is about discussion, sense-making, and connections between ideas. These tasks draw on homework as a way of building relationships among children, caregivers, and teachers. See Appendix A for an example of a handout that teachers can send home to caregivers to promote mathematical discussion.

My study is significant because it shows how teacher-caregivers experience tensions between home and school mathematics from both professional and caregiving perspectives. Despite possessing pedagogical experiences and familiarity with school mathematics that may not be available to all caregivers, teacher-caregivers still described tensions navigating homework interactions between home and school mathematics. These findings raise important questions about how caregivers without familiarity with educational systems and school mathematics experience relationships between home and school mathematics. Caregivers who face linguistic, cultural, or institutional barriers when interacting with schools may experience additional tensions that were not captured in this study. Conversely, teacher-caregivers

experienced excitement when identifying a shared vision of mathematics in their child's mathematics homework. Teacher-caregivers in my study recognized that homework and school communication do more than send mathematical tasks home to families. They also communicate a vision of mathematics and shape the kinds of mathematical interactions that become possible within families. My findings suggest that aligning home and school mathematics is not sufficient on its own. Rather, schools and families may need to share a vision of mathematics centred on discussion, sense-making, and children's ideas to support more positive mathematical relationships. Future research should examine how caregivers from a broader range of educational, linguistic, and cultural backgrounds experience these interactions. Such work could also explore what kinds of support help families participate in mathematics in ways that feel meaningful rather than pressured. My study contributes to existing discussions about homework by shifting attention away from homework completion alone and toward the kinds of mathematical relationships and interactions homework creates within families.

Implications for Mathematics Education and Directions for Future Research

My study opens up several important lines of inquiry related to caregivers' relationships with mathematics and their experiences of doing mathematics with their children. Much existing research examines how caregivers' negative relationships with mathematics influence children's mathematical experiences and outcomes (Gonida & Cortina, 2014; Silinskas & Kikas, 2019; Maloney et al., 2015). Less attention has been given to how caregivers' own relationships with mathematics might shift through mathematical interactions with children.

My findings suggest three major implications for mathematics education related to caregivers' experiences of doing mathematics with children. First, Supporting Caregivers' Relationships with Mathematics highlights the importance of attending to caregivers' own relationships with mathematics and recognizing that these relationships continue to develop through interactions with children and family members. Second, Supporting Relationships Through Mathematical Discussion emphasizes the role of mathematical discussion in fostering connection, shared sense-making, and opportunities for caregivers and children to learn from one another. Third, Fostering Conditions for Home-School Relationships highlights the importance of creating opportunities for meaningful dialogue and collaboration between caregivers and educators. Together, these implications position caregivers' mathematical experiences and relationships with mathematics as important considerations within mathematics education.

Supporting Caregivers' Relationships with Mathematics

My findings suggest that caregivers' relationships with mathematics warrant greater attention within mathematics education. Caregivers in my study described experiences connected to perceived competence, emotional disposition, and visions of mathematics, which Di Martino

and Zan (2010) identify as dimensions of mathematical attitudes. These experiences were shaped through interactions with children and family members. Existing research often focuses on how caregivers' relationships with mathematics influence children (Silinskas & Kikas, 2019; Maloney et al., 2015). My findings suggest that caregivers' relationships with mathematics also matter in their own right. Therefore, it is not enough to simply tell caregivers that their relationships with mathematics impact their children. Instead, caregivers may need strategies to improve their relationships with mathematics. My study sheds light on how doing mathematics with children may improve caregivers' relationships with mathematics.

Di Martino & Zan (2010) explain that visions of mathematics that focus on sense-making and problem solving promote positive attitudes towards mathematics. Caregivers in my study experienced an expanded vision of mathematics when mathematical interactions moved beyond narrow school-based ideas of mathematics as worksheets completed at the dinner table. Expanded ways of being mathematical were also described when participation in mathematics extended beyond producing fast, correct answers. Future research could build on these findings by examining how family mathematical interactions could influence caregivers' mathematical attitudes over time.

Mathematics education may therefore benefit from considering how caregivers experience mathematics, not solely as supporters of children's learning, but as individuals whose own relationships with mathematics continue to develop. Creating opportunities for caregivers to experience mathematics through discussion, curiosity, exploration, and shared sense-making may support more positive mathematical experiences within families. Further study on caregivers' relationship to mathematics is needed beyond its relationship to their children and school.

