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Can the Curse Be Reversed?: An Action Research Study of the Effect of Constructivist-Aligned Instructional Strategies and Practices on the Mathematical Identity Development of Fifth-Grade Students

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CAN THE CURSE BE REVERSED?: AN ACTION RESEARCH STUDY OF THE
EFFECT OF CONSTRUCTIVIST-ALIGNED INSTRUCTIONAL STRATEGIES AND
PRACTICES ON THE MATHEMATICAL IDENTITY DEVELOPMENT OF FIFTH-
GRADE STUDENTS

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DEDICATION

To my sweet husband, John. You are God's grace to me in so many ways. You have loved, guided, supported, and held me up through every step of this journey. You never let me give up and took on every imaginable responsibility so that I could focus on this work. You are my favorite. I love you with all my heart, for all my life.

To my parents who have supported this dream from day one. You have always encouraged my dreams and believed in me more than I have believed in myself. Thank you for always being my biggest cheerleaders. I love you both so much.

To the friends and family who have cheered me on every step of the way and understood when I had to stay in and work, thank you. Your love and support mean the world. I look forward to more free time now.

I also dedicate this dissertation to the students and educators who have served as my inspiration. To every student who has secretly feared mathematics and felt less than because of their anxiety and to every educator who has poured their lives into these precious babies we get to work with every day, this is for you.

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ABSTRACT

The aim of this mixed-methods action research study was to determine how my fifth-grade students were impacted by negative mathematical identity and/or math anxiety and to uncover the impact of constructivist-aligned instructional strategies on students' mathematical identity. Grounded in a theoretical framework based on constructivist learning theory, identity theory, and communities of practice, the study used a convergent mixed-methods action research approach to investigate the following research questions:

1) How does negative mathematical identity and/or math anxiety impact my students? 2)

What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced? 3) How do constructivist-aligned instructional strategies affect mathematical identity in fifth-grade students? Results derived from pre- and post-intervention surveys, semi-structured interviews, and exit slips indicate that many of my students suffered from some degree of math anxiety or negative mathematical identity. Additionally, study results show an increase in overall positive beliefs about mathematics and increased self-efficacy in mathematics during constructivist-aligned intervention. Based on these results, I conclude that constructivist-aligned strategies and practices contribute to an increased positive mathematical identity in fifth-grade learners.

Keywords: Action Research, Math Anxiety, Identity, Mathematical Identity, Elementary Mathematics, Constructivism

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LIST OF ABBREVIATIONS

ESEA.....	Elementary and Secondary Education Act
MASYC-R	Math Anxiety Scale for Young Children- Revised
STEM.....	Science, Technology, Engineering, Mathematics

CHAPTER 1

INTRODUCTION

Imagine the wonder of sitting in a college classroom as a 20-year-old, using mathematics manipulatives previously only used in your schooling career as toys, and finally understanding the why behind the basic mathematical processes you had previously meaninglessly memorized. As early as elementary school, I remember an underlying uneasiness when mathematics time rolled around each day. I could perform the procedures my teachers taught me but never understood why they worked or how they all fit together. I began to feel that maybe I just was not a “mathematics person” and doubted my ability to be successful as mathematics classes got harder. Though I coasted along quite successfully by memorizing procedures and algorithms in elementary and middle school mathematics, I always had the sense that I was missing something. Upon entering my honors mathematics classes in high school, however, the little twinges of confusion I had felt at times over the years quickly compounded. Added to this frustration was the fact that my parents told me often that once I reached high school, they would not be of much help with mathematics homework. By the end of freshman year, I was sure that I was terrible at mathematics and the discipline quickly became my enemy. The uneasiness gave way to stress, and ultimately, my negative view of myself as a mathematics learner turned to math anxiety. With this anxiety came shame and fear and I committed to avoiding mathematics at all costs and letting no one in on my secret anxiety. My struggle was a very private one, as I knew that my parents were not equipped

to help me, and I was ashamed to not understand. Though I managed good mathematics grades, they were hard earned, and I graduated high school determined to stay far away from mathematics. Thankfully, through my course work in college, teaching experience, and a Master's program devoted to mathematics curriculum and instruction, I was able to develop a conceptual understanding of the mathematics that had been a mystery for so long and ultimately overcome my own math anxiety.

Over the course of my twelve years of teaching upper-elementary-aged students, more and more learners have begun our year together already showing signs of math anxiety or mathematics avoidance. These students struggle to find the importance of mathematics or the relevance to their lives. Having faced anxiety associated with mathematics as a student, I am keenly aware of the paralysis students can feel when hearing the word mathematics. I know the lengths one may go to in order to avoid the subject because I, too, have been there. As an incoming college freshman, I simply chose not to take the mathematics entrance exam and effectively avoided the basic mathematics requirement for my degree program until my junior year, when, finally, I began to overcome my anxiety. The experience of overcoming this anxiety was life altering and only occurred as a result of the opportunity I had to understand mathematics conceptually through my elementary education coursework.

Due to my own experiences with mathematics avoidance and anxiety, I recognize these behaviors in my students. At the beginning of the 2018-2019 school year, I polled my students on their feelings about mathematics, and more than 50% began the school year with negative attitudes toward mathematics, some even showing signs of math anxiety. The groans when it was time for mathematics each day, the chorus of "I can't do

this, it's too hard," and the task avoidance when students worked independently were all telltale signs of negative attitudes toward mathematics. However, as a student who made As in mathematics throughout the majority of my school career and hid my feelings about the subject, I was also able to recognize the more covert signs of math anxiety in my students.

When given the opportunity to move up from fourth grade to fifth grade with the same group of students for the 2019-2020 school year, I was excited to continue teaching such a hard-working, but mathematically discouraged group of young mathematicians. I hoped to help these students become more positive toward mathematics before they enter middle school. Through this action research study, I aimed to help these students begin to reconstruct their mathematical identities to reflect positivity, confidence, and a different view of the relevance of mathematics. Additionally, I undertook this study to inform and improve my teaching, eliminating practices that may contribute to the construction of negative mathematical identity or the development of math anxiety.

While this problem is salient in my own life and the lives of many of my elementary students, the impact of negative attitudes toward mathematics is well documented across age groups and geographic locations, creating potential roadblocks for affected students. The role of teachers and families in this phenomenon is clear, with research indicating that the environment in which students grow before ever entering school can impact students' attitudes toward mathematics. These negative attitudes may be compounded by the instructional techniques used for mathematics instruction in elementary classrooms involving rote memorization and a focus on skills over conceptual understanding (Geist, 2010).

Through her large body of research on the topic of math anxiety dating back to the 1970s, Sheila Tobias (1978) has worked tirelessly to shed light on the link between math anxiety, student achievement, and adult success. Tobias (1991) detailed a path toward math mental health, reporting that students' lack of mathematical self-efficacy is debilitating and hinders their academic achievement and potential for future success. A recent study on the correlation between mathematical attitudes and math anxiety reiterates the connection between students' attitudes and achievement, finding that students with more negative attitudes had lower confidence, higher anxiety, and consequently, often lower achievement (Haciomeroglu, 2017), thus demonstrating the critical importance of addressing this anxiety and negative self-efficacy early in students' lives.

Tobias (1991) challenges teachers, "Your goal, like mine, should be to guarantee every student math mental health, namely, the willingness to learn the math they need, when they need it" (p. 93). In light of this call, my personal experience, and the literature on the devastating impact of negative attitudes toward mathematics, I resolved to address the math mental health of the students in my classroom and school by eliminating practices that may foster anxiety and moving students toward mathematical identities that will enable them to confidently face the challenges on their chosen paths to success.

Theoretical Framework

An understanding of constructivist theory and the role of self-efficacy in the development of student identity, particularly mathematical identity, provided the lenses through which to view my problem of practice. Additionally, these underlying themes, based on the works of Lev Vygotsky (1978), John Dewey (1897), Jean Piaget (1976),

Albert Bandura (1993), Erik Erikson (1968; 1970) and Etienne Wenger (1988), guided the approach for this study, particularly the planned intervention.

Constructivist theory is the foundational theme on which all aspects of this study are based. This learning theory, originating from the works of Piaget, Dewey, and Vygotsky, suggests students construct knowledge based on personal interpretations and experiences and that students develop understanding and knowledge through experience with meaningful contexts and authentic work (Applefield et al., 2001; Dewey, 1897; Ertmer & Newby, 2013; Li & Stylianides, 2018; Mergel, 1998). When students create knowledge through the social contexts of daily life, they become members of collaborative learning communities (Dewey, 1897). Thus, collaborative social interaction is a hallmark of the constructivist theory (Applefield et al., 2001; Harasim, 2012; Piaget, 1976; Vygotsky, 1978; Wenger, 1988). As applied to mathematics education, constructivism is based on the idea that students construct mathematical knowledge by integrating concepts into their current schema while in a social setting (Clements & Battista, 2009).

These principles of constructivism have been significant in my own teaching practice. I have found from my experiences as a teacher, as well as in the literature, that the thoughts students have about mathematics and themselves as learners develop through their experiences, both positive and negative, with the subject and through their social interaction with others as they are learning mathematics (Hima et al., 2019; Radovic, et al., 2017). The idea that mathematics learning is dependent on the students' own construction of knowledge is fundamental to understanding how to help students

develop a positive attitude about mathematics as a discipline and about themselves as mathematicians.

Constructivism goes beyond the classroom content and curriculum, impacting the building of identity, as well. According to Erikson (1968), identity is mostly subconsciously constructed through observation and reflection. In this process, individuals are continuously redefining who they are in light of their observations of how they compare with others and others' perceptions of them. Further, Erikson (1970) finds that identity formation depends on an individual's past experiences and new encounters and is preserved and renewed throughout adolescence and adulthood. Likewise, when applying this theory to mathematics, Lutovac and Kaasila (2014) find that mathematical identity is fluid and shifts based on experiences, noting the intersection between students' individual and social mathematical contexts.

Mathematical identity, in particular, has been defined as “the dispositions and beliefs regarding an individual's ability to participate and perform effectively in mathematical contexts as well as to use mathematics to change the conditions of his/her life” (Pipere & Mičule, 2014, p. 7). In other words, students' experiences with the discipline of mathematics and their self-efficacy shape their mathematical identities. Self-efficacy is an influential aspect in students' mathematics success and in the development of a healthy mathematical identity because students' confidence in managing their own learning and mastering academics governs their goals, motivation, and academic success (Bandura, 1993). These implications illustrate the importance of students' development of mathematical self-efficacy, which leads to positive mathematical identity.

Due to the socially constructed nature of identity, it is within the context of the mathematics classroom learning community that students negotiate their mathematical identity. Wenger (1998) calls these learning environments communities of practice. Anderson (2007) elaborates, “Learning mathematics involves the development of each student’s identity as a member of the mathematics classroom. Through relationships and experiences with peers, teachers, family, and community, students come to know who they are relative to mathematics” (p. 7). This developing sense of who students are as mathematicians impacts the course of their lives, often limiting the opportunities students may have (Grootenboer, 2013). These dispositions and beliefs can be impacted by the mathematical experiences, attitudes, and approaches of those within the students’ mathematical communities, including teachers and parents (Geist, 2010).

The role of constructivism and identity in this problem of practice will be further explored in Chapter 2. It is through these lenses that the problem of practice for this study has been analyzed and from this point of view that the research questions were designed.

Research Questions

The purpose of this action research study was to explore best practices for constructing positive mathematical identity and to discover and eliminate instructional practices that contribute to the development of negative mathematical identity or math anxiety in my fifth-grade students. Though the reported prevalence of math anxiety and negative mathematics attitudes varies from study to study, research points to the significance of this problem (Dowker et al., 2016). The impacts of math anxiety go beyond achievement and include mathematics avoidance that can affect mathematics-related tasks ranging from homework to everyday calculations and can severely limited

career opportunities (Ruff & Boes, 2014). With such high stakes and far-reaching impacts, mitigating the effects of negative mathematical attitudes and anxiety while promoting a positive mathematical identity is crucial for student success.

To that end, this study investigated the following research questions through a convergent parallel mixed-methods action research approach:

- 1) How does negative mathematical identity and/or math anxiety impact my students?
- 2) What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced?
- 3) How do constructivist-aligned instructional strategies affect mathematical identity in fifth-grade students?

With the reality of preparing students to join a workforce comprised of jobs that do not currently exist, current educational reform aims at developing students' science, technology, engineering, and mathematics (STEM) skills. However, research shows that negative attitudes toward mathematics and math anxiety are factors that may impede students' achievement, potentially derailing college and career readiness (Foley et al., 2017; Geist, 2010, 2015; Soni & Kumari, 2015; Tobias, 1991). With evidence that negative mathematical mindset and math anxiety can start even before entering school (Geist, 2010, 2015), identifying ways to mitigate negative attitudes and anxiety is vital to give every student an equal opportunity for future success. Consequently, the selected research questions focused on what I could do as a classroom teacher to positively impact the development of students' mathematical identity.

To address this problem, I led study participants in an intervention built into daily mathematics activities over the course of six weeks. While the original intervention was planned for eight weeks, schools were closed for the final 12 weeks of the school year due to the COVID-19 pandemic, which I will explain further in another section. Most of the specific activities were designed using participant responses to pre-intervention surveys and semi-structured interviews. These constructivist-aligned activities were student-centered and focused on helping students develop a mathematical mindset (Boaler, 2016). For example, as suggested by Anderson (2007), rather than engaging in closed mathematics tasks with only one correct answer, students were allowed to work collaboratively on open mathematics tasks that could be solved using various approaches and led to varied answers. Students were engaged in the creation of a mathematical autobiography and participated in activities to define what mathematical success looks like. These activities promoted and prioritized student voice and gave students the opportunity to own who they are mathematically (Allen & Schnell, 2016). Through the use of these daily constructivist-aligned mathematics activities and practices in conjunction with daily reflective exit slips, I was able to learn how these practices positively or negatively affected students' mathematical identity formation.

Researcher Positionality

In this action research study, my role as both teacher to the study participants and researcher made me an insider practitioner researcher. Herr and Anderson (2015) suggest the kind of contextual knowledge that comes from being an insider can be influenced, biased, and include assumptions that need to be examined. Efron and Ravid (2013) characterize the role of an action researcher as immersive and explain the importance of

researchers recognizing how their beliefs may shape insights and understandings.

Similarly, Bourke (2014) proposes that the identity of the researcher could conceivably influence the research procedures. To mitigate my insider bias, I considered my own positionality and acknowledged how who I am could impact the study.

My upbringing and school experiences played a vital role in the design of this study. The desire to help students develop positive mathematical identity was born from my own private struggle with negative mathematical identity and experience with math anxiety as a student. The shame and apprehension I felt as a student fueled my passion to ensure my students did not experience the same negative attitude and anxiety. These experiences gave me unique positionality within this study.

My personal knowledge of the struggles these students were potentially dealing with in private primed me to recognize signs of math anxiety or negative mathematical identity that others may not notice. Having this in common with the participants of the study allowed them to identify with me on a different level and strengthened my position as an insider in the study. On the other hand, this experience limited my study in that my experiences have created assumptions about the antecedents of the negative attitudes and the strategies most effective to combat this problem. To mitigate this bias, the interventions proposed for the participants in my study were grounded in literature and targeted to the specific experiences of the learners participating in the study.

This action research study was conducted in one of two Title I schools in an otherwise affluent and rapidly growing suburban school district. Many of my students come from single parent households or live with other guardians, so my background is quite different than that of many of the participants in this study. Differing backgrounds

could also indicate a difference in world view, values, and beliefs and could have impacted the validity of the study if not examined for bias. As a teacher researcher, I worked to balance the similarities I had with the participants in the study with the differences and keep the aim of the study at the forefront throughout the research process. Further it was important to have a carefully designed study to mitigate the impact of my position of authority as their teacher.

Research Design

My study used a convergent parallel mixed-methods action research methodology. A benefit of action research is the flexibility with which complex problems can be solved through cycles of action (Dick, 2015). Herr and Anderson (2015) assert that action research is focused on an action or a sequence of actions taken by or with insiders to the research setting with the goal of addressing a problematic situation. Educators undertake action research inquiry to improve their own practice and positively impact students' learning (Efron & Ravid, 2013). This study employed an action research methodology because the aim of the study was to solve the complex problem of negative mathematical identity by helping my students develop mathematical self-efficacy and inform my practice in teaching math anxious students. Qualitative and quantitative research approaches were combined in a convergent parallel mixed-methods approach to pull from the strengths of both methods (Efron & Ravid, 2013). In line with this approach and to determine the effectiveness of the intervention strategies, both qualitative and quantitative data were analyzed separately, then mixed during the interpretation phase of the study to get a full picture of the impact of the intervention (Ivankova, 2015).

The study was conducted in my fifth-grade classroom in a Title I school in a rapidly growing district in the Southeastern United States. All 24 students in my mathematics class were invited to participate in the study by completing pre- and post-intervention surveys and daily exit slips. Some students were also selected to participate in pre- and post-intervention interviews.

A variety of data-collection instruments aligned with the research questions, including quantitative tools: the Math Anxiety Scale for Young Children–Revised Version (MASYC-R) (Ganley & McGraw, 2016) and a researcher-created survey (See Appendices A and B) and qualitative tools: semi-structured interviews (See Appendix C) and a teacher journal. Additionally, daily Google Form exit slips (See Appendix D) were used that had both quantitative and qualitative questions. More information on these tools will be provided in Chapter 3.

A variety of measures were used to ensure trustworthiness and validity in this mixed-methods study. The researcher-created survey was guided by suggestions from Efron and Ravid (2013, pp. 112-115), and an additional teacher reviewed the survey to ensure credibility of the instrument and its appropriateness for fifth-grade learners. Further, the school guidance counselor reviewed my interview protocol to ensure the credibility and appropriateness of the questions. The use of a teacher journal as a data collection tool also helped ensure the trustworthiness of the study by providing an opportunity for me to track my own subjectivity. The journal was another way to practice self-reflexivity in addition to the discussion of my biases and experiences (Efron & Ravid, 2013). These measures allowed me to gather a range of data that contributed to validity and trustworthiness.

Significance of the Study

With research dating back to the 1950s on the debilitating impact of math anxiety (Dowker et al., 2016), this study aimed to further illuminate a well-documented phenomenon plaguing mathematics education and its connection to the development of mathematical identity as it pertained to my teaching context and practice. While much of the literature focuses on the impacts of negative mathematics attitudes and math anxiety, there is far less research on strategies to successfully overcome the effects of a negative mathematical identity, particularly in elementary school settings. As studies continue to point to the importance of students' capacity in STEM disciplines to their future success academically and professionally, as well as to their ability to aid in improving our nation's economy (Geist, 2015), it is evident that helping students overcome their negative mathematical mindsets early in their educational careers is crucial. Thus, this study brings a new perspective to previous work on overcoming math anxiety and negative mathematical identity to identify strategies for mitigating the impacts and eliminating the classroom practices that lead to negative outcomes.

The ultimate goal of this action research study was to improve my practice and positively impact my own students and students like them at my school. My experiences with mathematics avoidance and anxiety have afforded me the opportunity as a teacher to recognize the prevalence of this phenomenon in my own elementary students. With this realization, I felt tasked with figuring out how to help my students change their mindset about the discipline of mathematics and their self-efficacy in relation to the subject. As these fifth graders approach their secondary school years and begin seriously considering their future plans, it was my hope they would each be able to confidently make decisions

without the debilitating effects of math anxiety or negative mathematical identity impacting their choices. Additionally, I felt a duty to help figure out what was happening in the lives of these students that led to these negative attitudes and anxiety at such a young age, in hopes of determining a solution to prevent this phenomenon altogether.

It is my hope for the results of this study to inform the practices of other teachers in my school and generate a conversation about the importance of positive mathematical identity within and beyond the walls of the research site. Additionally, I hope that this study will connect with the countless individuals who have suffered silently from a negative mathematical identity or math anxiety, bringing a sense of hope for overcoming this debilitating phenomenon.

Limitations of the Study

One limitation of this study was the relatively short intervention period. Though eight weeks of intervention were planned for this study, school closure due to the COVID-19 pandemic impacted this time frame, resulting in only six weeks of intervention. During this pandemic, a virus swept the globe and led to national school closures and stay at home orders. This disruption in normal school procedures necessitated remote learning in which students learned at home using online platforms like Google Classroom or using daily packets of instructional materials created by teachers for students with limited technology access.

Further, as a classroom teacher who conducted the intervention lessons while also trying to stay on track with my grade level's long-range plans, I had to strike a balance between the two. Additionally, as a Title I school, we have the benefit of grade-level interventionists who work individually with students to provide mathematics intervention

based on areas of weakness demonstrated on benchmark assessments. Working around the schedule of our grade-level interventionist provided some challenges and required some scheduling changes for our mathematics learners. In spite of these limitations, which I will address further in Chapter 5, the study resulted in valuable improvements for my students and my instructional practices.

Organization of the Dissertation

Chapter 2 presents the Literature Review, documenting the variety of research that grounds and informs this study. Chapter 3 shares the research design and the specific methodological approach employed in the study. In Chapter 4, the data collected in the study are analyzed and results are presented. To conclude this dissertation, Chapter 5 presents a discussion of the findings and implications for my practice and further study.

Glossary of Terms

Math anxiety: Math anxiety is the feeling of concern, unease, fear, and trepidation associated with mathematics performance, situations involving numbers, and/or mathematical problem solving across academic situations and in daily life. Math anxiety can lead to mathematics avoidance and underperformance and impact the academic and personal lives of those affected (Andrews & Brown, 2015; Ashcraft, 2002; Beilock & Willingham, 2014; Vahedi & Farrokhi, 2011).

Mathematical identity: Mathematical identity refers to people's perceptions of themselves in relationship to mathematics, including their mathematical aptitude, attitude toward the discipline, and their understanding of the discipline and its relevancy to themselves (Latterell & Wilson, 2017).

Mathematical mindset: Mathematical mindset is a personal belief about mathematics that acknowledges that anyone can learn and can find mathematical success (Boaler, 2016).

CHAPTER 2

LITERATURE REVIEW

Conducting a thorough literature review, a synthesis of previous research that is relevant to the topic of interest in a research study (Efron & Ravid, 2013), can inform a research study. Reviewing books, scholarly journal articles, and other resources enables the researcher to explore the historical context and empirical data from prior studies (Merriam & Tisdell, 2016). Additionally, identifying gaps in the literature “provides a framework for establishing the importance of the study as well as a benchmark for comparing the results with other findings” (Creswell & Creswell, 2018, p. 26). The comprehensive understanding of what is currently known about the research topic thus frames the need for the research study (Machi & McEvoy, 2016).

The literature reviewed in this chapter provides a comprehensive look at the history of math anxiety and negative mathematical attitudes in American culture and how these have impacted the achievement and self-efficacy of mathematics learners. Research on the formation of mathematical identity reveals how this identity shapes the mathematical experiences of students. In addition, reviewing literature on the impact of instructional practices on students’ development as mathematical learners has provided a complete picture of the current status of mathematical practices and their effects. This literature guided my study by identifying areas that have already been explored as well as gaps in the current research that can be further investigated through action research.

To gain a comprehensive understanding of the research problem, I consulted a variety of databases, including Education Source, ERIC, JSTOR and Academic Search Complete. Through a series of Boolean searches using key words *math anxiety*, *mathematical identity*, *causes*, *effects*, *achievement*, and *instructional practices*, I searched for peer-reviewed journals and reviews of books. The book reviews led me to books on math anxiety and mathematical mindset. Scholarly journal articles provided empirical data on the topics of math anxiety, negative mathematical attitudes, the formation of mathematical identity, and impactful instructional practices.

Although the problem of practice, research questions, and purpose of my study were introduced in Chapter 1, I briefly revisit them in the section that follows to provide context for the literature review. I also elaborate on my theoretical framework and discuss how mathematical identity develops. The remainder of this chapter reviews literature on instructional practices that reinforce negative mathematical identity, explores the history of math anxiety, and shares existing research on math anxiety that guided my study.

Statement of Problem of Practice

In over a decade of teaching elementary-aged students, I have observed that the number of students beginning the school year already frustrated by or fearful of mathematics has continually been on the rise. More and more of my students demonstrate symptoms of math anxiety or negative mathematical identity, even at such a young age. The debilitating effect of these negative attitudes and fears is already evident in more than half of my current fifth-grade students, who exhibit apprehension toward mathematics, mathematics avoidance, and very limited confidence in mathematics. As an adult who also suffered math anxiety and negative mathematical attitude as a student, I

know firsthand how detrimental the effects can be on students' daily lives. To help students develop into problem solvers and prepare them for potential careers in science, technology, engineering, and mathematics (STEM) fields, I must also consider how their attitudes and mathematical identities might impact their future. Evidence suggests that the influence of math anxiety or negative mathematical identity can potentially disturb students' preparation for careers in STEM fields (Foley et al., 2017; Geist, 2015; Soni & Kumari, 2015; Tobias, 1991). With research indicating that negative mathematical identity and math anxiety can start in early elementary school (Sorvo et al., 2017) or even prior to entering formal schooling (Geist, 2015), it is critical to investigate strategies for developing a positive mathematical identity and to eliminate the classroom practices that support development of a negative mathematical identity in order to provide equitable access to success for all learners.

Research Questions

In light of the identified problem of practice, this convergent parallel mixed-methods action research study examined the following research questions:

- 1) How does negative mathematical identity and/or math anxiety impact my students?
- 2) What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced?
- 3) How do constructivist-aligned instructional strategies affect mathematical identity in fifth-grade students?

Purpose of the Study

As introduced in Chapter 1, the purpose of this action research study was to examine my classroom practice to explore the best practices for constructing positive mathematical identity and to discover and eliminate instructional practices that contribute to the development of negative mathematical identity or math anxiety in my fifth-grade students. With a large body of research indicating the significance of the problem of negative mathematical attitudes and math anxiety and the effects of this anxiety numerous (Dowker et al., 2016), it was critical to explore how to mitigate the negative effects and discover best practices to support mathematics positivity in my students.

Theoretical Framework

As noted in Chapter 1, this study is built upon an understanding of constructivist learning theory (Dewey, 1897; Piaget, 1977; Vygotsky, 1978) and how self-efficacy (Bandura, 1993) informs students' identity, specifically mathematical identity. The concept of communities of practice (Wenger, 1998, 2010) also informed the intervention.

With origins going back to Piaget (1977), Dewey (1897) and Vygotsky (1978) constructivism is a learning theory focused on students' construction of knowledge based on their experiences and personal interpretations (Applefield et al., 2001; Li & Stylianides, 2018; Mergel, 1998). Constructivists encourage meaningful and relevant situations to frame authentic problems that facilitate students' understanding of concepts (Dewey, 1897; Ertmer & Newby, 2013; Mergel, 1998). As Dewey (1897) argued, "the only true education comes through the stimulation of the child's powers by the demands of the social situations in which he finds himself. Through these demands, he is stimulated to act as a member of a unity" (p. 77). Consequently, constructivist learning

theory emphasizes collaboration and social interaction (Applefield et al., 2001; Dewey, 1897; Harasim, 2012; Piaget, 1976; Vygotsky, 1978; Wenger, 1988).

For mathematics education, constructivist theory suggests understanding is constructed within a social setting in which students can integrate mathematical concepts into their current schema (Clements & Battista, 2009). Students' perceptions of themselves as mathematics learners are born from their experiences with mathematics as well as the social interactions they have with others, including parents, teachers, and peers (Dowker et al, 2015; Grigg et al., 2018). As students construct their own mathematics knowledge, their self-perception as mathematics learners also develops.

Pipere and Mičule (2014) refer to this concept as mathematical identity, which includes a student's beliefs about the "ability to participate and perform effectively in mathematical contexts as well as to use mathematics to change the conditions of his/her life" (p. 7). Thus, self-efficacy is a critical component to success in mathematics and the development of a positive mathematical identity. Bandura (1993), prominent self-efficacy expert, posits, "Students' beliefs in their efficacy to regulate their own learning and to master academic activities determine their aspirations, level of motivation, and academic accomplishments" (p. 117), illustrating the importance of students' construction of positive self-efficacy and, therefore, mathematical identity.

Learners negotiate their identity in the context of what Wenger (1988) terms communities of practice. Students' involvement in a mathematics community, including their experiences and relationships with others in the classroom, helps shape their mathematical identities (Anderson, 2007). If the constructed identities are negative, the

course of students' mathematical lives may be impacted, potentially derailing future opportunities (Grootenboer, 2013).

Historical Perspectives

The recognition of math anxiety as an educational construct worth investigating dates back over sixty years, though evidence suggests people have been plagued by this anxiety for centuries (Dowker et al., 2016). Acknowledging the lack of research on emotional responses to mathematics, Dreger and Aiken (1957) endeavored to study a potential emotional syndrome related to mathematics, which they called number anxiety. In their study with over 700 college students, they distinguished number anxiety from general anxiety, noting that number anxiety is a separate phenomenon unassociated with general intelligence but typically associated with lower mathematics achievement.

Richardson and Suinn (1972) later called this phenomenon mathematics anxiety and developed the Mathematics Anxiety Rating Scale to measure its incidence. The researchers defined mathematics anxiety as the “feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations” (p. 551). Additionally, Richardson and Suinn noted that this anxiety often prevents sufferers from finding success in basic mathematics classes and pursuing advanced mathematics or science classes.

In work dating back to the 1970s, Sheila Tobias (1978) investigated math anxiety, its causes and effects, and potential solutions. Like Dreger and Aiken (1957), Tobias (1991) believed that math anxiety evident in students is unrelated to students' intelligence and further explored the idea that success in mathematics is not caused by having a mathematical mind. Through her work interviewing hundreds of students who

experienced math anxiety, Tobias (1990) realized that sufferers of math anxiety could pinpoint the onset of their anxiety to a single moment or experience. Additionally, Tobias' work confirmed the long-term effects of math anxiety. By 1993, Tobias asserted, "Millions of adults are blocked from professional and personal opportunities because they fear or perform poorly in mathematics. Most of these adults are capable of learning more mathematics. Theirs...is not a failure of intellect, but a failure of nerve" (p. 9).

To further investigate the construct of math anxiety, Hembree (1990) conducted a meta-analysis of 151 studies on math anxiety, revealing correlations with decreased mathematical achievement, negative mathematical attitudes, and avoidance of mathematics as a discipline. Additionally, Hembree analyzed a variety of interventions used in an attempt to reduce math anxiety in participants and found that group psychological interventions were ineffective.

Research on this phenomenon has continued over time, delving into various aspects of math anxiety like its relationship with achievement, gender, age, culture, and the identity of the learner (Dowker et al., 2016; Galla & Wood, 2011; Hilton, 1980a; Hilton, 1980b; Ho et al., 2000; Kazelskis et al., 2000; Maloney & Beilock, 2014; Tobias, 1990). As attention to mathematical performance has increased in recent years, so has research on math anxiety (Dowker et al., 2016). While the phenomenon itself is well documented across the last half century, strategies for developing a positive identity as a mathematics learner, particularly in young children, have not been thoroughly explored.

Related Research

To guide my study, I consulted literature on the development of mathematical identity and instructional practices that reinforce mathematical identity, as well as

literature on the causes and effects of math anxiety and negative attitudes toward mathematics.

Development of Mathematical Identity

Understanding identity and its intersection with mathematics is valuable in analyzing students' development as mathematics learners (Anderson, 2007; Pipere & Mičule, 2014; Wood, 2013). Developing positive mathematical identities can lead to greater success in mathematics, while negative mathematical identity can be detrimental to future success with mathematics (Anderson, 2007; Wood, 2013). As identity is formed in social contexts through relationships with others (Wenger, 1998), providing learning environments that support the development of positive mathematical identity is crucial.

Identity Theory

The concept of identity is multi-faceted and has been theorized in a variety of contexts and differently across disciplines (Allen & Schnell, 2016; Erikson, 1968; Gee, 2001; Wenger, 2010). Allen and Schnell (2016) generally define identity as “how people see themselves and how others perceive them, taking into account personal histories, abilities, character, [and] culture” (p. 400) and go on to explain that students' conceptions of their identities are shaped by a variety of factors including family, class, race, gender, religion, language, and academic success. Likewise, Walshaw (2013) finds that identity is formed in relation to others and is “socially structured and historically inflected” (p. 104).

Erikson's (1968) well-known theory on identity argues that it forms through a mostly subconscious process of observation and reflection in which individuals compare themselves to their own perceptions of how others judge themselves. Erikson points out

that identity consciousness is generally associated with particularly beautiful or painful events and notes that identity is constantly changing and developing over the lifetime.

Gee (2001) suggests that while individuals each have a core identity that represents who they are across all situations, they also each have a variety of identities related to their assorted social roles. In this vein, identity formation happens within social contexts, such as education. Like Gee, Wenger (1998), in his work on communities of practice, finds that constructing identity occurs through negotiating experiences within social communities. Additionally, Wenger suggests identity is not a destination at which one arrives, but rather a constant evolution that is frequently negotiated and renegotiated based on experiences.

Intersection of Identity and Mathematics

When considering the social aspect of learning (Gee, 2001; Wenger, 1998; Wenger 2010), researchers suggest that understanding how math learners find a sense of belonging and identity within the classroom is imperative (Nasir & McKinney de Royston, 2013). Nasir (2002) finds that the relationship between mathematics learning and identity formation is bidirectional, meaning that as identity is constructed, learning is supported and as learning increases, identity is strengthened. Like Wenger's (1998) theory that identity is frequently renegotiated through the course of time, Hall et al. (2018) suggest that one's mathematical identity is fluid and may shift according to the place and time.

Aguirre et al. (2013) define mathematical identity as “the dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the contexts of

their lives” (p. 14). Correspondingly, Hall et al. (2018) define mathematical identity as “the narratives people create to explain themselves in relationship to mathematics” (p. 181). Research indicates that while mathematical identity is an entirely individual concept, the formation of mathematical identity happens within social contexts and is heavily influenced by a variety of factors including school experiences, life experiences, and the impact of others (Anderson, 2007; Wood, 2013).

Through a study conducted with 54 high school participants, Anderson (2007) identified the means by which four aspects of identity are developed in the mathematics classroom: *engagement*, *imagination*, *alignment*, and *nature*. Anderson explains that the majority of students’ understandings about mathematics come from their *engagement* in mathematics class, which includes their interaction with the mathematics itself and the social interactions with teachers and peers. Through this engagement, students develop a vision of themselves as mathematics learners, either positive or negative. The second aspect, *imagination*, refers to students’ ability to imagine the intersection of mathematics and their real-world lives. The development of a positive mathematical identity gives students the confidence to pursue careers that rely on mathematics while negative mathematical identity leads to future mathematics avoidance (Anderson, 2007). The third aspect, *alignment*, relates to students’ development of imagination. When students are able to imagine advanced mathematics as imperative for their future, they align their interactions and participation in the mathematics classroom with this goal. Conversely, students who do not see themselves as mathematical learners or view mathematics positively, act accordingly. The final aspect, *nature*, focuses on defining characteristics such as gender and race, which can affect how students perceive themselves in

relationship to mathematics. Anderson notes that teachers have a unique opportunity to promote mathematically positive identities in each of the four aspects of the construct.

At the college level, Latterell and Wilson (2017) enlisted 131 participants from a midwestern U.S. university, using metaphors written by pre-service elementary and pre-service secondary mathematics teachers to uncover any fundamental differences in their mathematical identities. The results of this qualitative study, in which students wrote metaphors to describe their relationship with mathematics, indicate a general identity difference between the elementary and secondary education majors. While secondary mathematics majors felt capable of doing the work associated with mathematics, elementary education majors identified mathematics as something that requires more work or thinking than they are capable of completing. Though metaphors from students in both majors identified mathematics as a process, secondary mathematics majors identified themselves as in control of the mathematics while the elementary majors viewed control as external and cited a process of ups and downs or successes and failures. These different viewpoints illuminate the various manifestations of mathematical identity, which influence thinking about mathematics as a discipline.

In an interpretive phenomenological study investigating the dialogical models of mathematical relationships in three doctoral students engaged in mathematics research, Pipere and Mičule (2014) analyzed participants' life-long experiences with mathematics in order to understand how they developed mathematical identities. Study findings show mathematical identity varies from person to person and uniquely shapes feelings toward the discipline, life, and the world. Though all three participants were mathematics educators, their own relationships with mathematics were very different, as were their

views of mathematics. While all three reported positive feelings about the discipline, two participants saw mathematics as a way of doing life and problem-solving, while the other participant found mathematics beautiful but did not acknowledge its impact on the rest of life. All participants noted the role of social influences on their mathematical identity and self-efficacy, including teacher competency. All participants also identified the overall social attitude toward mathematics as negative. It is clear through the data that the way in which participants experienced mathematics throughout their lives impacted how they view their students' own experiences with mathematics and how they navigate relationships with these students.

Hall et al. (2018) conducted a four-step qualitative study based on the Listening Guide method and shared data from one fifth-grade participant's autobiographical interview. This unique approach to qualitative analysis, which involves using interview data to create an "I poem," is relatively new to the field of mathematics education and provides understanding on the fluid nature of mathematical identity. The researchers praised the approach for providing an in-depth method for understanding the complex and layered construct of mathematical identity. Their work illustrates how students' mathematical identities can be contradictory and can be hidden underneath a desire to please as well as influenced by relationships with peers, families, and teachers. In addition to modeling an interesting option for data analysis, this study is relevant to my work because of its focus on the elementary student perspective.

From this literature, it is evident that the development of mathematical identity is a complex and fluid process that is influenced by a variety of factors. Students develop their identities as mathematical learners and doers in a social context and the learning

environment shapes this development, and, in turn, students' self-efficacy. While the body of research on mathematical identity is growing, most studies focus on high school or adult learners (Hall et al., 2018), which points to a need for further research on mathematical identity and factors that influence the development of positive mathematical identity in elementary school students.

Instructional Practices that Reinforce Negative Mathematical Identity

Because the learning environment can reinforce students' beliefs about mathematics and, ultimately, their beliefs about who they are as mathematical learners, Tobias (1990) suggests the classroom can be a "source of trauma for many young people" (p. 47), especially when mathematics is presented to students as a fixed set of procedures that are to be completed without question or flexibility. Such teacher-centered practices, as well as the use of timed tests, discourage mathematical learners and help set the stage for anxiety and negative attitudes.

Teacher-Centered Instructional Practices

Teachers' instructional decisions can have long-term effects on students' development of math anxiety and negative mathematical identity (Finlayson, 2014; Furner & Marinas, 2016; Lin et al., 2017; Núñez-Peña et al., 2013). The Scholar Academic ideology, whereby teachers are the transmitters of knowledge about the academic discipline(s) in which they teach, focuses on knowledge and content over specific students and emphasizes the use of textbooks. Schiro (2013) explains:

Within the Scholar Academic ideology, learning is the result of an intentional activity initiated by the teacher and deliberately aimed at the student. That which

is learned is primarily a result of activity on the part of the teacher and secondarily a result of activity on the part of the learner. (p. 47).

This type of one-size-fits-all curriculum with a rigid focus on only one pathway to get a correct answer and a heavy emphasis on the use of textbooks can foster math anxiety or negative attitudes and identity in learners (Anderson, 2007; Furner & Marinas, 2016).

In a teacher-centered classroom, the teacher does the majority of the talking and less mathematical thinking is constructed, while in a constructivist classroom, student conversations and thinking are encouraged (Van de Walle et al., 2010). When the learning environment focuses on the teacher as the giver of knowledge, the interest of today's learners may not be piqued, particularly those who already have a negative attitude toward mathematics (Davadas & Lay, 2018). Relying on independent work and mathematics tasks with a single correct answer can lead students to develop a positive mathematical identity if they are easily able to arrive at the correct answer. On the other hand, students who struggle to quickly arrive at the correct answer learn that they are not competent mathematical learners, even if they have developed strong conceptual strategies. Additionally, requiring students to follow one set of procedures repetitively without providing opportunities for them to make their own meaning may impact their view of themselves as mathematics competent (Anderson, 2007).

Conversely, Anderson (2007) reports, "When students are able to develop their own strategies and meanings for solving mathematics problems, they learn to view themselves as capable members of a community engaged in mathematics learning" (p. 9). Kulkin (2016) found that when students are given the opportunity to answer meaningful questions, they have the opportunity to overcome negative attitudes and math anxiety.

Similarly, Núñez-Peña et al. (2013) suggest that instructional practices encouraging students to focus on understanding over achievement can reduce math anxiety.

In a Canadian qualitative study, Finlayson (2014) investigated the causes of math anxiety and the strategies that 70 pre-service teachers found successful in overcoming math anxiety. A questionnaire uncovered participants' different manifestations of math anxiety, as well as the various root causes the participants associated with their anxiety. One major factor across their experiences with math anxiety was the use of teacher-centered instructional practices like direct, authoritative instruction focused on procedures over concepts and heavy reliance on workbooks and textbooks. Study participants reported an onset of anxiety when the pace was too fast for their comfort level and when memorization was forced. When categorizing participants' responses about strategies for overcoming their mathematics fears, many students' strategies illustrated constructivist teaching practices, such as active student engagement, teacher facilitation, encouraged risk-taking, a focus on student strengths and interests, and celebrating multiple approaches to doing the mathematics. The findings of this study highlight the need for replacing teacher-centered instructional practices in order to reinforce positive mathematical identity.

Timed Tests

One particular instructional and assessment practice often linked with high incidence of math anxiety and the development of negative feelings toward mathematics is timed testing (Boaler, 2014; Finlayson, 2014; Geist, 2010; Tobias, 1990). Among its damaging impacts is the pervasive myth that to be good at mathematics is to be fast (Boaler, 2014). In Finlayson's (2014) study, participants reported that time constraints

created anxiety, often leading them to draw a blank rather than focus on the mathematics. Timed tests in mathematics create controlling negative emotions for many students, particularly those who suffer from math anxiety. Beyond these negative emotions, the use of timed tests also sends a negative message: students learn that mathematics is about performance, competition, and evaluation and miss the diversity and applicability of the discipline (Boaler, 2014). Kling and Bay-Williams (2014) posit, “Timed tests offer little about how flexible students are in their use of strategies or even which strategies a student selects. And evidence suggests that efficiency and accuracy may actually be negatively influenced by timed testing” (p. 490). Because timed tests may lead to the development of math anxiety or negative mathematical attitude or perpetuate these negative emotions (Tobias, 1990), other assessment strategies are vital to promote a more positive mathematical identity.

Math Anxiety and Negative Attitudes Toward Mathematics

Because negative mathematical attitudes and math anxiety begin early in life, understanding the factors that influence their development is critical. Such factors include the roles of family, teachers, school, and culture.

Family Influence

Learners’ academic success and development is often associated with the role played by family in the life of the child (del Rio et al., 2017). Parents’ own experiences with and feelings toward mathematics, particularly their experiences with math anxiety, influence how they approach mathematics with their children and the messages they send about the discipline (del Rio et al., 2017; Geist, 2015; Gunderson et al., 2012; Kiwanuka et al., 2017; Krinzinger et al., 2009; Soni & Kumari, 2017). Tobias (1993) explains that

parents often excuse their child's struggle with mathematics because they believe they are not "mathematically-minded," either because of their own struggle with mathematics or because they find mathematics easy and cannot understand why their children struggle.