Supporting Relationships Through Mathematical Discussion

My findings suggest that mathematical discussion can support relationships among caregivers, children, and educators. Across my study, caregivers described positive mathematical experiences when interactions focused on listening to children's ideas, making predictions, testing possibilities, comparing strategies, and making sense of mathematics together. These interactions created opportunities for caregivers to learn about children, children to share their thinking, and family members to engage with mathematics collaboratively.

These findings align with research suggesting that parent-child discussion is an influential form of parental involvement (McNeal, 2014). My findings extend this work by illustrating what these discussions can look like in the context of mathematics. Caregivers described learning about children's thinking, sharing mathematical ideas, and engaging in collaborative sense-making through discussion. These interactions supported both mathematical engagement and relationship building within families.

One way schools might support these kinds of interactions is through discussion-oriented homework. Existing literature often identifies homework as a source of tension within families, particularly when caregivers feel pressure to teach procedures in specific ways (Gonida & Cortina, 2014; Matthes & Stoeger, 2018). In contrast, caregivers in my study described more positive experiences when mathematical interactions focused on discussion and curiosity. Teachers might therefore include prompts that encourage caregivers and children to compare strategies, explain their ideas, make predictions, or identify mathematics within everyday experiences. Prompts such as “Can you find my idea in yours?” or “Where do you use fractions

in your home?" may create opportunities for meaningful mathematical conversations while also communicating a vision of mathematics centred on discussion and sense-making.

My findings suggest that mathematical discussion can be a way of strengthening relationships through mathematics. Mathematical tasks that promote discussion may also play an important role in developing caregivers' positive relationships with mathematics. In my study, caregivers described more positive mathematical experiences when mathematical activity involved parent-child discussion. These interactions differed from mathematical experiences centred primarily on completing tasks correctly rather than discussing ideas together. Future studies could therefore examine how homework tasks might encourage parent-child discussion, draw on caregivers' interests and experiences, or support collaborative problem solving. Future research could examine whether the conditions that supported positive mathematical discussions in this study are experienced similarly by families from different cultural, linguistic, and socioeconomic backgrounds.

Fostering Conditions for Home-School Relationships

Building non-hierarchical relationships between families and educators depends on conditions that extend beyond the work of individual teachers. These institutional conditions play an important role in sustaining connections between families, educators, and researchers. The findings of my study highlight the relational nature of doing mathematics. Family relationships, personal histories, and caregivers' self-perceptions influenced how caregivers participated in their children's mathematics.

Civil and Bernier (2006) show that caregivers' participation in mathematics supports children. Therefore, relationships between caregivers and educators also matter. Caregivers and

educators need opportunities to come to know each other beyond formal institutional roles. These opportunities may be particularly important for families whose experiences, languages, or cultural practices are not routinely recognized within school settings. Opportunities for conversation, shared experiences, and informal interactions can allow educators and families to learn about each other as people. Ippolito (2010) describes these kinds of interactions as "middle spaces" where parents and educators can engage in shared conversations about schooling.

Mathematics itself may provide a particularly fertile ground for building relationships. Mathematical ideas often develop through participation in discussions where ideas are explained, questioned, and negotiated with others (Sfard, 2008). Creating relational spaces where educators and caregivers do mathematics together may open up new experiences with mathematics. Educators may learn more about caregivers' mathematical ideas while sharing how mathematics is explored in their classrooms. Through these experiences, they may also build relationships with one another.

Caregivers in my study often described mathematical competence in terms of having mathematics degrees, experiencing success with mathematics, or having experience teaching mathematics. Caregivers with teaching backgrounds also emphasized the importance of listening to children's ideas in ways that did not appear in the accounts of non-teacher caregivers. Building relational spaces where educators and caregivers do mathematics together may allow new ways of being mathematical to emerge. These ways of being mathematical might include asking good questions, listening carefully to others' ideas, or helping make connections between mathematical strategies. Relational spaces may offer new possibilities for the "experienced other" (Anderson, 1997) to see themselves as mathematically competent.

Limitations

While my study offers insight into caregivers' experiences of doing mathematics with their children, it is important to consider its limitations.

The participant group in this study reflected a relatively narrow demographic range. The caregivers who participated were predominantly white and middle-income. In addition, all participating families included at least one caregiver with professional experience in education. As a result, participants had access to specialized pedagogical knowledge related to the teaching and learning of mathematics. The findings therefore do not represent the full range of caregivers' experiences doing mathematics with children across different cultural, linguistic, racial, socioeconomic, or educational contexts. Experiences of doing mathematics with children are shaped by broader social and community conditions, and caregivers situated differently may experience mathematics in ways that are not captured in my study. For example, caregivers who face language barriers or experiences of marginalization within schools may encounter different opportunities and challenges when doing mathematics with their children. Caregivers with limited familiarity with school mathematics may also experience relationships between home and school mathematics differently than the participants in this study.