In a quantitative study focused on exploring the causal relationships between parents' experiences with math anxiety and their children's experiences with math anxiety and achievement, Soni and Kumari (2015) found that math anxiety displayed by parents impacted students' own experiences with math anxiety and negatively influenced students' attitudes toward the discipline. The study, which engaged 595 student participants ranging from 5th to 10th grades, as well as one parent of each student, led the researchers to conclude that parents' math anxiety serves as an antecedent to the experience of math anxiety and the negative mathematical attitudes of their children, which then negatively impact students' mathematical achievement as well.

Similarly, del Rio et al. (2017) investigated the influences of parents on their kindergarten students' performance in the number sense strand of mathematics in a quantitative study. The influence of the mother and father of the 180 participants was analyzed separately in terms of impact on numeracy achievement as well as the influence of expectations on the incidence of anxiety noted. Results indicated that parents who have high expectations and lower incidence of math anxiety are more likely to engage in number sense building practices with their students. The engagement of mothers in these practices correlated with the students' achievement rather than the engagement of fathers. The study illustrated how parents who fear mathematics or have had negative experiences with the subject are not confident to help their young mathematics learners.

Conversely, in her study of contextual factors impacting math anxiety in second-grade students, Jameson (2014) discovered that parental experience with math anxiety was an insignificant predictor. The purpose of this study was to investigate the factors, both environmental and personal, that affect the incidence and intensity of math anxiety in second graders. Such factors included gender, self-concept, self-efficacy, the incidence of parents' math anxiety, and home mathematics activity. By investigating influences traditionally linked with math anxiety in this young population, Jameson aimed to uncover how early math anxiety begins in young students. Jameson acknowledged that research indicates parental math anxiety is a predictor of math anxiety in older learners and suggested further research should determine the onset of this connection.

Maloney et al. (2015) conducted a quantitative field study on the relationship between parents' math anxiety and the achievement and math anxiety of first- and second-grade students. Sampling 529 students and their primary caregivers, the researchers found that when students have parents with math anxiety, the students themselves have more math anxiety and learn less mathematics throughout the course of the school year. However, this result was only consistent among students whose parents provided frequent help with mathematics homework, which provided the opportunity for parents to express their negative attitudes toward mathematics. Sharing such beliefs, the study concluded, may be "demotivating to children, likely reducing the amount of effort they invest in math and reducing the amount of math they learn and remember. As a result of learning less math, these children may then become more math anxious" (p. 1485).

Research indicates a correlation between home environment and students' experiences with math anxiety and illustrates how families have the potential to shape students' attitudes and beliefs about mathematics. While the onset and degree of this influence can vary, there is conclusive evidence that family members' experiences with mathematics can have detrimental impacts on the attitudes and experiences of children.

Teacher Influence

Much like families, teachers also play a role in influencing students' experiences with mathematics. Teachers' own experiences with negative mathematical attitudes or math anxiety can impact their confidence as mathematics teachers and, in turn, influence what and how they teach when it comes to mathematics (Beilock & Willingham, 2014; Dowker et al., 2016; Finlayson, 2014; Geist, 2015, Gunderson et al., 2012; Krinzinger et al., 2009; Stoehr, 2019). On the other hand, teachers who have had no struggles with mathematics can paint an unrealistic picture for students and lead them to believe that some people are "math people," while others are not (Tobias, 1993).

In a qualitative study on the effect of 31 Head Start teachers, Geist (2015) examined if teacher attitudes toward mathematics and opinions about their own mathematics proficiency impacted their approach to teaching mathematics. Participants with more anxiety had less confidence in their own ability to teach mathematics, while teachers who perceive themselves as competent mathematics learners and reported liking mathematics had more confidence in their mathematics teaching. Teachers who showed more confidence also identified a greater need for mathematics instruction in preschool and were more likely to teach mathematics, as well as to use developmentally appropriate teaching strategies. Based on these findings, Geist recommended professional learning

opportunities for Head Start teachers to focus on their own mathematical knowledge and confidence.

Similarly, in a study of the impact of teacher math anxiety on the achievement of students, Beilock and Willingham (2014) discovered that female students with female teachers who experience math anxiety have lower achievement at the end of the school year. This study included 17 teacher participants and 117 first- and second-grade student participants. A larger follow-up study was conducted with 70 teachers and 650 male and female students with similar results, indicating the impact that teachers' own math anxiety can have on the achievement of all students.

Ramirez et al. (2018) reviewed data from the National Mindset Study to determine if teacher math anxiety impacts the mindset and achievement of high school mathematics students. This quantitative data revealed that with higher math anxiety from teachers came lower student mathematics achievement as well as the student perception that not everyone is permitted to be good at mathematics. Additionally, the researchers noted how math anxious teachers use different teaching strategies that impact student performance and mindset.

Based on these studies, it is clear that teachers' own experiences with and attitudes toward mathematics can impact their students in terms of achievement as well as their mindset toward mathematics. The negative attitudes of teachers can influence their instructional decision-making as well as what mathematics they teach, how they teach mathematics, and their mindset toward the teaching and learning of mathematics.

School Influence

Beyond individual teachers, schools also play a role in students' mathematical identities. Schools are not only organizations for learning, but also provide space for a rich assortment of social experiences, which contribute to students' learning and growth (Radišić et al., 2015). The culture and learning environment in schools, the instructional focus and interventions offered, and how school transitions occur play a part in the development and perpetuation of negative mathematical attitudes and math anxiety in learners (Madjar et al., 2018; Radišić et al., 2015; Skagerlund et al., 2019).

In their study of the link between math anxiety, number sense, and working memory in college students, Skagerlund et al. (2019) investigated the extent to which math anxiety interferes with mathematical ability and working memory, the effect of math anxiety on avoidance, and the relationship of the type of mathematical task with the experience of math anxiety. A sample of 170 adult learners from a Swedish university were selected for the quantitative study using various measures of math anxiety, working memory, basic number processing, numeracy, and calculation. Results indicated a clear connection between math anxiety, working memory, and achievement, suggesting it is critical to create a rich mathematical learning environment in elementary school if educators hope to nurture positive mathematical attitude before students become adults. The investigators emphasized that early intervention in elementary school can make a tremendous difference in students' experiences with mathematics positivity versus math anxiety and reduce the need for similar interventions for adolescents and adults.

Through a 2015 analysis of recent Programme for International Student Assessment (PISA) survey data from over 4,000 adolescent students from 151 schools

across Serbia, Radišić et al. (2015) uncovered several connections between the school environment and students' experiences with math anxiety. During the reported PISA cycle, assessment questions focused on students' relationship with mathematics as an educational discipline as well as their experiences of math anxiety. The researchers sought to identify the connections among a variety of influencing variables such as the climate of the school and classrooms, motivation, attitudes, socioeconomic status, and students' experiences with mathematics and math anxiety. The most conclusive predictor of students' experiences with math anxiety was a lack of discipline in the classroom. Investigators also found that when the school mathematics instructional focus was formal and based on abstract concepts versus hands-on conceptual learning, students were more likely to experience math anxiety. Finally, study results indicated that an overwhelmingly strict school atmosphere is associated with higher incidences of math anxiety.

In a quantitative longitudinal study of the predictors of math anxiety in middle school students, Madjar et al. (2018) aimed to explore the development of math anxiety in middle school students over time and to examine associated factors such as school transition, gender, and achievement on this development. The study sample included 413 sixth graders from six Israeli elementary schools who participated in surveys and math anxiety questionnaires every six months throughout the study period. Madjar et al. learned that levels of math anxiety increase just before and after the transition from elementary school to middle school and decrease again once learners settle into middle school. The investigators indicate that the anticipation of changes within and across school during transitions has the potential to influence students' mathematics attitudes and worries.

It is clear from these studies that the school environment can influence the attitudes of learners and their experiences with math anxiety. Support through school transitions, the instructional focus of the school, discipline at the classroom and school levels, and the types of interventions provided can lead to the development of math anxiety and the perpetuation of negative attitudes toward mathematics in students if these experiences are negative.

Cultural Influence

Outside of school, being unsuccessful with mathematics has almost become a joke in American culture (Furner & Marinas, 2016). Noting the societal perception that mathematics is an art only for the most talented, Barba (2018) posits, “Popular culture exploits the eccentricities of mathematicians while at the same time lauding their significant achievements. As a result, we are made to believe that mathematicians are not regular people, doing mathematics is quick, and mathematics knowledge is obscure” (p. 13). Stereotypes associated with mathematics as well as societal pressure to conform can impact the beliefs and attitudes of mathematics learners (Foley et al., 2017). These societal misconceptions about who can be successful at mathematics can be detrimental to the development of positive mathematical attitudes.

In a discussion of mathematics attitudes across countries and cultures from their synthesis of research on math anxiety, Dowker et al. (2016) report that some dimensions are common; examples include the likelihood of mathematics attitudes becoming more negative as students get older and the inclination of young students to enjoy mathematics. On the other hand, the authors indicate that mathematics achievement and enjoyment differ across countries and cultures, as does the societal emphasis placed on mathematics

and its importance. In a similar synthesis of research on math anxiety's link to achievement, Foley et al. (2017) suggest the competitive environments and focus on high-stakes testing in varying countries can contribute to the increase in math anxiety as students become anxious about performing to the cultural expectations. Additionally, the researchers share that the variance in students' math anxiety as indicated in PISA data potentially reflects cultural differences instead of achievement differences.

Tobias (1990) also explored cultural influence when sharing interview data from hundreds of college-aged students suffering from math anxiety. All of the students could pinpoint the moment of the onset of their debilitating anxiety, which often occurred when students were told that people like them, whether according to race, gender, socioeconomic background, or other contextual factors, could not do or be successful at mathematics. Reflecting on the societal norms of the time, Tobias (1990) claimed, "Because our American culture is ambivalent about mathematicians as role models, some students decided they did not want to enter the field. Besides, math seemed dreary, never any fun" (p. 47). Subsequently, Tobias (1993) argued that until those most influential in the lives of students stop publicly allowing themselves to be fearful or indifferent toward mathematics, myths will continue to be perpetuated about who can be successful in mathematics. Tobias also emphasized the importance of debunking the myth that those who are successful at mathematics are naturally superior to those who are not.

The messages about mathematics accepted by American culture, though often myths, have the potential to negatively impact students' mathematics attitudes and feed feelings of math anxiety. With the impact of the media on students' perceptions of who they are and who they can and cannot be ever growing, it is critical to understand the

influence culture has on students' attitudes and beliefs about mathematics and themselves as mathematics learners.

Effects of Math Anxiety and Negative Attitudes toward Mathematics

Math anxiety and negative attitudes toward mathematics impact students in a variety of ways. Wilson and Raven (2014) posit, "It is a complex phenomenon, involving physiological symptoms, negative thoughts, avoidance behaviors, and poor cognitive performance" (p. 646). With the majority of U. S. citizens acknowledging their distaste for and fear of mathematics, the personal and national consequences of math anxiety are numerous (Andrews & Brown, 2015). When learners avoid mathematics due to math anxiety or a negative mathematical identity, there are implications for society, the economy, and politics in our country and globally (Wilson & Raven, 2014) as well personal consequences such as lifelong mathematics avoidance (Boaler, 2016).

Student Achievement

The connection between math anxiety and student achievement is widely reported in the literature from students as young as first grade through adult learners (Andrews & Brown, 2015; Dowker et al., 2016; Foley et al., 2017; Geist, 2010; Geist, 2015; Madjar et al., 2018; Maloney & Beilock, 2014; Ramirez et al., 2013; Ruff & Boes, 2014; Skagerlund et al., 2019; Sorvo, 2017). Many studies have indicated a link between the level of math anxiety experienced and students' grade point average or standardized test scores (Madjar et al., 2018). The impacts of math anxiety on students' mathematical performance are long lasting and can affect sufferers well into adulthood, potentially derailing career opportunities (Foley et al., 2017; Skagerlund et al., 2019).

Andrews and Brown (2015) conducted an exploratory observational study using data from a previously conducted *Freshman Orientation Survey* completed by 180 incoming freshmen at a southeastern university. The purpose of this study was to investigate the connection between students' previous experiences with math anxiety, achievement scores, and their success in mathematics courses during their freshman year at the university. Data were analyzed using descriptive, frequency, and correlational procedures. Study findings indicate that math anxiety impacts students' standardized tests scores. Additionally, most participating students suffering from math anxiety also earned lower final grades in mathematics. Based on study data, Andrews and Brown also suggest assessments in mathematics increase students' incidence of math anxiety as compared to their levels of anxiety during instruction in mathematics courses.

In another study on the impact of math anxiety on the mathematics skills of adult learners, Skagerlund et al. (2019) identified three ways mathematics achievement is impacted by math anxiety. The study's sample included 170 college students at a Swedish university. Participants completed a math anxiety rating scale as well as a numeracy and calculation assessment. From these data, researchers found that math anxiety influences the working memory of sufferers by creating an affective drop in performance and that learners who suffer from math anxiety also struggle with basic number processing. Moreover, the study established a clear correlation between math anxiety and the mathematics achievement of those who struggle with this anxiety in terms of arithmetic calculations.

Employing a mixed-methods action research approach, Ruff and Boes (2014) aimed to determine how math anxiety impacts fifth-grade student achievement and to

determine if school counselors can assist students in reducing math anxiety and mitigating its negative impacts. Through the first phase of the study, the researchers were able to identify a correlation between mathematics benchmark scores and the level of math anxiety indicated by students' responses to the Math Anxiety Scale for Children. Students showing high levels of math anxiety also did not meet the targeted scores on one or both sections of the mathematics benchmark assessment. As opposed to the two previously mentioned studies, these results indicate the link between math anxiety and mathematics performance in elementary-aged learners. Similarly, Ramirez et al. (2013) studied the link between math anxiety, working memory, and performance in mathematics in 154 first- and second-grade students from five urban elementary schools. Similar to results in older students and adults, students who reported feelings of math anxiety also had lower mathematics achievement scores, particularly if the student also had an average or above average working memory.

As these studies indicate, one of the most powerful effects of math anxiety is the impact on students' mathematics performance. This link appears across age groups and in varying contexts, with consistently serious consequences for students' future success.

Student Self-Efficacy

Students' self-efficacy determines their feelings, thoughts, motivation, and behaviors (Bandura, 1994). Arguably one of the most studied personal aspects in relationship to math anxiety, self-efficacy is frequently impacted by experiences with math anxiety and the often associated lower mathematics achievement. Students' perception of their mathematical ability is largely determined by their attitude toward mathematics (Soni & Kumari, 2017). Research indicates when students have negative

attitudes about mathematics and lower mathematics achievement, they also have lower self-efficacy, while the opposite is also true (Ashcraft, 2002; Grigg et al., 2018; Gurefe & Bakalim, 2018; Jameson, 2014; Jameson & Fusco, 2014).

In a quantitative study of the relationship between math anxiety, perceived mathematics self-efficacy, and learned helplessness in mathematics in 277 Turkish teacher candidates, Gurefe and Bakalim (2018) found that as math anxiety increased, students' self-efficacy decreased. Additionally, findings of the study indicate that students who continually suffer from math anxiety develop learned helplessness associated with mathematics, which can lead to mathematics avoidance and impact students' career choices.

In another study with 226 adult participants, Jameson and Fusco (2014) investigated math anxiety and its relationship with mathematics self-concept and mathematics self-efficacy in 166 adult learners as compared to 60 traditional undergraduate students. This quantitative study, which used the Abbreviated Math Anxiety Scale and Mathematics Self-Efficacy Scale, discovered that the non-traditional students were more likely to report higher math anxiety and lower mathematics self-efficacy when compared to traditional undergraduate students. These findings suggest that as the age of students increases, so does their level of math anxiety. Along with this increasing math anxiety comes lower self-efficacy in mathematics. These results underscore the need to eliminate math anxiety at an early age in order to avoid this increase in anxiety and decrease in self-efficacy.

Jameson (2014) also conducted a study on math anxiety and its associated factors with second-grade students from four schools in central Indiana. Noting the gap in

literature for knowledge about math anxiety in young students, particularly in relationship to mathematics self-efficacy, the researcher had 91 students and 81 parents complete a variety of surveys about math anxiety and contributing factors and effects including mathematics self-concept and mathematics self-efficacy. Study findings suggest that mathematics self-concept, which Jameson notes is an aspect of self-efficacy, is the most closely connected factor to math anxiety. These results indicate the connection between students' experiences with math anxiety and their self-efficacy, even as young as second grade.

While most literature on the connection between math anxiety and self-efficacy comes from studies of adult learners, the literature suggests this connection applies to early elementary students as well. The effects of low mathematics self-efficacy also point to mathematics avoidance and have implications for students' future career choices.

Effects on Higher-Level Mathematics and Careers

Math anxiety, even at a young age, has the potential to impact the rest of students' lives, including the mathematics courses they take, careers they pursue, and the comfort with which they take part in day-to-day activities (Andrews & Brown, 2015; Ashcraft, 2002; Boaler, 2016; Dowker et al., 2016; Foley et al., 2017; Galla & Wood, 2011; Geist, 2010; Geist, 2015; Haciomeroglu, 2017; Ramirez et al., 2013). In a discussion of the effects of math anxiety, Ashcraft (2002) reports, "Perhaps the most pervasive – and unfortunate tendency is avoidance. Highly math anxious individuals avoid mathematics. They take fewer elective mathematics courses, both in high school and in college, than people with low math anxiety" (p. 181). The impacts of taking fewer mathematics

courses are numerous and include lower wages, less job productivity, and fewer job promotions (Boaler, 2016).

Núñez-Peña et al. (2013) conducted an investigation on the influence of math anxiety and negative mathematics attitudes on the achievement of college students. One hundred ninety-three psychology students from the University of Barcelona took part in the study and completed a math anxiety questionnaire including additional questions about their motivation and appreciation for mathematics. These scores were compared with participants' achievement scores in a university course. The results of the quantitative study not only indicate that students' negative attitudes toward mathematics or math anxiety have an impact on academic performance, but also suggest these factors have the potential to impact students' work in higher mathematics courses and influence readiness for entrance into the workforce in STEM related careers.

Ramirez et al. (2013) suggest that identifying math anxiety in students at an early age and working to treat this anxiety is imperative as early math anxiety can mount and potentially lead to avoiding higher-level mathematics courses and careers in mathematics-related fields. Correspondingly, findings from Ahmed's (2018) study of "developmental trajectories of math anxiety during adolescence" (p. 158) and the relationship of these trajectories with students' later career choices, particularly in STEM fields, revealed that students with higher levels of math anxiety do not typically pursue careers related to mathematics. The mixed-methods longitudinal study followed a sample of 3,116 seventh grade students from across the country for an initial seven-year period to determine if students' experiences with math anxiety as adolescents would predict their career path after graduation. Based on the data, Ahmed (2018) suggests mitigating the

effects of math anxiety and negative mathematical attitudes during adolescence through interventions is imperative to students' success in STEM careers after graduation.

Based on the variety of evidence suggesting that negative mathematical attitudes and math anxiety can impact students' participation in higher-level mathematics and foster mathematics avoidance in their life and career choices, interventions to tackle these negative attitudes should be implemented as early as possible in students' mathematical careers.

Equal Access to Mathematics

When considering the debilitating impacts of math anxiety, the issue of equitable access to mathematics arises. Equity in mathematics access is one of the foundational principles of a high-quality mathematics education, informing the development of curriculum, instructional strategies, creation and analysis of assessments, and the match between teachers and students (National Council of Teachers of Mathematics [NCTM], 2000). This concept has been long discussed in the world of mathematics education (Secada & Meyer, 1989). As NCTM (2000) states, "Excellence in mathematics education requires equity – high expectations and strong support of all students" (p. 12). While providing this equal access to mathematics is a critical component of mathematics education, historically this access has been limited for students who struggle with mathematics, English Learners (ELs), students of color, students from low socioeconomic backgrounds, and females (Tobias, 1993; Van de Walle et al., 2010).

Gender is arguably one of the most studied factors associated with mathematics achievement, math anxiety, and equity in mathematics education, with considerable research suggesting a higher incidence of achievement in male students (Anis et al.,

2016; Ramirez et al., 2018; Tobias, 1993; Van de Walle et al., 2010). Ramirez et al. (2013) note that while the once reported achievement gap between male and female students has closed, the negative attitudes of female students can still impact their access to higher levels of mathematics and math-related career paths at a greater rate than boys. The researchers also find the persistent presence of a social stereotype about mathematics being a boys' discipline. As long as these stereotypes continue, the issue of gender equity in mathematics will persist.

NCTM (2000) states, "The vision of equity in mathematics education challenges a pervasive societal belief...that only some students are capable of learning mathematics" (p. 12). In order to truly achieve this vision of equitable mathematics education for all students, teachers must challenge this societal belief and make efforts to mitigate the effects of math anxiety and help all students develop a positive mathematical identity.

Conclusion

The construct of math anxiety is well documented in the literature over the past 60 years. The causes and effects of this anxiety, as well as negative attitudes toward mathematics, have been studied internationally, particularly in adolescent, teenage, and adult learners. Some of the most influential factors in students' development of math anxiety are parents, teachers, and school and cultural influences. The effects of this anxiety are numerous, with the impact of math anxiety on student achievement as one of the most frequently studied effects. Student self-efficacy is also damaged by experiences with math anxiety, leading students to believe they are unable to learn and do mathematics. The lower achievement and self-efficacy students deal with as a result of negative attitudes toward mathematics and math anxiety often leads to mathematics

avoidance, which ultimately limits career opportunities and inhibits students' equal access to mathematics, particularly for females.

The concept of mathematical identity, the way in which students identify themselves in relationship to mathematics, has gained attention over the past two decades and adds to the conversation on math anxiety. Mathematical identity is a complex, multi-faceted construct that is renegotiated frequently based on students' individual and social experiences. Much of the research on mathematical identity focuses on teenage and adult learners. However, research does indicate that the instructional practices to which students are exposed can be very influential on the development of mathematical identity. The use of teacher-centered practices and timed tests has been linked with the development or perpetuation of math anxiety and negative mathematical beliefs in students, whereas evidence suggests that constructivist teaching practices can help support the development of positive mathematical relations.

With the causes and effects of negative mathematical attitudes and math anxiety well established in the literature, the importance of eliminating this anxiety and mitigating its effects is apparent. It is also clear that the learning environment and teacher practices shape students' experiences with mathematics, their self-efficacy, and ultimately their mathematical identities. Despite the variety of literature on math anxiety and mathematical identity, much of the literature focuses on older learners, with little research involving primary- or upper-elementary-aged students. This action research study addresses this gap by investigating the way in which constructivist instructional practices may disrupt math anxiety and support positive mathematical identity development in upper-elementary students.

CHAPTER 3

METHODOLOGY AND METHODS

This chapter outlines the convergent parallel mixed-methods action research study (Ivankova, 2015) designed to address my problem of practice. The themes of constructivism, identity – specifically mathematical identity, and communities of practice provided the theoretical framework for this study and thus underpin all design aspects.

As noted in Chapter 1, the purpose of this action research study was to explore the best practices for constructing positive mathematical identity and to discover and eliminate the practices that foster negative mathematical identity or math anxiety in my fifth-grade students. In my twelve years of experience teaching fourth and fifth graders, a rise in the number of students demonstrating symptoms of negative mathematical identity or math anxiety caused me to wonder what I could do as a practitioner to improve the outcome for these learners, especially because my own experience with mathematics avoidance and anxiety as a student provided insight into the detrimental impacts these negative attitudes could have on students' academic and day-to-day lives.

Given that developing students' science, technology, engineering, and mathematics (STEM) skills has been on the forefront of recent educational reform (Foley et al., 2017), this problem is significant beyond my classroom. Research points to the impact negative mathematical identity or math anxiety can have on students' achievement, potentially disrupting students' readiness for STEM careers (Foley et al., 2017; Geist, 2010, 2015; Soni & Kumari, 2015; Tobias, 1991). Alarming, research

shows that a negative attitude toward mathematics, often to the point of math anxiety, can begin even before students reach elementary school (Geist, 2010, 2015). Thus, identifying strategies to help students develop positive mathematical identity is crucial for all students to enjoy an equal prospect for academic and personal success.

To determine best practices for the construction of a positive mathematical identity and discover ways to mitigate the effects and causes of math anxiety, I conducted a convergent parallel mixed-methods action research study. Action research flexibly addresses a potentially complex problem through cycles of action (Dick, 2015; Herr & Anderson, 2015). An additional benefit of action research inquiry is the improvement of educators' practice and the positive impact on students' learning (Efron & Ravid, 2013; Merriam & Tisdell, 2016). Through a mixed-methods approach, the combination of quantitative and qualitative methods drew from the strengths of each method (Efron & Ravid, 2013). Both qualitative and quantitative methods were used to give an in-depth and full picture of the problem and results of the intervention.

Using the design described, I investigated the following research questions:

- 1) How does negative mathematical identity and/or math anxiety impact my students?
- 2) What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced?
- 3) How do constructivist-aligned instructional strategies affect mathematical identity in fifth-grade students?

These questions specifically addressed a need in the research setting given the rise of students with negative feelings toward mathematics. My findings can inform my future instruction and improve the strategies used to teach mathematics in my classroom.

Context, Participants, and Researcher Positionality

A discussion of the school and classroom setting and study participants, as well as my positionality as a practitioner researcher provides the context for this study.

Setting and Participants

The study was conducted in a Title I school in one of the most affluent and rapidly growing school districts in the Southeastern United States. Our district, located in the suburbs of a large city, serves over 17,000 students in 17 schools in a town that covers only about eight square miles. The current student enrollment for my school is 814 students. Of this population, 48% identify as female and 52% identify as male. Additionally, 32% of these students live in poverty and 24% of students receive free or reduced-priced lunch, indicating financial need. It is this factor that informs the school's Title I status. Title I is part of the Elementary and Secondary Education Act (ESEA) and provides funding for specific schools and/or districts that require financial support to meet the needs of students from low-income families in order to ensure all students have the opportunity to rise to challenging academic expectations (Snyder et al., 2019).

As a fifth-grade classroom teacher, I worked with my own fifth-grade students for this study. All 24 mathematics students were invited to take part in the study, and all students and their guardians provided informed consent (See Appendix E). However, only 23 students ultimately participated in the study because one student transitioned to homebound instruction. Of these 23 participants, 16 were from my homeroom and

therefore spent the entire day in my classroom, while the remaining seven participants were from another teacher's homeroom. Of the 23 participants, 13 were female and 10 were male. According to fall data from the Star mathematics test (Renaissance Learning, 2016), a nationally normed online mathematics assessment for 1st-12th grade learners used by my district, my mathematics students' scores ranged from the 6th percentile to the 90th percentile, with a median percentile rank of 43.

From the larger sample of 23 students, six participants were invited to participate in semi-structured interviews based on evidence of negative self-efficacy and/or above average levels of math anxiety. While only consenting students with indicators pointing to the highest levels of math anxiety and the lowest level of mathematical self-efficacy were interviewed, all students participated in the intervention as the changes to instructional practice impacted all learners. Merriam and Tisdell (2016) report, "Purposeful sampling is based on the assumption that the investigator wants to discover, understand, and gain insight and therefore must select a sample from which the most can be learned" (p. 96). For the purposes of this study, the full sample of students provided the most information from which to draw conclusions to inform my practice. During our mathematics lessons, students participated in daily activities designed to build a positive mathematical identity in addition to constructivist-aligned, student-centered mathematics learning experiences informed by survey and interview data. Strategies included the use of bibliotherapy, collaborative grouping with mathematics toolkits, tasks that focus on developing mathematical mindsets, and self-reflection opportunities.

Researcher Positionality

It was through my experience in this research setting that I identified the problem of practice for this study. For the past eleven years, I was a fourth-grade teacher in a variety of contexts in this same rapidly growing Southeastern school district. In my experience at two different elementary schools within our district, I had the opportunity to teach students in one of the district's most affluent schools and in my current setting, which is one of only two Title I schools in our district. I taught self-contained classes of students identified as gifted and talented as well as heterogeneous classes with many students working far below grade level in mathematics. Despite the differences in school setting and differing levels of achievement and socioeconomic status of my students, the problem of negative mathematical identity and math anxiety observed in students upon entering fourth grade has been constant, though more pronounced in the current setting. When offered the unique opportunity to loop up from fourth grade (in 2018-2019) to fifth grade (in 2019-2020) with my students, I was eager to have a second year to work with the students in hopes of getting to the bottom of this problem before students leave the elementary school and begin their middle school careers. As an insider participant researcher, I conducted this study with my own students in hopes of also informing my instructional practice.

With this insider status, I was mindful of my role within my school and classroom when conducting this study. As Herr and Anderson (2015) state, the familiarity with the research context and participants can lead to bias and assumptions that must be considered. The immersive nature of insider action research required me to consider how my own beliefs and experiences shaped my insights and interpretations (Efron & Ravid,

2013). As a teacher conducting research with my own students, I also had to be mindful of the potential power imbalance, particularly when conducting interviews about math anxiety, which can be a sensitive topic. However, my own experiences with negative mathematical identity and math anxiety gave me unique positionality and allowed me to empathize with my students.

Research Design

To investigate the impact of constructivist-aligned instructional strategies on students' mathematical identity and determine which practices contribute to students' development of negative mathematical identity, I employed convergent parallel mixed-methods action research.

Historical Review of Methodology

The decision to employ a mixed-methods action research methodology was based on the historical and current applications of this paradigm along with the nature of the problem of practice, theoretical framework, and research questions of this study.

Action Research

Action research methodology is most often defined as an inquiry led by practicing educators in localized settings with a goal of advancing their own practice and making improvements to the learning of their students (Efron & Ravid, 2013). Mertler (2009) expands upon this definition by suggesting that action research “focuses specifically on the unique characteristics of the population with whom a practice is employed or with whom some action must be taken” (p. 4). As such, action research is a highly reflective, but systematic, process (Herr & Anderson, 2015) defined by cycles of action (Dick, 2015; Herr & Anderson, 2015).

Action research dates back to the progressive era of education in the early 20th century and to the work of John Dewey and others who believed that educators should reform education by putting their ideas to the test and taking action on their developing theories (Efron & Ravid, 2013). Though John Collier is credited with coming up with the term *action research*, Kurt Lewin is credited with developing action research theory, making it a reputable option for research (Efron & Ravid, 2013; Herr & Anderson, 2015; Townsend, 2014). According to Efron and Ravid (2013), action research was brought onto the educational research scene in the 1950s by Stephen Corey, who saw it as a way for practitioners to make changes to instructional practices and curriculum through their own inquiry. Since the 1980s, action research has gained popularity in many fields, particularly education, because of its focus on solving practical problems, improving practice, and empowering participants to make social changes (Ivankova, 2015).

Efron and Ravid (2013) characterize action research as constructivist, situational, practical, systematic, and cyclical. While step-by-step procedures for action research are used, “in reality, action research is much more dynamic, fluid, and - at times - messier than is implied by the linear description of the process” (Efron & Ravid, 2013, p. 8). The practical, cyclical, and even messy, nature of action research provided me flexibility as a practitioner-researcher to gather data that will not only improve my own practice in my research setting, but also improve the learning environment for my current and future students. Additionally, the constructivist nature of action research (Efron & Ravid, 2013; Ivankova, 2015) connects with the constructivist framework for this study. With action research focused on systematic cycles of action, my knowledge as a researcher and

practitioner was constructed throughout this cyclical process in the context of my classroom environment and the community of practice developed throughout the study.

Action research is practical in that it is conducted in specific settings and produces a benefit for those involved in that setting; therefore, the goal of action research is the improvement of practitioner-researchers' practice, not necessarily the construction of new knowledge (Townsend, 2014). According to Herr and Anderson (2015), "practitioner researchers often want to study their own contexts because they want the research to make a difference in their own setting" (p. 2). This was certainly the case for my study. The problem of negative mathematical identity, often leading to math anxiety, has been consistently observable across my career as a classroom teacher. Further, this problem deeply impacted my own life as a mathematics learner. As such, action research was a fitting approach because of my hope for positive changes for my students and other students in my school who may suffer from math anxiety or negative mathematical identity. Through this study, I also hoped to improve my own practice as a mathematics teacher.

Mixed-Methods Approach

Mixed-methods research is categorized by the collection of both qualitative and quantitative data in a research inquiry (Ivankova, 2015). Creswell and Creswell (2018) state, "The core assumption of this form of inquiry is that the integration of qualitative and quantitative data yields additional insight beyond the information provided by either the qualitative or quantitative data alone" (p. 4). Further, Creswell et al. (2011) suggest that mixed-methods research is the best approach when neither qualitative nor quantitative approaches alone are adequate to generate a complete understanding of the

research problem. Ivankova (2015) notes this integration can occur at different points and to different degrees in each study, based on the research problem, questions, and design.

The origin and rise of mixed-methods research is an area of uncertainty and debate. Many researchers believe the approach is relatively new, starting less than 40 years ago, while others argue it is much older (Ivankova, 2015; Teddlie & Tashakkori, 2009). Despite these differing views, Ivankova (2015) reminds readers that mixed-methods research is “an effective and advantageous approach to research” that is “now extensively applied” (p. 14) in many fields.

The benefits of mixed-methods research are many. Efron and Ravid (2013) find that mixed-methods research can cross the “boundaries between worldviews and blend (or combine) qualitative and quantitative research methods and techniques into a single study” (p. 45) and therefore draws from the strengths of both qualitative and quantitative research (Creswell & Creswell, 2018; Ivankova, 2015). An additional benefit is the opportunity for the triangulation of research findings (Creswell & Creswell, 2018; Efron & Ravid, 2013; Ivankova, 2015). By employing mixed-methods, I was able to use both quantitative and qualitative measures to gather data to answer my research questions, give story to the quantitative data, and create a richer picture of the research problem and the effect of the intervention. By collecting both quantitative and qualitative data pre- and post-intervention, I was able to compare and integrate the various data to more fully understand participants’ experiences with mathematical identity and math anxiety.

Specific Research Design

To best answer the research questions, I employed a convergent parallel mixed-methods design. This specific type of research uses concurrent timing of the qualitative

and quantitative aspects of the research process and gives equal priority to both. In this type of design, the qualitative and quantitative data are analyzed separately, then compared and related during the interpretation phase of the study (Creswell & Plano Clark, 2011; Ivankova, 2015). I used quantitative and qualitative measures pre-intervention to gather specific data about students' experiences with the discipline of mathematics. Then, during the two-phase intervention, qualitative and quantitative data were collected concurrently through the use of a daily exit slip and a teacher journal. Finally, after the intervention period, quantitative and qualitative data were collected again in the form of surveys and semi-structured interviews. The various data were analyzed independently before I integrated the qualitative and quantitative data to determine the impact of the intervention on students' mathematical identity formation.

Data Collection Methods

Consistent with my convergent parallel mixed-methods design, I used a variety of qualitative and quantitative data collection instruments to gain a fuller picture of the problem as well as to determine the effectiveness of the intervention (See Table 3.1).

Quantitative Measures

The quantitative measures for this action research study were two formal surveys: The Math Anxiety Scale for Young Children – Revised Version (MASYC -R) (Ganley & McGraw, 2016) and a researcher-created survey (See Appendices A & B). Smaller-scale surveys were used after each day's lesson during the intervention period through the use of a Google Forms exit slip (See Appendix D). Surveys are one of the most commonly used means of data collection (Efron & Ravid, 2013; Ivankova, 2015) and have many benefits. Surveys are often used in mixed-methods action research studies to gather

Table 3.1 *Data Collection Methods*

Method	Data Type	Description and Frequency	Research Question Alignment
Math Anxiety Scale for Young Children-Revised Version (MASYC-R) (See Appendix A)	Quantitative	Completed by all participants prior to the study to gather baseline data about student experiences with math anxiety and to aid in selecting participants for semi-structured interviews	RQ #1
Researcher-Created Likert-Scale Survey (See Appendix B)	Quantitative	Completed twice by all participants to gather more specific data about students' mathematics attitudes and experiences with math anxiety – at the beginning of the research study and again at the end of the intervention period	Pre: RQ #1 Post: RQ #1, RQ #3
Semi-structured Interviews (See Appendix C)	Qualitative	Completed before and after intervention with 6-8 participants to gather qualitative data about student attitudes and experiences	Pre: RQ #1 Post: RQ #1, RQ #3
Google Form Exit Slips (See Appendix D)	Quantitative Qualitative	Completed daily after mathematics lesson during the two intervention cycles, including 2 Likert-scale survey questions (QUANT) and one open-ended question (QUAL)	RQ #2, RQ #3
Teacher Journal	Qualitative	Completed daily at the end of each lesson during the two intervention cycles as a memory aid about body language, comments, and emergent themes	RQ #1, RQ #2, RQ #3

quantitative data from fixed-response questions to “collect attitudes and opinions on the studied issue from a large group of people” (Ivankova, 2015, p. 197) and can be used to identify specific needs, inform instruction, and determine participant attitudes (Efron & Ravid, 2013). Ivankova (2015) finds that surveys are beneficial to gather background information on participant perspectives in a relatively short period of time. Surveys also can be used post-intervention in action research studies to collect data on the effect of the intervention. Further, surveys serve as effective tools to help identify appropriate participants for follow-up semi-structured interviews (Efron & Ravid, 2013; Ivankova, 2015). Thus, surveys played an integral role in collecting pre- and post-intervention data during this mixed-methods action research study.

As one aim of this study was to disrupt students’ negative feelings about mathematics, I used surveys to gain insight into their current attitudes toward mathematics and the experiences that have shaped their mathematical identities. To specifically learn more about participants’ incidence of math anxiety, the MASYC-R (See Appendix A) was administered to all participants in my classroom during the mathematics block several weeks before the intervention. This questionnaire measures students’ feelings about mathematics using a 4-point Likert Scale for 13 items organized into three groups: Negative Reactions, Numerical Confidence, and Worry (Ganley & McGraw, 2016).

Additionally, pre-intervention, a 10-question researcher-created survey (See Appendix B) was administered during a subsequent mathematics block. As suggested by Efron and Ravid (2013), the research questions and literature review informed the development of this survey, which sought more specific data about the influencing

factors on students' mathematical identities, self-efficacy, anxiety, and student mathematics learning preferences. Like the MASYC-R, this researcher-created survey used a 4-point Likert Scale, intentionally avoiding the option of a neutral choice (Efron & Ravid (2013). The researcher-created survey was also used post-intervention to measure change in students' feelings and determine the effectiveness of the action research intervention.

In addition to the two formal surveys, smaller-scale surveys in the form of exit slips (See Appendix D) were used at the end of each lesson during the intervention period. Exit slips are short surveys or writing opportunities for students to “digest ideas, to question, to ponder, to ruminate over what has been shared and discussed in class,” and ultimately to document their learning (Leigh, 2012, p. 190). To gather specific data about which instructional practices promote the development of negative mathematical identity (in alignment with Research Question #2), these short exit slips elicited students' overall feelings after each lesson and also had an open-ended question regarding how the instructional practices impacted their view of themselves as mathematicians. These exit slips allowed participants to express their evolving attitudes toward mathematics, particularly their self-confidence, and reflections on the specific content and instructional strategies. Like other surveys, the exit slips also included 4-point Likert-scale questions (Ivanokva, 2015). To keep data organized and expedite analysis, daily exit slips were completed using a Google Form, which sorted data by participant.

Qualitative Measures

Qualitative measures, semi-structured interviews and a teacher journal (See Appendix C), gave story to the experiences of the study participants and fostered a richer

understanding of the problem and the impact of the intervention. Ivankova (2015) reports, “An interview is the most common data source in action research” (p. 201) and suggests interviews should be guided by a 10- to 15-question interview protocol consisting of open-ended questions and probes. Semi-structured interviews provide detailed firsthand perspective on the problem or topic of interest and can be implemented both pre- and post-intervention (Efron & Ravid, 2013; Ivankova, 2015).

Based on the results of the MASYC-R and the teacher-created survey, I invited six participants identified to have above average levels of math anxiety and/or below average mathematical self-efficacy to participate in interviews. These semi-structured interviews were conducted pre- and post-intervention to hear students’ feelings about mathematics as a discipline and about themselves as mathematicians and to discover what previous experiences formed their mathematical identities. As Merriam and Tisdell (2016) suggest, the pre-intervention interviews surfaced past events that shaped participants’ attitudes and identities, recording the contexts that aided students in constructing negative mathematical identities. This pre-intervention information assisted in designing and selecting intervention tasks to help participants construct a more positive mathematical identity and mitigate the effects of math anxiety. While the protocol consisted of seven standard questions, the use of a semi-structured format provided some flexibility and the opportunity to respond to participants’ answers with further probes or clarifying questions while also allowing emerging themes to fully develop (Efron & Ravid, 2013; Merriam & Tisdell, 2016). This was especially helpful while working with my fifth-grade participants as follow-up questions and new lines of questioning became apparent through our discussions of such sensitive, difficult to discuss themes.

One-on-one semi-structured interviews took place in the grade level science lab during the daily intervention block to ensure the privacy of participants. Merriam and Tisdell (2016) suggest, “The way in which questions are worded is a crucial consideration in extracting the type of information desired” (p. 117), encouraging familiar language. Interview questions used kid-friendly language and were developed based on Patton’s (2015) six types of good questions—experience and behavior, opinion and values, feeling, knowledge, sensory, and background/demographic questions—to glean a full range of information from participants. Further, the school guidance counselor reviewed the interview questions to ensure their quality. At her suggestion, I changed the wording of the second question, which originally asked students what makes them most nervous about mathematics. I removed the word nervous from this question as it could be leading and instead used students’ answers to the first question about their feelings about mathematics to guide the phrasing of this question. The interviews were video-recorded, with permission from participants and their guardians, and transcribed for analysis. The use of video allowed me to note student responses as well as facial expressions and other nonverbal forms of communication.

A teacher journal served as another source of qualitative data. Anecdotal records entered into the journal throughout the intervention period included observed body language, student comments, and behaviors, as well as my own insights and questions throughout the process. The journal also housed notes about emerging themes brought up in the intervention lessons, which guided further development of activities for the intervention period. As Efron and Ravid (2013) suggest, journal entries were completed

as soon as possible after daily intervention activities and organized based on the research questions for the study. Entries were digitally transcribed to facilitate data analysis.

Data Collection Challenges and Considerations

When planning for data collection, I considered the challenges associated with each measure. In terms of quantitative data, one potential challenge was the collection and analysis of daily exit slips from all 23 students. This was a time-consuming endeavor, despite the use of a digital exit slip. When considering potential challenges of the qualitative measures and collection, one challenge associated with the use of semi-structured interviews was the amount of time required for transcription (Ivankova, 2015). An additional consideration was the time required to complete the teacher journal. As our mathematics block ended only 15 minutes before lunch and recess duty, I had to diligently jot notes as they came to mind during class and solidify my thoughts during the time before lunch. To expedite my journaling, I took quick anecdotal notes during class, which then became a memory-aid during the 15-minute reflection time when I typed my digital teacher journal.