The participating families also had access to conditions that supported mathematical interactions in the home. Both families included multiple adults who participated in children's care, and each family had access to professional knowledge of teaching and schooling. These conditions created opportunities for caregivers to identify opportunities to mathematize everyday interactions, ask children questions, and listen to children's mathematical ideas. Caregivers in other families may face barriers such as work schedules, limited time, language barriers,

unfamiliarity with school mathematics, or limited access to other adults who can provide support. My findings should therefore not be interpreted as suggesting that all caregivers have equal opportunities to do mathematics with their children. Future research could examine how family structures and material conditions influence caregivers' opportunities to do mathematics with their children.

The interviews generated detailed descriptions of caregivers' experiences and revealed meaningful variation across participants' accounts. This was a great start and pointed to the potential of studying caregivers' experience with math in their home setting.

Conclusion

In this dissertation, I argue that caregivers' relationships with mathematics matter. Caregivers are often positioned in mathematics education as supporters of children's learning, particularly through homework help or encouragement. However, my findings show that caregivers also experience mathematics emotionally, relationally, and personally. Caregivers reflected on their own mathematical histories, negotiated competence within family interactions, and experienced themselves differently through doing mathematics with children. In particular, caregivers' experiences are frequently related to perceived competence, one dimension of Di Martino and Zan's (2010) model of mathematical attitudes.

My study also suggests that improving children's relationships with mathematics cannot depend solely on encouraging caregivers to "be positive" about mathematics for the sake of their children. Caregivers in my study did not choose their relationships with mathematics or how they felt while participating in mathematical interactions. These relationships developed over time through schooling experiences, family interactions, and broader messages about who is considered mathematically capable. Supporting families in mathematics therefore requires attending to caregivers' own relationships with mathematics, not simply asking them to perform positivity for children.

At the same time, my findings point toward the possibility that relationships with mathematics can change. Caregivers in my study experienced moments of joy, reflection, insight, and connection while doing mathematics with children. Some caregivers began to see themselves differently through these interactions. Others experienced mathematics in ways that challenged longstanding assumptions about competence, learning, and what it means to "be good at math."

These findings suggest that mathematical relationships are not fixed. They continue to develop through relationships, experiences, and opportunities to engage with mathematics in meaningful ways.

Ultimately, my study points toward the importance of creating more enjoyable mathematical experiences for caregivers, children, and families. Mathematics can be experienced as a part of daily life, a way to come to know others, and a way to be with people. Paying attention to caregivers' mathematical experiences opens possibilities for building more relational and compassionate approaches to mathematics education across homes, schools, and communities.

Finale

Doing a PhD changes you and the way you think. Throughout this dissertation, I argued that identities and relationships are fluid. They change as you engage with others and the world. Looking back, I now recognize that this also describes my own experience. Completing this PhD reshaped how I think about research, scholarship, and mathematics.

Reflecting on research

When I wrote my proposal, I wanted to hear from caregivers whose voices have often been overlooked within educational research. Scholars such as Moll et al. (1992) and Civil & Bernier (2006) have already challenged deficit views of marginalized families by emphasizing the knowledge and practices that exist within family life. More recently, scholars have continued to argue that dominant models of family engagement continue to privilege middle-class, school-centred forms of participation while overlooking the experiences of marginalized families (Hine, 2024). My goal was to follow in the footsteps of the scholars I so greatly admired.

I remember during my proposal defence, Dr. Ippolito asked me to clarify my plan to recruit caregivers. I was confident that I had enough existing relationships within my school community that would allow me access to the voices and stories of people who might typically be left out of education research. When I explained my existing relationships with families within my diverse community and other community groups that I had participated in, I felt confident in my answer. Dr. Ippolito respectfully accepted my response, but as he brought his attention back to his notes, I noticed he ever so slightly raised an eyebrow. That gave me pause.

At the time, I assumed that my relationships with the school community I had spent eight years working in would be enough. I quickly learned that recruitment was not entirely up to me,

my relationships, and my convictions. Institutional structures, like the school board, would play a strong role in whether I was allowed to draw upon these relationships and how recruitment would unfold.