Research Procedure

Ivankova (2015) proposes a new framework for mixed-methods action research with six sequential, but interconnected, phases of action: diagnosing, reconnaissance, planning, action, evaluation, and monitoring. During the diagnosing phase of the mixed-methods action research cycle, a problem is identified and a rationale for a mixed-methods approach emerges (Ivankova, 2015). For this phase, I identified the problem of negative student mathematical identity, potentially leading to math anxiety, and

determined that a mixed-methods approach would yield the best data to fully understand the problem as well as the impact of the proposed intervention.

The second phase identified by Ivankova (2015) is reconnaissance in which the problem is investigated to help develop a plan of action or intervention. In this phase, I conducted the literature review presented in Chapter 2, which revealed that my problem of practice is well documented in the literature and has the potential to stand in the way of equitable access to future opportunities. Based on this assessment of the available literature, per Ivankova's third phase, I created the plan of action described below and continued to the acting phase, when the intervention was implemented.

Table 3.2 provides the timetable for the study, which originally included two four-week intervention cycles. However, due to the immediate closure of schools during the COVID-19 pandemic, Phase 2 lasted only two weeks.

For this convergent parallel mixed-methods action research study, I had three weeks pre-intervention to gather consent documents (See Appendix E) as well as preliminary data before beginning the first phase of intervention. After obtaining informed consent from both the student participants and their guardians, I administered the MASYC-R and the researcher-created survey. Based on the data generated from these surveys as well as my knowledge of students' experiences and responses in the mathematics classroom, six participants were selected for semi-structured interviews, which were completed over the course of the next week. Based on the data gathered from these surveys and interviews, I planned the first four-week intervention cycle.

Table 3.2 Study Timetable

Week(s)	Events
1-3 (Pre-intervention preparations)	<ul style="list-style-type: none"> • Gathered informed consent from participants and guardians • Gave the MASYC-R • Gave the researcher-created survey • Analyzed surveys • Selected participants for semi-structured interviews • Conducted semi-structured interviews • Analyzed data to plan Intervention Phase 1
4-7 (Intervention Phase 1)	<ul style="list-style-type: none"> • Conducted daily intervention as part of daily mathematics lesson • Gathered daily exit slip data • Recorded in teacher journal • Analyzed data from exit slips to plan Intervention Phase 2
8-9 (Intervention Phase 2)	<ul style="list-style-type: none"> • Conducted daily intervention as part of daily mathematics lesson • Gathered daily exit slip data • Recorded in teacher journal • Analyzed data from exit slips
10+ (Evaluation Phase)	<ul style="list-style-type: none"> • Gave the post-intervention survey • Conducted post-intervention interviews • Analyzed quantitative and qualitative data separately • Integrated quantitative and qualitative data for interpretation • Analyzed new inferences gleaned from the data collection and analysis to determine if revisions or further intervention were necessary to answer research questions • Made recommendations based on data

During Intervention Phase 1, participants took part in daily student-centered mathematics lessons, which addressed the mathematics content from the grade-level long-range plans through a constructivist-aligned strategy and/or a mini-lesson designed to guide students in developing a mathematical mindset. Throughout, students were engaged in developing a mathematical mindset. Throughout, students were engaged in learning collaboratively and solidifying a classroom community of practice (Wenger, 1998). The specific strategies were selected based on student responses in the pre-

intervention data and included the writing of a mathematical autobiography, student-centered mathematics lessons with the teacher acting as facilitator, and the frequent use of bibliotherapy – a technique that uses carefully selected literature based on children’s needs as a discussion and reflection starter (Lucas et al., 2019). At the end of the mathematics lesson each day, students completed a Google Form exit slip to reflect on their experience of the day’s mathematics lesson.

Exit slip data and notes from my teacher journal during the first four-week intervention cycle guided my plans for the second cycle. This transitional analysis phase mirrored the fifth stage of Ivankova’s (2015) framework: evaluation, during which data are analyzed and interpreted, including any necessary integrated findings. Based on these findings, I moved into the sixth phase of the framework: monitoring, during which researchers use the new information gleaned from the previous phases to refine and revise the plan if necessary. Based on what I learned from Phase 1, I refined the plan and began Phase 2.

Strategies shown to be especially impactful on students were implemented with more frequency in Phase 2. Additional strategies highlighted in Jo Boaler’s (2016) *Mathematical Mindsets* were also planned for implementation in this second cycle to determine the impact of varying constructivist-aligned strategies on students’ development of mathematical identity. As noted earlier, Phase 2 was abbreviated due to the COVID-19 pandemic, although all participants completed the post-intervention researcher-created survey through Google Forms during the subsequent period of remote learning, and follow-up semi-structured interviews were conducted with the original interview participants using Google Meet.

At the end of the post-intervention data collection, I re-entered the evaluation phase by separately analyzing the qualitative and quantitative data before comparing and making connections to draw conclusions from the integrated data. In the sixth phase, the monitoring phase, I analyzed the new inferences gleaned from the data collection and analysis to answer the research questions.

Treatment, Processing, and Analysis of Data

Merriam and Tisdell (2016) assert, “Data analysis is the process of making sense out of the data...it is the process of making meaning” (p. 202). For the data in this mixed-methods action research study to be used in meaningful ways in the research setting, quantitative and qualitative data were analyzed separately and then compared and contrasted before making interpretations and drawing conclusions through a mixed-methods data analysis approach labeled *triangulation design* (Efron & Ravid , 2013).

MASYC-R Analysis

To analyze the quantitative MASYC-R data, the 4-point Likert scale was used to associate point values with each response. Total scores for each student were calculated by the section, mindful that the questions in the Numerical Confidence category were reverse-coded (Ganley & McGraw, 2016), which ensured students had carefully read each statement before selecting an opinion (Efron & Ravid, 2013). The first section of the MASYC-R, Negative Reactions, has four questions, with responses of 4 representing *yes*, 3 representing *kind of*, 2 representing *not really*, and 1 representing *no*. This section was scored out of 16, with scores over 8 indicating increased negative reactions. In the Numerical Confidence section, three questions yielded responses of 4 representing *a lot better*, 3 representing *a little better*, 2 representing *a little worse* and 1 representing *a lot*

worse. This section was scored out of 12, with scores less than 6 indicating lower than average numerical confidence. The final section, Worry, consists of six questions with responses of 4 representing *always*, 3 representing *often*, 2 representing *sometimes*, and 1 representing *never*. This section was scored out of 24, with scores over 12 indicating higher than average worry associated with mathematics. Data were organized by category, and students with scores demonstrating below average attitude or above average anxiety in multiple categories were considered for semi-structured interviews.

Teacher-Created Survey Analysis

The researcher-created survey also used a 4-point Likert scale, wherein 4 represented *always*, 3 represented *most of the time*, 2 represented *sometimes*, and 1 represented *never*. Comprised of ten questions, the survey data were originally collected out of 40 possible points for both pre- and post-intervention surveys. Upon analysis, however, I realized that the first six questions of the survey elicited information about attitudes and beliefs, while the final four questions asked about students' learning preferences. For this reason, I separated the data. The attitudes and beliefs section (six items) constituted 24 total points to determine students' feelings about mathematics and themselves as mathematics learners both pre- and post-intervention. The mean values for the first section of the survey were determined and then compared through the use of a paired *t*-test to identify the difference between pre- and post-intervention data (Efron & Ravid, 2013). As I will explain in Chapter 4, this analysis uncovered the value of the intervention by indicating a change in pre- and post-intervention survey scores.

Quantitative Exit Slip Analysis

Participant exit slip data were collected digitally through daily Google Forms, exported to Google Sheets, and labeled based on the specific instructional strategy. As the two quantitative survey questions used 4-point Likert Scales, individual student totals were recorded daily. Originally, I planned to calculate a total score out of 8 for the two questions, but upon analysis, I realized that the questions gathered different information, so data were reported separately and the mean values for each question were calculated daily and recorded with the instructional strategy used for that day. As I will illustrate in Chapter 4, these data demonstrated the effectiveness of the intervention and students' confidence associated with each strategy or practice.

Semi-Structured Interview Analysis

Qualitative data analysis was on-going throughout the study to allow for further development of the research design (Merriam & Tisdell, 2016). Pre-intervention semi-structured interviews were videoed, and I transcribed them myself. Transcriptions were coded, grouped into charts, and further analyzed to identify salient themes and emerging patterns (Efron & Ravid, 2013; Merriam & Tisdell, 2016). Interview data shaped the activities selected for the intervention period, illuminated specific areas of need for the participants, and aided in the selection of strategies to help participants construct a positive mathematical identity. Additionally, transcriptions recorded specific causes of math anxiety and negative attitudes to gain insight into how to potentially avoid this phenomenon. Post-intervention semi-structured interviews were similarly videoed and transcribed, coded, grouped, and analyzed to determine overarching themes. These data were compared with the pre-intervention interview data to identify areas of growth and

determine the overall effectiveness of the intervention strategies in light of the second and third research questions. Post-intervention interview data were also used to further build answers to the second research question: What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced?

Qualitative Exit Slip Analysis

The final portion of the daily exit slip completed using Google Forms was an open-ended question eliciting student reflection on the day's activities. These responses were exported daily into Google Sheets, labeled with the date and the day's instructional strategy/practices, and coded for emergent themes specific to participants as well as in association with the instructional practice used each day. These data informed further instructional shifts within the intervention period and provided guiding information when planning post-intervention semi-structured interview questions.

Teacher Journal Analysis

The anecdotal notes from my physical teacher journal were transcribed daily and elaborated upon in the digital teacher journal housed in Google Docs. Each day's entry was labeled with the date and the specific instructional strategy/practices used. The digital journal was coded regularly throughout the intervention period for recurring themes to guide the further development of intervention activities. Recurring themes were color-coded and highlighted and this information was included in a chart to help organize these data. Developing themes noted from the journal data were used to drive the development of activities tailored to the specific roots of negative identity and anxiety demonstrated by participants. The developing themes emerging from these data also informed the post-intervention interview questions and probes.

According to the triangulation design approach for mixed-methods data analysis, after collecting and analyzing the pre- and post-intervention data for the qualitative and quantitative instruments, the body of data was compared in light of the research questions to determine the most appropriate answers to each question. Further, content analysis was used to compare the data according to the overarching themes that emerged throughout the study (Efron & Ravid, 2013). When analyzing the data, each source was considered in light of the three research questions guiding this study and the theoretical framework of the study as outlined in Table 3.3.

Ethical Considerations and Quality Criteria

As with all research, principles of ethics apply to this mixed-methods action research study. As a researcher using both qualitative and quantitative data collection methods, I considered the ethical demand of both of these approaches (Ivankova, 2015). To ensure trustworthiness and validity of this mixed-methods study, a variety of measures were employed. Prior to beginning the study, I obtained university Institutional Review Board (IRB) approval as well as approval at the local level from my school district and secured informed consent from both guardians and student participants (See Appendix E). As part of this informed consent, overall study procedures were disclosed and participants were reminded that participation was voluntary and could be stopped at any point. The emotional, physical, and mental well-being of all participants was constantly monitored to ensure they were safe. Further, I preserved participants' confidentiality by using pseudonyms and password-protected Google accounts that required unique logins. The teacher journal used in this study was locked in a file cabinet each day.

Table 3.3 *Research Design Alignment*

Research Question	Theoretical Framework Alignment	Data Sources
How does negative mathematical identity and/or math anxiety impact my students?	<ul style="list-style-type: none"> • Mathematical identity <ul style="list-style-type: none"> ○ Identified the extent to which participants experienced negative mathematical identity and/or math anxiety and the implications in the classroom 	<ul style="list-style-type: none"> • MASYC-R (QUANT) • Researcher-created survey (QUANT) • Teacher journal (QUAL)
What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced?	<ul style="list-style-type: none"> • Mathematical identity <ul style="list-style-type: none"> ○ Identified how specific classroom activities and instructional practices contributed to the development of negative mathematical identity • Communities of practice • Identified how the classroom community could be used to help students negotiate their mathematical identity 	<ul style="list-style-type: none"> • MASYC-R (QUANT) • Researcher-created survey (QUANT) • Exit slip (QUAL/QUANT) • Teacher journal (QUAL)
How do constructivist-aligned instructional strategies affect mathematical identity in fifth-grade students?	<ul style="list-style-type: none"> • Constructivism <ul style="list-style-type: none"> ○ Instructional strategies selected based on constructivist learning theory • Mathematical identity <ul style="list-style-type: none"> ○ Identified how student mathematical identity was impacted by various instructional strategies • Communities of practice <ul style="list-style-type: none"> ○ Noticed how the classroom community, developed as a result of the instructional strategies, impacted students' negotiation of their mathematical identity 	<ul style="list-style-type: none"> • Researcher-created survey (QUANT) • Semi-structured interviews (QUAL) • Exit slip (QUAL/QUANT) • Teacher journal (QUAL)

I also applied quality standards to my data collection instruments. The Math Anxiety Scale for Young Children – Revised (MASYC-R) has been found reliable and valid based on previous results (Ganley & McGraw, 2016). The researcher-created survey was designed for reliability by including clear questions using kid-friendly language and appropriate responses that match the questions. I also avoided prompts that might have made assumptions or created bias (Efron & Ravid, 2013) and invited the school mathematics coach to review the survey accordingly. As previously mentioned, the school guidance counselor also reviewed the survey and interview questions to ensure they were appropriate, free of bias, and free of assumptions. All interview questions were research-based to ensure quality (Patton, 2015) and were reviewed by a grade-level teacher to ensure suitability for fifth-grade interviewees. The teacher journal provided the opportunity for me as an insider to screen for my own bias and practice self-reflexivity (Efron & Ravid, 2013).

In line with the constructivist paradigm, the strategy of disconfirming evidence was used to analyze the data for themes counter to those originally emerging in the analysis to inspect the variety of perspectives from which a theme could be viewed (Creswell & Miller, 2000). Creswell and Miller (2000) recommend thick, rich description and prolonged engagement in the field to validate data analysis, particularly with qualitative data. My role as fifth-grade classroom teacher provided the prolonged engagement in the field, as I was a regular part of the day-to-day school happenings for each participant, providing a level of trust from the beginning of the study. Thick, rich description was used to lend voice to the participants and situate the reader in the context of the research setting to promote credibility within the data analysis.

As with any research study, there are limitations that came with this research plan. The relatively small sample size might have limited the interpretations and conclusions that could be made from the data. However, by only selecting participants from my own class, I was able to control most aspects of the study and gather data based on my own instructional practices. The smaller sample of students invited to participate in the semi-structured interviews allowed for thorough analysis of the data, as opposed to attempting to conduct, transcribe, and analyze dozens of interviews.

Another limitation is related to the relatively short intervention window. With only six-weeks of intervention, the change in student mathematical identity may be less significant than would be noted in a longer study. Though brief, the use of two intervention cycles was manageable for a practitioner researcher and allowed enough time to document student responses to a variety of constructivist-aligned instructional strategies. Also, while the intervention period ended after six weeks, I had the opportunity to finish the school year with these students and continue informally gathering data about the impact of these instructional shifts, though this was also limited by the implementation of remote learning due to the COVID-19 pandemic.

Conclusion

As detailed in this chapter, I employed a convergent parallel action research methodology to investigate the impact of constructivist-aligned instructional strategies on student development of mathematical identity and determine the effects of classroom practices on students' development of negative mathematical identity. This methodology allowed me to investigate how my own instructional decisions can affect my students' mathematical identities and determine which instructional practices to add to and take

away from my daily practice. Through the use of qualitative and quantitative measures in a two-part intervention based on Ivankova's (2015) mixed-methods methodological framework for action research, I gained critical information to improve student learning and my practice as a mathematics teacher.

CHAPTER 4

DATA ANALYSIS AND FINDINGS

This chapter presents the findings from a two-phase constructivist-aligned intervention aimed at discovering the impact of math anxiety and negative mathematical identity on my students, investigating the strategies that support the development of negative mathematical identity, and determining how to replace those strategies. These goals addressed a problem of practice in my classroom, as introduced in Chapter 1. The findings are presented in light of the research questions and through the theoretical lenses of constructivism, mathematical identity, and communities of practice.

As noted in Chapter 3, I used a variety of data collection opportunities in an effort to understand how my students' experiences with mathematics have affected their development of mathematical identity and/or math anxiety. Based on these data, I designed a two-phase intervention that endeavored to replace practices that promote a negative mathematical identity in favor of constructivist-aligned instructional strategies.

Throughout data collection, I kept my research questions in view:

- 1) How does negative mathematical identity and/or math anxiety impact my students?
- 2) What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced?
- 3) How do constructivist-aligned instructional strategies affect mathematical identity in fifth-grade students?

These questions were investigated using a convergent parallel mixed-methods action research approach, as described in Chapter 3.

To understand the data analysis, it is also important to operationalize self-efficacy and mathematical identity as these definitions inform how the research questions are answered. For the purposes of this study, self-efficacy refers to students' beliefs about, and confidence in, their own competence to effectively navigate the mathematics in the classroom and beyond. Similarly, for this study, mathematical identity refers to students' story about who they are as mathematicians and their beliefs about their own capacity to confidently interact with mathematics in their day to day lives. Students' self-efficacy and mathematical identity were measured using the Numerical Confidence and Worry sections of the MASYC-R, the attitudes and beliefs items on the researcher-created survey, and the confidence question on the Google Forms daily exit slip. Additionally, student responses to semi-structured interview questions and my notes in my teacher journal provided insights into students' confidence, self-efficacy, and mathematical identity.

This chapter provides a detailed description and analysis of my data and the interpretations made during analysis. As explained in Chapter 3, a variety of methods, including daily student exit slips and a teacher journal, provided abundant data and rich descriptions of the daily impacts of the intervention. Pre- and post-intervention surveys and semi-structured interviews also measured the impact of the intervention on students' attitudes and beliefs about mathematics and themselves as mathematics learners.

Pre-Intervention Data

Before intervening, I needed to understand participants' attitudes and feelings about themselves as mathematics learners and their general feelings toward the discipline. Based on quantitative data from two surveys, I selected six students for semi-structured interviews to further investigate their attitudes and perceptions. These data informed the specific intervention activities and also served as pre-intervention baseline data.

Pre-Intervention Math Anxiety Scale for Young Children-Revised Results

The Math Anxiety Scale for Young Children – Revised Version (MASYC-R) (Ganley & McGraw, 2016) was administered to all 23 participants two weeks before the intervention. Students had a paper copy of the survey, and to ensure readability for all participants, I also read the questions aloud. Table 4.1 presents the results of the questionnaire by item and category (Negative Reactions, Numerical Confidence, and Worry).

To analyze these data, each student's total score was calculated by category and data were further disaggregated to determine the number of students who indicated increased negative reactions toward mathematics, lower than average numerical confidence, and higher than average worry. For the Negative Reaction and Worry categories, participants scoring half or more of the total points in these categories were noted. For the reverse-coded Numerical Confidence section, participants scoring less than half of the total points were noted. Figures 4.1, 4.2, and 4.3 show the results: 39% of students reported increased negative reactions to mathematics, 43% of students reported less than average numerical confidence, and 82% of students indicated higher than average worry about mathematics.

Table 4.1 MASYC-R Responses

	4	3	2	1	Mean	Mode
Negative Reactions	Yes	Kind Of	Not Really	No		
1. Math gives me a stomachache.	1 (4.3%)	4 (17.4%)	4 (17.4%)	14 (60.9%)	1.7	1
2. When it is time for math my head hurts.	1 (4.3%)	4 (17.4%)	4 (17.4%)	14 (60.9%)	1.7	1
3. I am scared in math class.	4 (17.4%)	3 (13%)	2 (8.7%)	14 (60.9%)	1.9	1
4. My heart starts to beat fast if I have to do math in my head.	8 (34.8%)	4 (17.4%)	6 (26.1%)	5 (21.7%)	2.7	4
Numerical Confidence	A lot better	A little better	A little worse	A lot worse		
5. I like doing math problems on the board in front of the class.	6 (26.1%)	6 (26.1%)	3 (13%)	8 (34.8%)	2.4	1
6. I like to raise my hand in math class.	5 (21.7%)	4 (17.4%)	7 (30.4%)	7 (30.4%)	2.3	2 & 1
7. I like being called on in math class.	5 (21.7%)	4 (17.4%)	5 (21.7%)	9 (39.1%)	2.2	1
Worry	Always	Often	Sometimes	Never		
8. I get nervous about making a mistake in math.	8 (34.8%)	3 (13%)	8 (34.8%)	4 (17.4%)	2.7	4 & 2
9. When the teacher calls on me to tell my answer to the class, I get nervous.	5 (21.7%)	7 (30.4%)	5 (21.7%)	6 (26.1%)	2.5	3
10. I get worried before I take a math test.	8 (34.8%)	5 (21.7%)	7 (30.4%)	3 (13%)	2.8	4
11. I get nervous when my teacher is about to teach something new in math.	0 (0%)	4 (17.4%)	9 (39.1%)	10 (43.5%)	1.7	1
12. I get worried when I don't understand something in math.	9 (39.1%)	5 (21.7%)	8 (34.8%)	1 (4.3%)	3	4
13. I feel nervous when I am doing math.	3 (13%)	3 (13%)	7 (30.4%)	10 (43.5%)	2	1

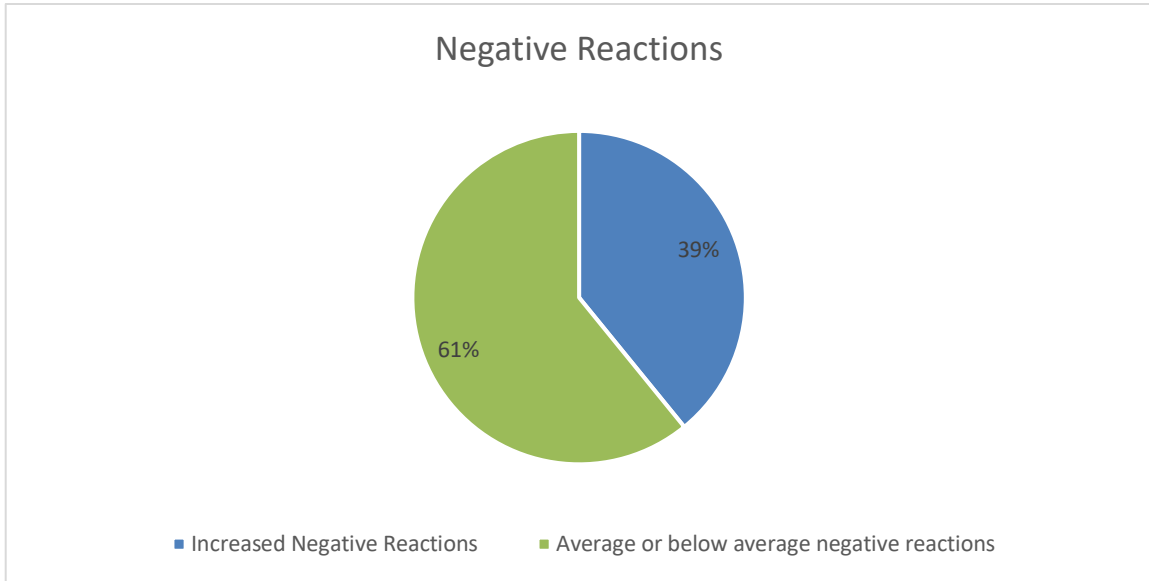


Figure 4.1 Visual representation of scores in the Negative Reactions section of the MASYC-R.

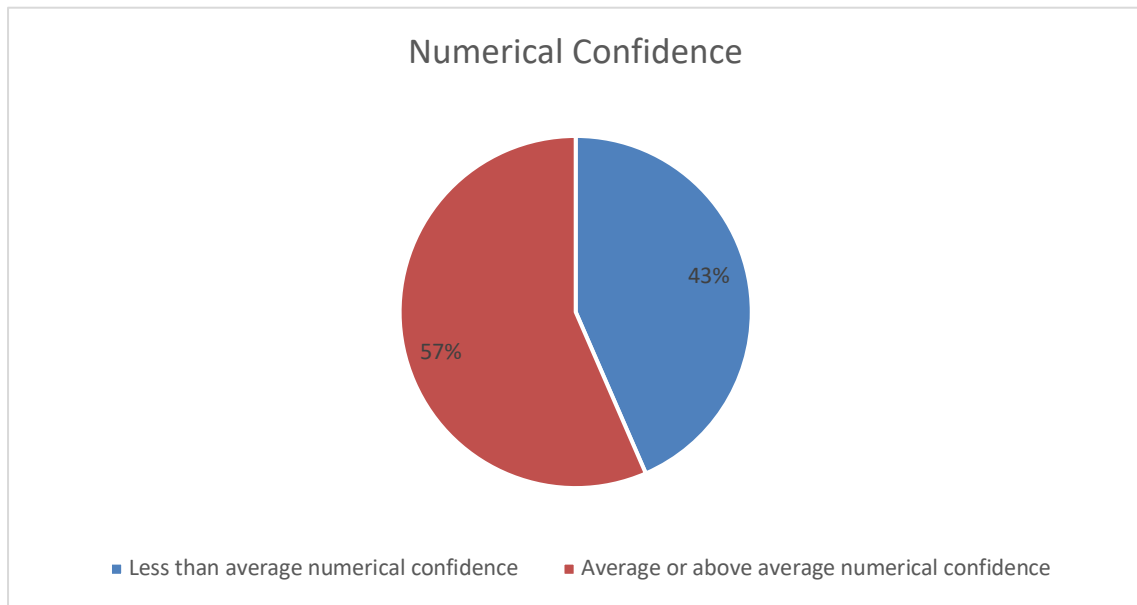


Figure 4.2 Visual representation of scores in the Numerical Confidence section of the MASYC-R.

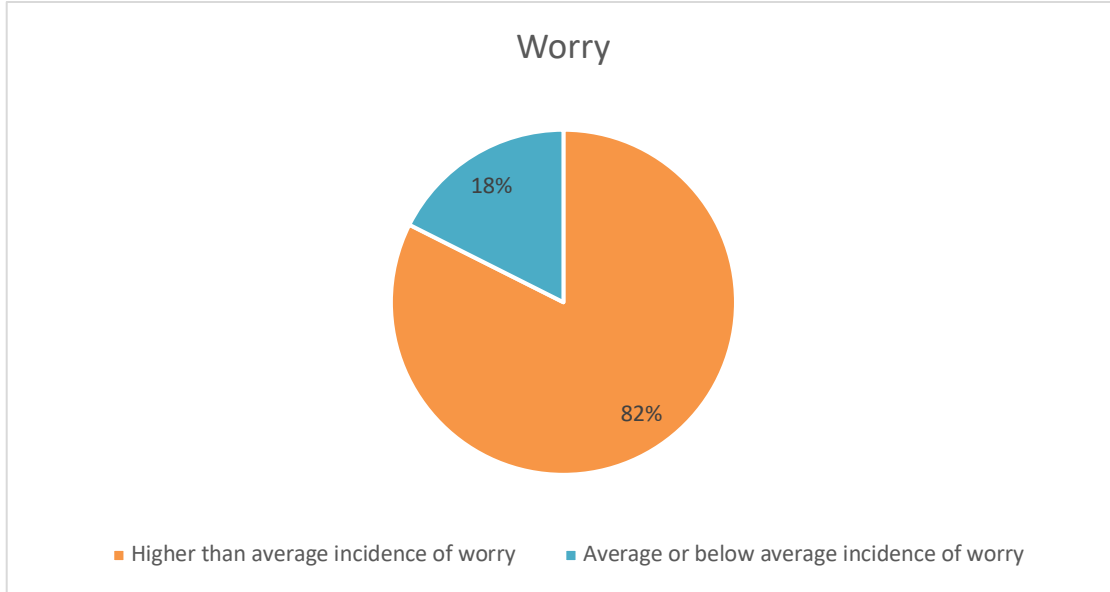


Figure 4.3 Visual Representation of Scores in the Worry Section of the MASYC-R

The class average for each category was also determined (See Table 4.2), revealing that 9 participants scored above the class average of 7.8 in terms of negative reactions toward mathematics, 11 participants reported numerical confidence lower than the class average of 7.0, and 12 students reported worry about mathematics above the class average of 14.6. Participants scoring higher than the class average in the Negative Reactions and Worry categories and lower than the class average in the Numerical Confidence categories were considered for semi-structured interviews.

Table 4.2 MASYC-R Average Student Score by Category

	Negative Reactions (out of 16)	Numerical Confidence (out of 12)	Worry (out of 24)
Class Average	7.8	7.0	14.6
# Students	Above Average: 9 Below Average: 14	Above Average: 12 Below Average: 11	Above Average: 12 Below Average: 11

Further analysis yielded several takeaways. In the Negative Reactions section, more than half of students reported little or no physical reactions to mathematics like headaches or stomachaches, while 52% of students reported experiencing rapid heart rate. From the Numerical Confidence section, nearly half of the class (47.8%) lacks confidence when coming to the board to solve a problem, while 60.8% lack confidence when raising their hands and being called on in mathematics class. From the Worry section, a large percentage of students worry about making mistakes in mathematics (47.7%) and not understanding mathematics content (60.8%), while relatively few students are worried when the teacher is about to teach something new (17.4%). Data from the Numerical Confidence and Worry sections of this survey indicate that many of my students have low self-efficacy and potentially negative mathematical identity. Data collected from the MASYC-R thus confirmed what I have observed about these students in my time as their teacher over the last two school years and further fueled my desire to understand students' experiences with mathematics and improve my practice to support their development of a more positive relationship with mathematics.

Pre-Intervention Researcher-Created Survey Results

After giving the MASYC-R, I administered the 10-question researcher-created survey to gather more specific quantitative data. Students rated six statements related to their attitude toward mathematics, their perceptions about current and future applications of mathematics, their confidence levels in mathematics class and during assessments, and their comfort level as problem-solvers. The last four items consisted of statements about students' learning preferences in the mathematics classroom. The answer choices for all 10 items were *always*, *often*, *sometimes*, and *never*, corresponding to a 4-point Likert

scale. As with the MASYC-R, students received a paper copy of the researcher-created survey, and I also read each question aloud to ensure equal access to the questions. The results of the questionnaire, by item, are provided in Table 4.3.

As mentioned in Chapter 3, during analysis, I decided to group the statements according to their purpose. The results for items 1-6 provided a more in-depth look at students' attitudes toward mathematics and beliefs about themselves as mathematics learners, while items 7-10 pertained to students' mathematics learning preferences. Thus, responses for 1-6 (Attitudes and Beliefs) were analyzed separately from responses for 7-10 (Learning Preferences). For the first six statements, each student's score was calculated out of a total of 24 possible points to determine an overall Attitudes and Beliefs score. I noted 3 students (13%) scored below 12 points, or 50% of the total (See Figure 4.4). I also calculated the class average for the Attitudes and Beliefs questions: 15.9 out of 24. Ten of the 23 participants scored at or above this average, while 13 students (57%) scored below (See Figure 4.5) and were considered for semi-structured interviews.

The results from the Attitudes and Beliefs questions provided several insights about students' self-efficacy as mathematics learners and about their mathematical identities. First, while nearly 61% of participants indicated they always or often like mathematics, only 43.5% reported always or often feeling confident in mathematics, and only 39.1% reported feeling confident during mathematics assessments. Nearly 61% of students reported only feeling confident during assessments sometimes or never. Further, 56.5% of students reported never or only sometimes feeling confident in their problem-solving skills. Collectively, this indicated a lack of confidence in mathematics for the

Table 4.3 *Researcher-Created Survey Responses*

	Item	Always 4	Often 3	Sometimes 2	Never 1	Mean	Mode
Attitudes and Beliefs	1. I like math.	4 (17.4%)	10 (43.5%)	8 (34.8%)	1 (4.3%)	2.7	3
	2. I think math is useful to my daily life.	5 (21.7%)	7 (30.4%)	9 (39.1%)	2 (8.7%)	2.7	2
	3. I think math will be important to my future.	11 (47.8%)	7 (30.4%)	3 (13%)	2 (8.7%)	3.2	4
	4. I feel confident during math class.	6 (26.1%)	4 (17.4%)	9 (39.1%)	4 (17.4%)	2.5	2
	5. I feel confident during math assessments.	6 (26.1%)	3 (13%)	7 (30.4%)	7 (30.4%)	2.3	2 & 1
	6. I can use my problem-solving skills to figure out challenging problems.	5 (21.7%)	5 (21.7%)	11 (47.8%)	2 (8.7%)	2.6	2
Learning Preferences	7. I like to learn math by practicing independently.	3 (13%)	4 (17.4%)	4 (17.4%)	12 (52.2%)	1.9	1
	8. I like to learn math in small groups.	13 (56.5%)	8 (34.8%)	2 (8.7%)	0 (0%)	3.5	4
	9. I like to learn math by collaborating with others.	13 (56.5%)	7 (30.4%)	3 (13%)	0 (0%)	3.4	4
	10. I like to learn math by working with my teacher.	10 (43.5%)	9 (39.1%)	4 (17.4%)	0 (0%)	3.3	4

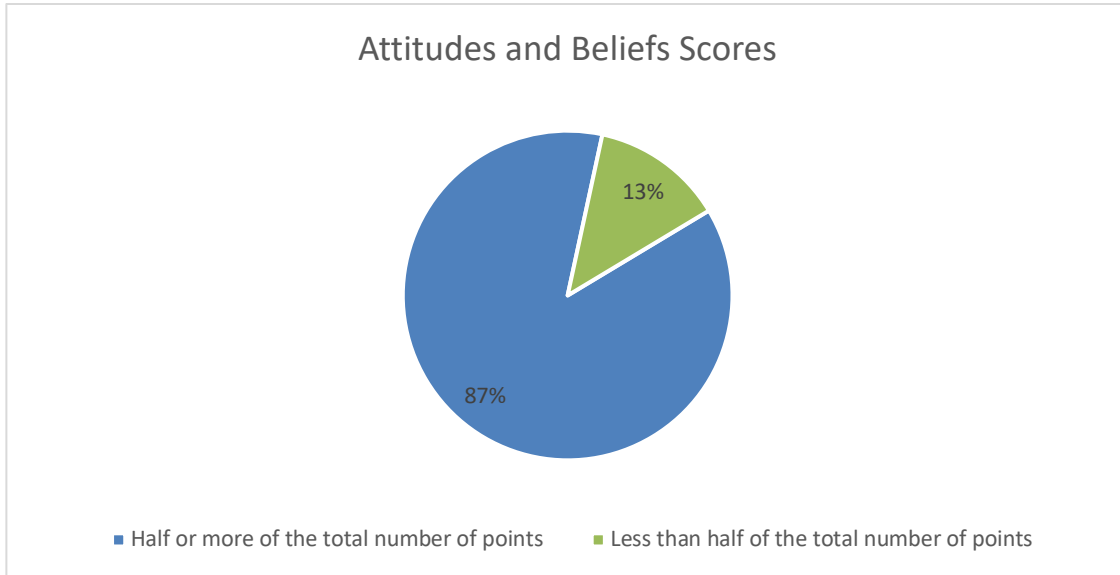


Figure 4.4 Visual Representation of Scores above 12 on the Attitudes and Beliefs Statements in the Researcher-Created Survey

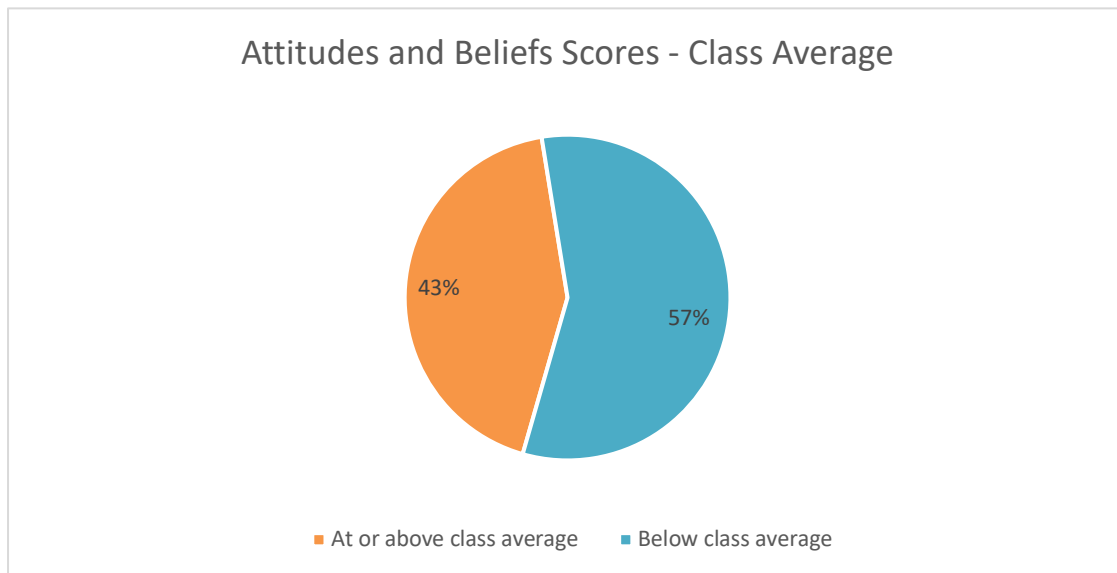


Figure 4.5 Visual Representation of Scores in Relation to the Class Average on the Attitudes and Beliefs Statements in the Researcher-Created Survey

majority of study participants and underscored the need for intervention. Interestingly, only 52.1% of participants always or often find mathematics relevant to their daily lives, but 78.2% always or often believe mathematics will be important to their future. This indicated a gap in students' recognition of the current day-to-day application and usefulness of mathematics, which provided context for understanding their mathematics learning preferences, which were gauged in items 7-10.

Data from questions 7-10 were analyzed based on each statement and revealed that study participants much prefer to learn mathematics in small groups, in collaboration with others, and when working with the teacher versus working independently. Just over 30% of students reported always or often enjoying learning mathematics through independent practice, while 91.3% of participants reported always or often enjoying mathematics in small groups, 86.9% always or often found mathematics collaboration enjoyable, and 82.6% always or often found learning mathematics with the teacher enjoyable. These data significantly impacted the intervention design, as I will explain in a later section.

Pre-Intervention Semi-Structured Interviews

As indicated above, based on the data from the MASYC-R and the researcher-created survey, six participants were selected to participate in pre-intervention semi-structured one-on-one interviews due to higher than average incidence of negative reactions and worry about mathematics and lower than average incidence of numerical confidence and positive mathematical attitudes and beliefs. Interviewees, whom I refer to using pseudonyms below, included five females and one male student whose scores indicated the least confidence and most worry or negative reaction to mathematics.

Interestingly, the male interviewee was the only male in the class whose scores consistently indicated low mathematics confidence and negative reactions to mathematics. As explained in Chapter 3, all semi-structured interviews were video-recorded and transcribed to identify themes. Student participants responded to seven questions from the Semi-Structured Interview Protocol (Appendix C) as well as further probes based on their initial responses.

Student responses to question 1, *How does math make you feel?* included a variety of physical and emotional reactions to the discipline. Four of the six participants reported mixed feelings. Haleigh said, “Sometimes when there’s hard questions and stuff, it makes me nervous, but when I’m doing stuff with a group it doesn’t make me feel nervous.” Sabrina’s thoughts were similar, and she noted that some lessons were easy, but other times, lessons “make me feel like I can’t do it at all.” A couple of participants indicated a negative physical reaction to mathematics. Katie said, “It kind of makes me feel worried and have a big knot in my stomach and makes me sweat a lot.” She went on to add, “Oh, and a headache!” Similarly, Jaden reported feeling nauseous during mathematics time.

The second interview question was designed to ascertain the causes of these reactions by asking: *What makes you most _____ [student response to previous question] when doing math?* Jaden noted that new things make him most nauseous in mathematics, while Katie stated, “getting something wrong or just doing it without understanding” makes her nervous or worried. Haleigh reported getting confused when she has to work alone or follow along in a whole-group lesson. Zoe and Sabrina both mentioned being worried or nervous to be called on to share an answer and not knowing it or being caught off guard. Blaire and Sabrina also mentioned specific nervousness

about assessments. Specifically, Sabrina stated, “During our math tests, like if I really can’t figure it out and I try as best as I can...when I go over and...ask for help, it just makes me feel like I need to cry.” A couple of the students mentioned specific concepts in mathematics that make them nervous or worried, including fractions and division.

Question three asked: *What kind of math lessons do you like most/least? Why?* Students reported enjoying lessons including the use of hands-on materials and mathematics toolboxes with mathematics manipulatives and also mentioned an enjoyment for working in small groups, particularly with the teacher, and playing games. Haleigh said, “I like the easy ones” and went on to explain, “the lesson is easy when I’m doing it with a group...and when I know what to do.” Blaire stated, “I like small groups because they are, like, easier to practice in and you get more practice.” The lessons students like least include working independently, working in a test-like environment or when the assignment resembles a test, and working on word problems. Over half of the interviewees mentioned their disliking working on mathematics individually. For Sabrina, being timed during mathematics workshop is also hard for her, especially when she is working independently. Blaire, on the other hand, mentioned having a hard time when working on mathematics in a whole-group format because she must cooperate with too many people.

The fourth interview question asked: *How do you learn math best?* All interview participants mentioned working in small groups, either with the teacher or in collaboration with other students. Zoe mentioned using mathematics tools, while Blaire preferred working in small groups with the teacher and in small collaborative groups because it is “easier because you get to ask more questions.” She followed up that she is

more comfortable asking questions in a smaller group. Similarly, Jaden shared that working in small groups or with the teacher is his preferred way to learn mathematics. Katie said she learns mathematics best “when it’s one-on-one mostly because it’s easier when someone talks to me and not talks to a whole group because then other people will distract me and it’s easier for me to understand when it’s just one-on-one.” Working with others is also helpful for Sabrina, who noted that having multiple people explain a concept is helpful.

The fifth interview question was: *What was your worst math experience?* Zoe said, “probably when I was trying to work out a problem and then I got called on and I didn’t know the question, so I just had to say that I didn’t know.” Haleigh reported her worst mathematics experiences as “when I have to do math in my head.” When probed, Haleigh clarified that estimating is hard for her. Sabrina said that her whole fourth-grade mathematics experience was the worst. When pressed for examples, she said that fractions were the hardest. Katie recalled a time when she did not have enough time to study for a test as her worst mathematics experience. I asked her what she would say is the optimal time to have to prepare for an assessment. She reported needing at least three days in class and three days at home to study. Similarly, Blaire’s worst experience was when mathematics was taught with the whole group and she did not get as much practice as she needed, leaving her feeling unprepared for a quiz, while Jaden’s worst mathematics experience was receiving a bad test score.

Conversely, question six asked: *What was your best math experience?* Students’ best experiences included times when they did well academically on assessments, when they worked in small groups to learn mathematics, and when they knew the answers to

the questions. Sabrina recounted an experience in fourth-grade mathematics class when we used what we had learned about fractions to create a recipe for ice cream and then made ice cream sundaes. She was quick to note, “It wasn’t the fact of we’re making ice cream, it was the fact of...using something I was used to.” Because she considers herself good at baking and cooking, she felt confident using fractions as tools for real-life activities. Haleigh said her best mathematics experiences are when she has mathematics tools to use.