As I worked through the recruitment process, Dr. Ippolito's raised eyebrow lived rent-free in my mind. He was deeply aware of something I would soon find out.

Re-reading Lingwood et al.'s (2020) work on parental participation in research after my recruitment experience felt very different than reading their work before entering the field. Prior to attempting recruitment, it felt like a guide. They identified four broad categories of barriers to participation with families and research: 1) building relationships and rapport, 2) having research sessions in a setting that is familiar to caregivers, 3) perceptions of research and the researcher, and 4) caregivers' time and logistical constraints. Their work highlighted that caregivers have complex needs when it comes to participating in research. Also, my area of study is emerging. Creswell (2007) identified that in emerging areas of study, it is common to have a small sample as the importance of the work is not yet widely known. I am sure that if I offered up a study that promised caregivers their child would have higher grades in school, I would have had a line up out the door. But asking caregivers to share their experiences with me because I wanted to learn about them…was different.

Nonetheless, I knew I could attend to these four barriers, and that is exactly why I wanted to meet with caregivers from my school, in my classroom, and after school hours. First, I had established relationships with the families in my community over the past eight years; there were few families where I had not taught a sibling, cousin, or family friend. Second, my classroom was a place caregivers were familiar with. I was always known to be open to meeting with a

parent for a coffee in my classroom during a planning time, even if it was just to catch up. Third, I had established myself as someone who cares deeply for the community and the families within it. I was always helping out at clothing swaps, fundraisers, and school events. I listened to everyone's stories, remembered the names of grandparents, and asked how everyone was doing. I actually wanted to know if someone's sister abroad had their baby! Fourth, once I had connected with caregivers, I wanted to negotiate a time that worked for everyone or find out what they needed to participate. This was evident in how Emilie participated. Since the meeting times I had established with Madison and Barbara clashed with her children's extracurricular schedules, we met for shorter periods when she was free. I was confident my plan had aligned with what Lingwood et al. (2020) recommend. Yet, I was not permitted to enact it. The school board research board prevented me from recruiting within familiar spaces, from drawing upon existing relationships with families, and even from communicating directly with caregivers about the study. As a result, I moved recruitment to a local library that was willing to work with me. However, I did not have the same relationship with the community.

My experience extends the work of Lingwood et al. (2020) by highlighting how institutions like school boards also play an important role in shaping who gets to participate in research. Moving recruitment from my school community to a local library fundamentally changed who I was able to recruit. Recruitment now favoured caregivers who felt comfortable accessing a library, had technical literacy skills to read online recruitment flyers and register digitally, and understood why parental experiences were important. So…teachers? Not exclusively, of course. But it is not surprising that both participating families included teachers. One of the more surprising findings was that these teacher-caregiver participants described

tensions between home and school. That left me wondering what tensions surface with families who do not have the same insider knowledge of school.

As my participants described a tension between home and school, I found myself navigating a similar tension between my research and school. I was left wondering: How do institutions shape who gets to participate in research?

Reflecting on identity

When I began this dissertation, I wrote about how my own relationship with mathematics had changed over time. I described moving from someone who believed mathematics had little place in my life to someone who unexpectedly built a career around teaching and researching it. That story is still true. But I now realize that the most significant change has been in my identity as a scholar.

This identity is still very new. I suspect I will continue negotiating what it means to be a scholar for many years to come. I have always loved being the et al. of a paper. There is something wonderfully comforting about learning alongside other scholars I deeply respect and admire. I can always go back and ask, "Is this what you meant? Have I understood this correctly?" I can spend my time learning without carrying the responsibility of defending every methodological decision or analytic choice. This dissertation asks something different of me. For the first time, I must stand behind those choices myself. Why phenomenography? Why Funds of Identity rather than Funds of Knowledge? Why these categories and not others? These are now my decisions to explain and defend.

Looking back, I realize I have been preparing for my doctoral work much longer than I previously realized. During my second-year ballet course in the Dance program at York

University, Dr. Jennifer Bolt had a phrase she repeated often: “Feedback is a gift.” It made a lot of sense to me. Dancers are constantly getting feedback on every detail, and we recognize that it is our teacher’s way of making sure we grow. Dr. Bolt would comment on details that seemed almost invisible to anyone outside the studio: the slight incline of a head, the tension in a hand, or to “keep your iris in the center of your eye while you move your head” (yes, that was real feedback I was given). I also needed to decide how I would use movement to communicate a feeling or to portray a character. Even though I was trying to hold my leg in a place it probably was not supposed to go, I still had to do it while making artistic choices that needed to be made thoughtfully and defended.