Recurring themes were noted across the interviews, such as students’ fearing making mistakes or being called on to answer a mathematics question, especially when unsure of the answer. Several students mentioned being worried about mathematics assessments and grades. Most students were able to pinpoint a specific strand of mathematics that they dislike or fear. Additionally, the interviews clearly established students’ preference for small groups and collaboration with peers and teachers, rather than working independently. Students’ candid responses extended my understanding of the survey data and helped me glean insight into their general and specific fears, likes, and dislikes for mathematics learning.

Pre-Intervention Data Interpretations

The pre-intervention quantitative data collected from the two surveys and the qualitative data collected from the semi-structured interviews confirmed observations I have made over the two years I have spent working with this group of students and yielded answers to my first research question: How does negative mathematical identity and/or math anxiety impact my students? The MASYC-R results identified a large percentage of my students with higher than average negative reactions to mathematics,

lower self-confidence as mathematics learners, and worry associated with mathematics. The results from the researcher-created survey indicated the majority of the class likes mathematics and finds it useful, particularly to their future endeavors, while reiterating students' lack of confidence in mathematics class. Student responses also indicated a strong desire for small-group and collaborative work and a general dislike for learning mathematics independently.

Interview data gave story to the quantitative data, highlighting specific areas of concern as well as learning preferences. I learned more about how students are especially anxious about mathematics assessments and working independently in mathematics and that they enjoy collaborating with one another and working in small groups. Interviews also unveiled students' specific anxieties about making mistakes in mathematics and being called on as well as worries about mathematics grades. I also learned more about students' physical reactions to mathematics, including headaches and stomachaches, as well as feeling the need to cry.

Together, these data indicate specific impacts of math anxiety or negative mathematical identity in my students, answering the first research question. Negative attitudes and anxiety lead to physical reactions, worry, and low self-efficacy as mathematics learners. These data also begin to point to answers to the second research question: What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced? Students indicated anxiety associated with independent work, tests, and being called on to share answers when unprepared. I thus designed intervention lessons to replace these practices.

Impact on the Intervention Design

The pre-intervention data from the MASYC-R, the researcher-created survey, and the semi-structured interviews pointed to the need for constructivist, student-centered practices with ample opportunity for students to explore concepts in collaboration with their peers. My students clearly crave social interaction in order to grapple with concepts and make sense of mathematics together. Further, the data encouraged me to plan real-world learning experiences that are more applicable from a fifth-grader's perspective.

The data provided specific insight into students' anxiety about mathematics assessments and fears of making mistakes. Based on this information, I was challenged to research constructivist-aligned assessment practices that would allow students more authentic, less anxiety-inducing opportunities to show content mastery. I also concluded that resources on growth mindset and normalizing making mistakes would enhance the intervention. It was clear, based on these data, that the intervention cycles should focus on positive social interactions, as well as small-group and one-on-one learning opportunities.

My own experiences and the literature on constructivist learning guided my decision to undertake this study and informed my initial intervention. Pre-intervention data from both surveys and semi-structured interviews confirmed the need for constructivist learning strategies and gave me more concrete strategies to employ in the next phase of the study. Following Ivankova's (2015) framework for mixed-methods action research—diagnosing, reconnaissance, planning, action, evaluation, and monitoring, I used pre-intervention data to plan the intervention and confirmed that my students may benefit from the intentional instructional shifts during the action stage.

Intervention Phase 1

Both the pre-intervention data and the literature reviewed in Chapter 2 guided the design of the intervention. Phase 1 lasted four weeks, during which daily mathematics lessons included a constructivist strategy or practice to align with students' learning preferences. Based on the pre-intervention data, most students had mixed feelings about mathematics, and many exhibited low-self efficacy and/or anxiety. It is also clear students felt most confident and comfortable when collaborating with peers, confirming Clements and Battista's (2009) instruction on constructivism in the mathematics classroom. They argue that mathematics should focus on students' developing their own strategies and methods for problem solving through interaction with others, while the teacher should be facilitative, providing tasks worth investigating and guiding students' focus. In the constructivist mathematics classroom, the social and academic climate must encourage students to reflect, discuss, and make sense of mathematics together (Clements & Battista, 2009). Likewise, Karagiorgi and Symeou (2005) note key aspects of constructivist practices: active learning in which students grapple with problems that can be solved in a variety of ways, authentic learning opportunities with real-world contexts, and the creation of a collaborative learning environment in which students work together to develop, discuss, and compare multiple viewpoints.

Phase 1 Strategies and Practices

The various activities used in the first phase of intervention are outlined in Table 4.4 and include the use of collaborative group and partner work, mathematics tool kits to support inquiry, bibliotherapy, small-group instruction with mathematics workshop groups, authentic assessment, real-world connections, and growth mindset lessons.

Table 4.4 *Intervention Phase 1 Strategies and Practices*

Week	Strategies and Practices
1	<ul style="list-style-type: none">• Me as a Mathematician “Mathography” mini-poster• Collaborative group work/partner work• Mathematics tool kits• Growth mindset mini-lessons• Bibliotherapy – <i>Math Curse</i> (Scieszka, 1995)
2	<ul style="list-style-type: none">• Collaborative group work/partner work• Small-group instruction with mathematics workshop groups• Mathematics tool kits
3	<ul style="list-style-type: none">• Daily Growth Mindset vs. Fixed Mindset mini-lesson• Bibliotherapy – <i>The Girl Who Never Made Mistakes</i> (Pett & Rubinstein, 2011) and <i>Your Fantastic Elastic Brain: Stretch It, Shape It</i> (Deak, 2010)• Collaborative group work• Small-group instruction with mathematics workshop groups• Authentic Assessment – collaborative group performance assessment with single-point rubric
4	<ul style="list-style-type: none">• Authentic Assessment – collaborative group performance assessment with single-point rubric• Collaborative group work• Small-group instruction with mathematics workshop groups

Me as a Mathematician “Mathography” Mini-Poster

At the beginning of the first phase of intervention, students were tasked with completing a Me as a Mathematician “mathography” to give me a better understanding of their mathematical identity. Allen and Schnell (2016) recommended the “mathography” assignment as a way to provide students the opportunity to reflect on their own mathematical stories. I supplied students with card stock paper and prompted them to use their creativity to make a mini-poster to show who they are as a mathematician, considering what mathematics is, their strengths as mathematicians, things that challenge them in mathematics, their view of themselves as a mathematician, and their view of themselves as a member of our mathematics learning community. Not only did this assignment give me insight into students’ mathematical identities, but it also gave

students the opportunity to reflect on their own story and share it with others. Students' mathographies (See Figure 4.6) illustrated their love for mathematics, their insecurities and confusions, and their eagerness to try, even when mathematics can be hard for them.

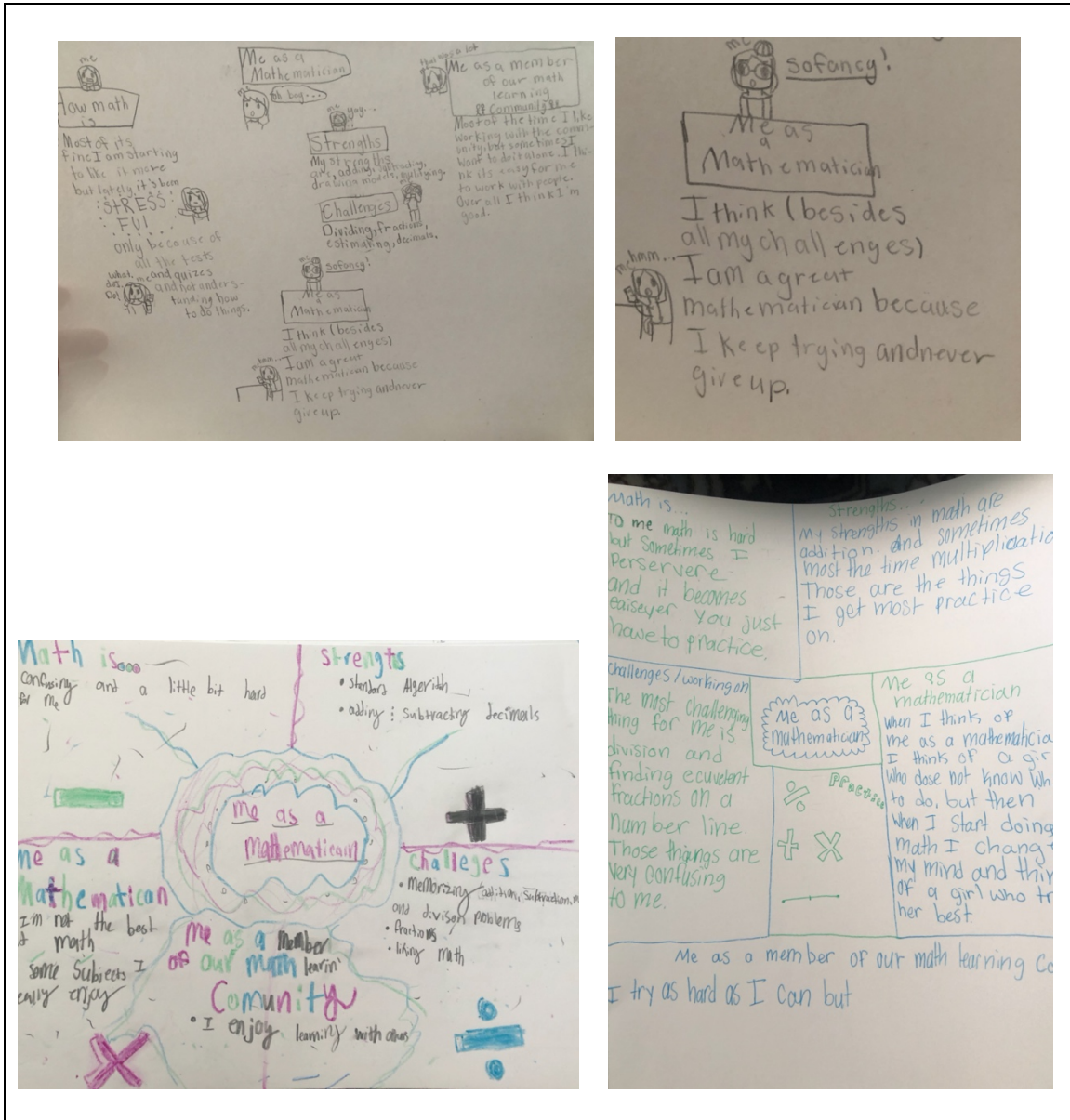


Figure 4.6 Four Samples of Student Me as a Mathematician Mathographies

Collaborative Group and Partner Work

Most days during Phase 1 of intervention included collaborative group or partner work, in accordance with pre-intervention data and constructivist learning theory which emphasizes collaboration and social interaction (Applefield et al., 2001; Dewey, 1897; Harasim, 2012; Piaget, 1976; Vygotsky, 1978; Wenger, 1988). Students were partnered or grouped by table, with arrangements shifting a few times through the intervention.

Groups worked

together using a variety of tools to find a solution or multiple solutions for a given task and were challenged to share their thinking with the class. While students worked collaboratively, I went from group to group, facilitating conversation and asking guiding questions, rather than explicitly teaching a strategy or concept. When groups shared their thinking with the class, I facilitated discussion on the varying answers and strategies, maintaining a focus on student thinking, as opposed to teacher-centered instruction.

Mathematics Toolkits

Van de Walle et al. (2013) explain mathematical tools as “any object, picture, or drawing that represents a concept or onto which the relationship for that concept can be imposed. Manipulatives are physical objects that students and teachers can use to illustrate and discover mathematical concepts” (p. 24). As several students mentioned the use of mathematics tool kits during their pre-intervention interviews, during this intervention phase, each group had access to a kit with a selection of commonly used mathematics manipulatives. Groups were also encouraged to add materials from the collection of other mathematics tools in the classroom as needed. Rather than modeling how to use the tools to solve the given tasks, I encouraged students to use tools that

worked best for them collectively and individually. Groups and individuals were encouraged to share how they used tools, modeling and justifying their thinking as well as answering questions and receiving constructive feedback from one another.

Small-Group Instruction with Mathematics Workshop Groups

Pre-intervention data also uncovered that students often enjoy learning mathematics in small groups. Thus, some intervention lessons used a mathematics workshop approach with a 10-15 minute mini-lesson, small groups with stations, and a debrief session. Sharp, Bonjour, and Cox (2019) state, “The math workshop approach transforms classrooms into mathematical communities of learners” (p. 71). As such, a shift to note from pre-intervention mathematics workshop is that during intervention mini-lessons did not include explicit instruction, but rather invited students to work with a group or partner to grapple with a short problem, to discuss vocabulary, to brainstorm strategies, and to attempt to apply mathematics manipulatives or tools to given scenarios. The remainder of the workshop time was spent in collaborative groups or stations on problem solving activities, mathematics games, or fluency practice activities. I also worked with students in groups, providing short periods of explicit instruction based on needs students identified in their daily exit slips. I also facilitated discussion among groups about strategies they uncovered or ideas they shared during the mini-lesson phase of the lesson. The block ended with a debrief session in which students shared new ideas, asked questions of the group, and celebrated their achievements.

Real-World Connections/Authentic Tasks

A takeaway from the pre-intervention data was that most students recognized the usefulness of mathematics for their future endeavors but were less likely to identify

mathematics as useful at present. Clarke & Roche (2017) suggest an authentic mathematics curriculum emphasizes problems that students are motivated solve which helps them make connections to, and sense of, mathematics and their role as mathematicians. To provide this sort of curriculum, I explicitly connected the mathematics tasks and contexts during this phase of intervention to students' daily lives, based on my knowledge of their interests and hobbies, e.g. cell phone data usage; athletics like running, dancing, and biking; gardening; baking; and cooking. I used students' names in the problems or tasks to facilitate personal connections. To help students make sense of the problems and reinforce connections, we also adopted a set of questions and practices to use when analyzing tasks: *What is happening in this problem? How can I act out or model this situation? What will the answer tell us?* These questions led to discussions about what is being asked and the application to the real world, and I also gave students the opportunity to actually act out the scenarios. After using these questions as a group during mini-lessons, students began to apply these questions in their collaborative groups and could be overheard asking each other the questions to make sense of problems.

Bibliotherapy

Lucas and Soares (2013) define bibliotherapy as an intervention using carefully selected texts like poetry, short stories, or biographies with the intention of helping students cope with changes or emotional issues. Using bibliotherapy in the classroom can serve as a “non-intrusive way to help student[s] solve problems and cope with issues in their personal life so that it will not affect their academic potential” (Furner, 2017a, p. 6). Bibliotherapy has been used with students of all ages as a technique to address anxiety or

negative attitudes associated with mathematics (Furner, 2017a; Furner, 2017b; Furner & Duffy, 2002; Higgins et al., 2020; Lutovac & Kaasila, 2011; Wilson, 2009; Wilson & Raven, 2014). When using bibliotherapy, it is important to not only read the text but to reflect on and discuss the text and its applications (Lucas & Soares, 2013).

For this intervention phase, I chose three children's books for bibliotherapy: *Math Curse* (Scieszka, 1995), *The Girl Who Never Made Mistakes* (Pett & Rubinstein, 2011), and *Your Fantastic Elastic Brain: Stretch It, Shape It* (Deak, 2010). In *Math Curse*, the main character is reminded of the applications of mathematics in her everyday life and becomes overwhelmed by the "math curse," finding a mathematics problem around every corner. This story illustrates the applications of mathematics in daily life from a kid's perspective while allowing readers to identify with the character's lack of confidence. *Math Curse* led to a spirited conversation about the presence of mathematics in our classroom, our homes, our lives, directly addressing pre-intervention study data. Additionally, it was a great vehicle for open dialogue about the wide variety of mathematics experiences and attitudes in the classroom. When a few students shared feeling overwhelmed, like the character in the book, I had students write all their feelings, positive or negative, about mathematics on a sheet of paper without their name. They balled up the paper and had a "snowball fight" by tossing their responses into the center of the room. Then, each student picked up a "snowball" and silently read the response. Some students shared the responses out loud; students were comforted by hearing others' responses and realizing they were not alone in their thinking. For one student, "the activity...made all those negative feelings melt away."

In response to the survey data indicating worry about making mistakes in mathematics, I also used *The Girl Who Never Made Mistakes* (Pett & Rubenstein, 2011) as a read-aloud during this phase of intervention. When Beatrice, the main character, finally does make a mistake, it is a very public one, yet Beatrice learns that trying to be perfect can make you nervous to try new things. This text resonated with many students and led to a discussion of the value in making mistakes in life and in the mathematics classroom.

To continue the discussion on the value of a growth mindset, I read *Your Fantastic Elastic Brain: Stretch It, Shape It* (Deak, 2010) at the beginning of an intervention lesson. Focusing on brain science and elasticity, Deak conveys how making mistakes contributes to learning and stretching the brain. On their own, students connected this book to the theme of *The Girl Who Never Made Mistakes* (Pett & Rubenstein, 2011) and were curious about the brain science as it related to their learning.

Alternative Assessment

It was overwhelmingly clear from pre-intervention data that mathematics assessments were a source of anxiety for my students, prompting me to research alternative options, such as “non-traditional paper-and-pencil tasks, use of open-ended questions, problem-solving investigations, journals, portfolios, focused observation, diagnostic interviews, and performance-based assessment” (Hopkins, 1997, p. 79). Based on my knowledge of my students and the pre-intervention data, I decided to implement collaborative performance assessments. Noting the reality of most work environments, Marcinek (2011) recommends collaborative assessment to validate our students’ “voices and give them the opportunity to build vast learning networks that will endure” (para. 2).

Using Marcinek’s specific advice, I modified a performance task (See Appendix F) to be completed collaboratively and assessed with the use of a single-point rubric (See Appendix G) in lieu of a traditional paper-and-pencil assessment. Students worked with their collaborative groups from the previous week to create a product to teach other fifth graders how to multiply and divide fractions. The single-point rubric allowed me to assess groups’ progress toward the mathematics content and process standards. Boaler (2016) suggests that grades should be replaced with diagnostic comments in order to eliminate fixed-mindset messages and help students build growth-mindset pathways. While grading is still very much a part of the grammar of schooling (Tyack & Cuban, 1995) in our district, state, and even nation, requiring that I give students grades in mathematics, I chose to use a single-point rubric in which the focus is less on the points earned and more on the feedback given to help individuals recognize what they know and give them insight into how they can continue to grow. While students worked on this assessment during two mathematics blocks, I was able to travel from group to group to observe students’ individual strengths and areas for improvement, which I noted on individual single-point rubrics.

Phase 1 Daily Exit Slip Quantitative Data

During this phase of intervention, students completed daily Google Form exit slips to share their confidence and perceived usefulness of the activities. The quantitative portion included two statements: *I felt confident in math today* and *Today’s activities were helpful to me as a math learner*, which students rated with a 4-point Likert scale: *yes, kind of, not really, and no*, with 4 representing *yes* and 1 representing *no*. Based on this scale, the higher the score, the higher the incidence of confidence or perceived

usefulness of the strategy or practice. Responses from each exit slip were exported into a spreadsheet and coded daily based on the strategies or practices used in that lesson, and the mean scores for each of the two questions were calculated. Table 4.5 provides an overview of these results. The mean for each day the strategy was used is listed, as well as the overall mean for each strategy.

Based on these data, the mean scores for each of the strategies and practices were very similar, except for the Me as a Mathematician Mathography strategy used on the first day of Phase 1, which resulted in a mean score of 2.4 out of 4 for student confidence and 2.7 out of 4 for student perception of the activity's usefulness. All other intervention activities had an overall mean of 3.2 or higher in terms of student confidence and a 3.4 or higher overall mean for perceived usefulness. The practice with the highest overall mean for student confidence was the collaborative performance assessment, indicating students' increased confidence when being assessed through a collaborative task instead of a traditional paper-and-pencil assessment. The bibliotherapy activities, growth mindset work, and collaborative performance assessment had an overall mean score of 3.6 in terms of student perception of usefulness, scoring slightly higher than cooperative problem solving and small-group rotations. Overall, data indicate the strategies and practices used during this intervention phase were well received by students.

To measure changes in student confidence and the strategies' usefulness from week to week, I calculated the weekly means for each question and displayed each data set in a line graph (Figures 4.7 and 4.8). From the beginning of this phase of intervention to the end, the mean score for confidence increased by 0.6 points from 2.8 to 3.4.