Years later, I found those same words from my time in the dance program repeated by my doctoral supervisor, Dr. Tina Rapke. Only now do I recognize how connected those experiences were. Ballet taught me precision, but perhaps more importantly, it taught me to justify my choices. Research has asked the same of me. I had to decide what I would study and how I would learn about it. Like choreography, qualitative research required careful judgment. I had to make analytic choices and accept responsibility for them.

Throughout this dissertation, I have argued that identities are continually negotiated through participation. I wrote those words while thinking about caregivers. I now recognize that they also describe my own experience. Participating in research has changed how I understand myself. Somewhere between the interviews, the analysis, countless conversations with colleagues and supervisors, and writing this dissertation, well, I became a scholar.

Reflecting on mathematics

Let me take you back to 19-year-old me (see photo). Braces, chunky necklaces, terrible relationship with mathematics. Yikes. At the time, I thought mathematics was something smart people did. It featured numbers and symbols that did not make any sense to me. Anytime I was asked to do mathematics, I repeated the age-old phrase, "WHEN will I ever use this?"

Figure 5.3

The author (age 19) with two of her dance students backstage at a recital.



When I began my graduate work, mathematics was something I joyfully shared with students. I especially loved teaching solving algebraic equations because I felt confident that I could (finally) explain why things worked. This was in stark contrast to how I was taught as a child! Whenever I asked why something worked, the teacher said: "because that's how it works." Deeply unsatisfying. As I finished my master's work, I was confident that mathematics was about problem solving, making connections, and sharing ideas.

As I said, the PhD changes you. Listening to caregivers talk about how they did mathematics in their home changed how I thought about mathematics. Researchers such as

Bishop (1988) have long argued that mathematics is a cultural activity. My work has strengthened that conviction while also leading me to see mathematics as profoundly relational. Mathematics does not happen apart from our lives. It is woven into family histories, conversations, identities, frustrations, joy, and care. Even when educational systems attempt to separate mathematics from relationships, my participants continually brought those relationships back into view.

Bourrie (2024) argued for mathematics as a way of being *with children*. Her work has been tremendously influential in the ways I think about teaching, especially in my own practice. My work has allowed me to consider Bourrie's idea as it pertains to my research with families, in that mathematics is a way of being with *each other.* I leave this work believing that mathematics cannot be fully understood without also understanding the people who are doing it together.

My biggest hope is that one day I will board a plane, sit beside someone who asks, "So what do you do?" and, when I reply, "I teach mathematics," they smile and say, "I have the best memories of doing math."

If you are reading this dissertation because you are a mathematics education scholar, or perhaps you hesitated because it had the word "mathematics" in the title, thank you for travelling alongside me through these pages. My participants changed how I think about mathematics. Because of them, I now find myself asking: *What does it mean to live in a world where everyone sees themselves as a doer of mathematics?*

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Appendix

Appendix A

Examples of Homework Designed to Support Mathematical Conversations at Home

Homework examples

Example 1: Prompts for homework to communicate a vision of mathematics aligned with positive attitudes towards mathematics:

1. We are interested in finding connections between your preferred strategy and your child's strategy. Tell us about the ways you can find your idea in your child's idea! Use pictures, drawings, arrows, and words.
2. We are interested in making predictions today! Using the information given, what do you predict will happen?
3. We are interested in predicting and testing out ideas today. Based on the predictions you made, test out your ideas to see if they came true. Document your testing and use your evidence to back up your ideas.
4. Today is about listening to your child's ideas. Instead of telling them how to do the mathematics, focus on asking questions. Here are some questions you can ask: "How do you know?" "Tell me more." "Are you sure?"

Example 2: Interviewing a Parent

Your child's homework is to find out about how you use mathematics in your day. Their job is to ask you questions and record your answers.

1. Tell me about what your day is like while I'm at school.
2. How do you use mathematics in your day while I'm at school?
3. At school, we're talking about _____. Can you tell me where you might use that in your day?

Example 3: Asking caregivers for questions

Dear Caregivers,

We would love for you to help us come up with two questions your child could complete for mathematics homework. We encourage you to think about how mathematics comes up in your everyday lives in the questions you create for your child. Your child's teacher will select one question for your child to complete as homework and discuss with you.

Question 1:

Question 2:

Example 3: Handout to Send Home



Note. This handout was developed by the author and published in The Abacus (Vol. 64, No. 1, September 2025).