Table 4.5 Phase 1 Daily Exit Slip Responses

Strategy or Practice	I felt confident in math today.	Today's activities were helpful to me as a math learner.
Me as a Mathematician	2.4	2.7
Mathography		
Collaborative Work with Mathematics	2.4	2.7
Toolkits	3.3	3.4
	3.4	3.5
	3.7	3.3
	3.7	3.6
	2.9	3.1
	3.4	3.5
	3.3	3.3
	3.5	3.6
	3.4	3.6
	3.4	3.5
	Mean: 3.3	Mean: 3.4
Bibliotherapy	3.3	3.4
	3.1	3.7
	3.2	3.6
	Mean: 3.2	Mean: 3.6
Small-Group Rotations	3.7	3.6
	2.9	3.1
	3.4	3.5
	3.3	3.3
	3.5	3.6
	3.4	3.6
	Mean: 3.4	Mean: 3.5
Growth Mindset	3.1	3.7
	3.2	3.6
	3.4	3.6
	3.4	3.5
	Mean: 3.3	Mean: 3.6
Collaborative Performance	3.6	3.6
Assessment with Single-Point Rubric	3.4	3.5
	Mean: 3.5	Mean: 3.6

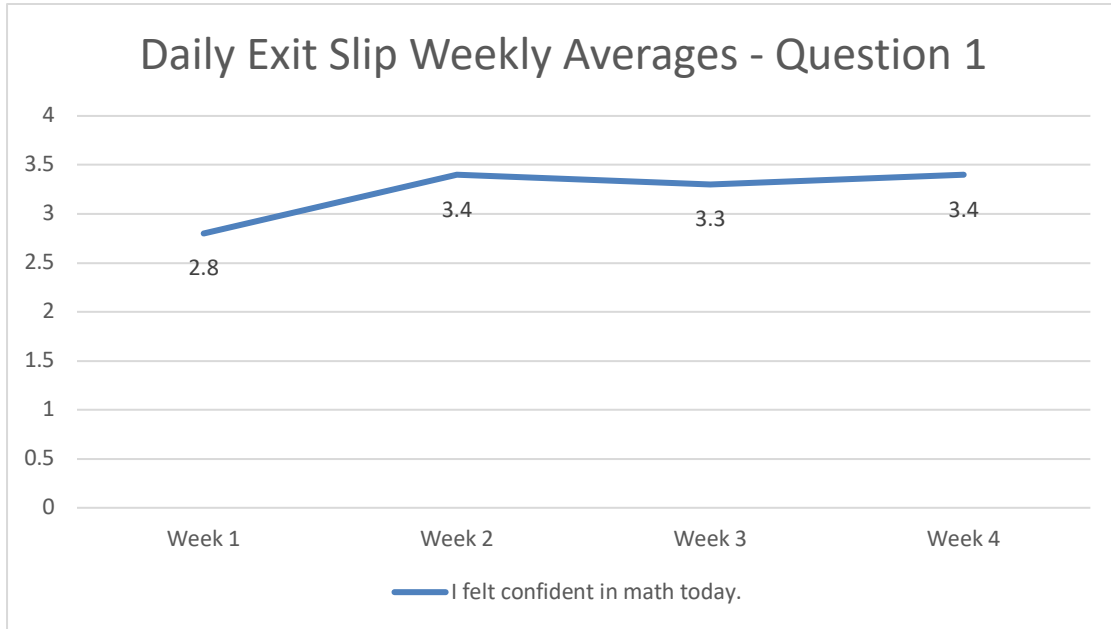


Figure 4.7 Phase 1 Daily Exit Slip Weekly Mean for Question 1

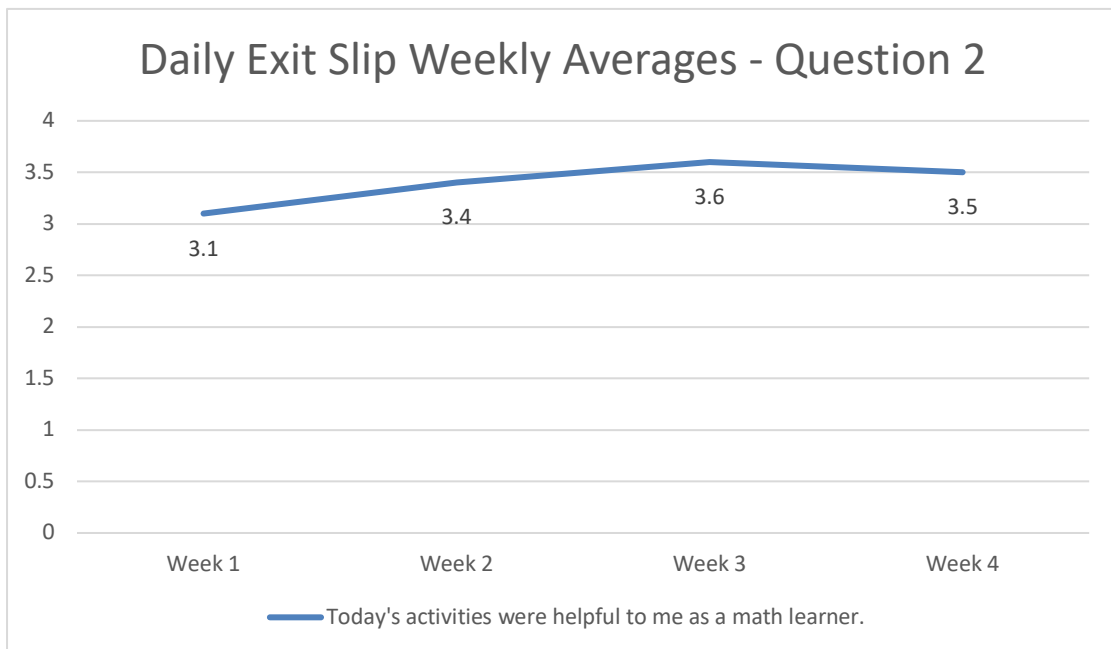


Figure 4.8 Phase 1 Daily Exit Slip Weekly Mean for Question 2

The mean score for the perceived usefulness of the strategies also increased, from a mean of 3.1 to 3.5 or a rise of 0.4 points. These data indicate an overall positive shift in student confidence in mathematics as well as an increase in perceived usefulness of class activities during this phase of intervention.

Phase 1 Daily Exit Slip Qualitative Data

Qualitative data were collected on the daily exit slip through the third question, which was open-ended: *Reflect on today's math lesson. Be sure to share your feelings about the math we learned, the activity we did, and your participation in our math learning community.* It was through this question that students were able to give insight into their evolving self-efficacy and mathematical identity. Student responses were exported into Google Sheets, coded for the strategies and practices, and coded for emergent themes, as seen in Table 4.6. This qualitative data illuminated student responses to the Likert-style questions.

Students' candid responses on the daily exit slips provided abundant insight into the impact of the intervention. On the first day, students' reactions to the Me as a Mathematician Mathography activity were mixed. While most students reported that they enjoyed making the poster and sharing and hearing others' feelings about mathematics, some also reported feeling worried or anxious to share their own feelings. One student stated, "I liked making the poster but I was nervous to share how I feel about mathematics with my group. What if they don't get it?" Another student said, "I don't know what to write. What if I'm not right?" These mixed feelings correlate with the lower mean scores for the confidence and perceived usefulness of this strategy as

Table 4. 6 Phase 1 Daily Exit Slips Themes

Strategy or Practice	Emergent Themes
Me as a Mathematician Mathography	<ul style="list-style-type: none"> • Enjoyed making the poster • Enjoyed learning about others' feelings about mathematics • Felt worried to share feelings about mathematics
Collaborative Work with Mathematics Tools	<ul style="list-style-type: none"> • Enjoyed exploring with tools and sharing theories with groups • Confused by all the strategies • Appreciated the teacher coming from group to group • Like seeing multiple strategies • Growing confidence • Confident when correct • Groups make the work fun • Helps to talk about mathematics with each other • Teaching other people how to solve problems leads to confidence
Bibliotherapy	<ul style="list-style-type: none"> • Appreciate knowing they aren't the only ones who get overwhelmed • Enjoy having a story read aloud • Identification with characters • Appreciate the discussion • Applications of brain science – students feel their brain is stretching, they can persevere through challenges and when making mistakes
Small-Group Rotations	<ul style="list-style-type: none"> • Appreciate working in a small group with the teacher • Feel at ease when working with teacher • Enjoy playing games with group members during rotations • Enjoy the variety of mathematics stations
Growth Mindset	<ul style="list-style-type: none"> • Perseverance • Stretching Brain • Growing from mistakes
Collaborative Performance Assessment with Single-Point Rubric	<ul style="list-style-type: none"> • A fun assessment • Enjoyed project over paper-pencil test • Frustration with group members if being rushed or if everyone isn't on task • Prefer to a test or quiz • Enjoyed the creativity of the performance assessment • Less stressful and less pressure than a test • More confident when working with a group

compared to the other strategies and indicate low self-efficacy and negative mathematical identity as some students were questioning their capacity to complete the task.

The majority of the first phase of intervention included collaborative group or partner work, yielding positive responses from students. Students enjoyed the structure of these lessons, which allowed me to travel from group to group to facilitate student learning. One student said, “Today was great because we got to explore and use our theories on what the answer would be. Everyone participated and got to share ideas. Today in math class was probably the best math lesson we have done this year,” while another noted, “Doing group projects is really helpful because people in my group helped me. I really liked our lesson.” However, some students noted that working with groups can lead to confusion if the group arrives at multiple answers or strategies for solving.

Student responses to the open-ended questions about bibliotherapy were also positive. Students shared their appreciation for learning that they were not alone in their feelings. They enjoyed having a story read aloud and noted they could identify with the characters in the stories. Many responses cited the bibliotherapy discussions and activities as helpful. Students especially responded to *Your Fantastic Elastic Brain: Stretch It, Shape It* (Deak, 2010). One student said, “Today I felt like I got a lot of brain growth because at first I didn’t understand and then I got it and felt more comfy about it.” Another found, “At first it was hard but then I got the hang of it. I also think my brain stretched because I persevered through something new that I’ve never seen before.”

Students’ feedback on the small-group instruction and mathematics workshop rotations also indicated a variety of positive themes. Working in a small group with me fostered feelings of confidence and ease. Students also enjoyed playing games with their

group members during stations. One student reported, “I like working in small groups either with our table or I like working with you in a small group.” Another stated, “Today was really good. I really like how we got to go to mathematics rotations. It lets us do a little bit of everything. My favorite part about it is working with you.”

In terms of growth mindset, students applied what they had learned in their responses to this exit slip question. One common theme was perseverance and not giving up. Students noted the importance of growing from their mistakes and indicated a general feeling that the challenges they face grow their brains. Some students also alluded to a lesson on the power of the word “yet.” One student said, “I remembered that we learned to think about not knowing yet instead of just not knowing.” Student responses show their growing understanding of the value of a growth mindset versus a fixed mindset.

Student responses to the alternative assessment used in this phase of intervention were also powerful. Most responses were overwhelmingly positive, noting that this type of assessment is fun and much preferred to a paper-pencil assessment. Many students enjoyed the creative aspect of working on a project and several noted that this type of assessment is much less stressful than a test. One student noted, “Today was great because I got to work in a group and make a poster about what we learned with decimals. It was great!” Another said, “Today was good and I liked this better than a test because it is not a lot of pressure for me and I don’t really have to worry about a lot of stuff and getting answers that are hard. Also, I’m doing it with my group so it makes me feel confident.” On the other hand, a couple of students expressed their frustration with some of their group members and noted feeling pressured to do well since it was a group project. One learner said, “It was a lot fun but some people I feel were out in space when

doing the project,” and another student said, “I was getting annoyed because I was getting rushed to do my problem.” These data highlight students’ preferences to problem solve together and work in collaborative groups rather than independently, but also highlight some areas I considered when planning future assessment opportunities for Phase 2.

Phase 1 Teacher Journal Data

During this phase of intervention, I also kept a teacher journal to collect qualitative data about what was happening in the classroom and my reactions during the intervention lessons. Each physical journal entry was transcribed and elaborated upon in a digital journal and coded for the specific strategy or practice. Emergent themes were then identified and appear in Table 4.7.

As I analyzed my own journal, I saw recurring themes and emerging ideas that correlated with the data provided in students’ daily exit slips, such as students’ lack of confidence when completing the Me as a Mathematician mathography. It was clear that many students were very concerned with getting the “right” answers for these prompts, rather than honestly reflecting on their own mathematics stories.

My journal data also added to student data on collaborative grouping. Students’ increased confidence, for example was echoed in my journal. After one lesson, I recorded, “The majority of students seem to be progressing with multiplying decimals and their confidence is definitely up!” On a different day, I noted:

Table 4.7 Phase 1 Teacher Journal Themes

Strategy or Practice	Emergent Themes
Me as a Mathematician Mathography	<ul style="list-style-type: none"> • Students concerned with doing this assignment correctly and getting “the right answers” to the mathography reflective prompts, even though this was a personal reflection • Some students at a loss for what to write about themselves
Collaborative Work with Mathematics Tools	<ul style="list-style-type: none"> • Initial frustration with mathematics tools gives way to confidence when students discover how to use the tools to solve problems • Collaborative problem solving gives me as the teacher more flexibility to support individuals and small groups • See students’ confidence blossoming as they find success, especially as they work together to discover the mathematics instead of hearing it from me • Some group dynamics do not work and moving students around is critical to find groupings that are a good fit • Debrief session at the end is powerful to allow groups to share their thinking and to get and give feedback • Powerful conversations • Sense of community growing • Students enjoy the creative aspects of selecting how they will show what they have learned
Bibliotherapy	<ul style="list-style-type: none"> • Discussion is rich and helps students connect their own feelings and attitudes with the characters in the text • “Snowball fight” activity beneficial to help alleviate tension and stress when learning something new – students realized they were not alone
Small-Group Rotations	<ul style="list-style-type: none"> • Struggling students feel excitement when they make progress in small groups • If a student is left with questions after the mini-lesson and I don’t get to their group that day, they are frustrated • Debrief sessions are so important to pull the group back together and check in on learning, students crave this closure to a lesson and reassurance it can provide

Strategy or Practice	Emergent Themes
Growth Mindset	<ul style="list-style-type: none"> • Connecting to the bibliotherapy texts • Students note the power of adding the word “yet” when they discuss not understanding a concept • Perseverance • Normalizing mistake-making, even celebrating how mistakes bridge from not knowing to understanding
Collaborative Performance Assessment with Single-Point Rubric	<ul style="list-style-type: none"> • General feel of excitement about trying something new • No “test-day” stress noted in groups • I enjoyed flexibility to check in with each group and observe individuals • Group strategies varied from group to group with some groups dividing and conquering, then coming back to check each other’s work, while other groups worked together the whole time • Ensuring that all group members are engaged throughout can be a challenge – need an individual accountability measure • Takes longer than a traditional assessment • Powerful conversations

Once students got started, their attitudes shifted, and I could see the confidence blossoming. This type of collaborative grouping, versus small group instruction, offers me the chance to move from group to group and give support or ask a helping question and then move on to different groups. I was able to check in with each group multiple times and see how they were processing the problems at different stages.

On several occasions during Phase 1, I also noted the growing sense of community within the classroom. Frequent use of collaborative groups with debrief sessions provided opportunities for our class to develop a stronger sense of community. Students were often observed supporting one another, cheering one another on, and helping one another through challenging problems. In one entry, I recorded, “I am impressed with how the students are supporting one another. One student in group 5 was upset and crying today, but her group members rallied around her to walk her through step by step and calm her fears.” Students gave quality feedback and partnered together to tackle their challenges.

While exit slip data suggest students mostly enjoyed the opportunity to work in these groups and their confidence increased overall, there were exceptions. On a day when the problem students were working on was particularly challenging, I noted in my journal, “Several groups worked together to solve the problem and worked well together. One group needed a lot of support in how to handle conflicting opinions.” This prompted me to consider collaborative group dynamics and be willing to shift these groups as necessary to ensure a good fit. I also realized students may need some more language and strategies for how to best communicate and collaborate with one another.

My teacher journal also captured students' overwhelmingly positive reactions to bibliotherapy, which yielded rich discussions about students' perceptions of themselves as mathematics learners. I recorded in my journal, "Reading *The Math Curse* today led to incredible conversation. The students discussed how the narrator was in a negative spiral, which impacted each part of his day. Some students recognized this own spiral in their lives." I also noted, "Students were able to apply their understanding of this character's problem to how they may change their reactions in the same situation. Zoe said that she needs to remind herself that it is okay not to know yet." This entry indicates the use of bibliotherapy was successful in helping students make connections and discuss ways to overcome their own negative feelings about mathematics.

The data provided in my teacher journal also point to students' enjoyment of small-group instruction, but indicate that this structure for learning can lead to frustration if students do not get to meet with the teacher each day. After one day's activities, I recorded, "We switched to small groups so that I could focus on some explicit teaching for those who were still confused. This worked well but those groups I did not get to today were frustrated." The value of a debrief session after small-group instruction is clear, as evidenced by the fact that during the four weeks of intervention in Phase 1, I mentioned it eight times. In one example, I wrote, "Today's debrief allowed students to unpack where they still need to grow. I can see a shift in their mindsets." This alludes to the effects of the growth mindset work during Phase 1. I noted, "So many students are realizing the value of making mistakes and having a growth mindset as a math learner. A few students still struggle with a negative mindset about their ability as math learners,

though.” There was work yet to be done in helping students shift their attitudes and beliefs.

The final takeaways from my teacher journal came from the entries on the two days we worked on the collaborative mathematical task. While I noted that this type of assessment takes longer than a traditional assessment, the lower stress environment was a worthy trade-off, and I was able to move from group to group to gauge individual students’ conceptual understanding. On the final day, I wrote, “The conversations about the math I am hearing are powerful. Students are explaining to one another, checking over each other’s work, and giving powerful feedback to one another.” I also noted that students really enjoyed the creative aspect of showcasing what they had learned, although some groups had a more difficult time keeping all team members engaged. I realized in the future I would need to have a more explicit plan in place for individual accountability.

Interpretation of Phase 1

After implementation of Phase 1, I began Ivankova’s (2015) fifth phase of action, evaluation, to determine the impact and effectiveness of each strategy. Data collected during Phase 1 of intervention were encouraging and pointed to answers to each of the three research questions. The exit slips and my teacher journal were especially helpful in addressing the first research question: How does mathematical identity and/or math anxiety impact my students? While the pre-intervention data suggested specific negative attitudes and anxiety associated with mathematics assessments, the Phase 1 data indicated an improvement in student self-efficacy and attitude owing to the opportunity to work collaboratively on a performance task rather than independently on a traditional paper-pencil assessment. Further, the open-ended exit slip responses and data from my teacher

journal suggested that students sometimes experience a spiral of negative attitudes during mathematics, which impacts their self-efficacy, attitudes, participation, and performance.

The classroom strategies and practices used during Phase 1 had been designed specifically in response to the pre-intervention data and with the hope of replacing practices that contribute to the development of negative mathematical identity, addressing research question two. Analysis of the Phase 1 data revealed that most of the strategies and practices had a positive impact on the confidence of students and were also perceived as useful. Collaborative group work, bibliotherapy, small-group rotations, growth mindset work, and alternative assessment yielded student exit slip responses with mean scores well above average for student confidence and perception of usefulness. The qualitative data from exit slips also indicated overall positive reactions to these strategies. Collaborative group work and the collaborative performance assessment were especially well received, as students consistently noted their confidence levels were higher and stress levels were lower when collaborating with others.

However, the Me as a Mathematician Mathography, the very first strategy during Phase 1, was far less popular. After completing this activity, students reported a lower incidence of confidence than with any other activity. The mean score for the perceived usefulness of this strategy was also lower than any other strategy. The qualitative exit slip data and my teacher journal echoed the quantitative data, highlighting student worry about doing the mathography “correctly.” While the goal was for students to explore their own mathematical stories and the hope was to revisit this activity at the end of the study, school closure due to the COVID-19 pandemic prevented us from circling back to compare and contrast student feelings and attitudes toward the activity itself and toward

themselves as mathematics learners, which would have indicated the true value of this activity. Based on student response to the use of this strategy during Phase 1, along with the data from their exit slips, I believe they are more willing to explore their identity and their experiences through bibliotherapy. Perhaps this is because the use of bibliotherapy allows students to make connections to a character or context outside of their own life and gives them language and context to discuss their own identities. I also believe the mathography was less popular because it was used at the very beginning Phase 1. I would be interested to see how students' responses would have differed had this activity been done later in Phase 1 or again at the end of Phase 2.

Phase 1 data also provided insight to answer the second part of question 2: What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced? The pre-intervention data made clear that independent work, traditional paper-pencil assessments, and being called on without preparation were negative experiences that led to some degree of anxiety and lowered self-efficacy in my students. During Phase 1, collaborative group work, small-group rotations, growth mindset work, alternative assessments, and bibliotherapy appeared to be useful practices for the mathematics classroom, able to ameliorate students' stress and anxiety.

The overall increase in student confidence captured by the quantitative exit slip data was encouraging. The increase in students' perception of strategy usefulness was also promising. These data indicate a positive shift in attitude and confidence from the beginning to end of this phase of intervention, which alludes to an answer to the third research question: How do constructivist-aligned strategies affect mathematical identity

in fifth-grade students? The qualitative data confirmed that student-centered, constructivist strategies like collaborative problem solving and authentic assessments led to an increase in student confidence. Students' dispositions and attitudes shifted when they were engaged in small-group learning opportunities or when they could explore their feelings about mathematics and themselves as mathematicians through the use of bibliotherapy.

These conclusions informed the planning for Phase 2. I resolved to continue using the beneficial strategies to gather more data over a longer period of time; to explore why and how these strategies impact students' self-efficacy, identity, and perceptions; and to further develop our community of practice. I also realized that while a focus on discourse had been woven through the work done in collaborative groups and small groups and the debrief sessions that followed, a more overt approach to how we talk with one another about mathematics would be helpful. Therefore, as I planned Phase 2, I specifically designed components that would address the language of our mathematical discussions.

Additionally, based on the noted issues with some group dynamics, I sought to strengthen our collaboration skills and the negotiation of our communities of practice. I also planned activities that explicitly addressed the creative nature of mathematics to build upon students' enjoyment of the creative aspect of the collaborative performance task.

Intervention Phase 2

As noted above, pre-intervention and Phase 1 data, in conjunction with the literature reviewed in Chapter 2, informed the intervention activities for Phase 2, which was shortened to two weeks due to the closure of schools during the COVID-19

pandemic. During Phase 2, each day’s mathematics lesson included an instructional strategy or practice to continue promoting constructivist learning, to address students’ identified learning preferences, and to build upon the major takeaways from Phase 1.

Phase 2 Strategies and Practices

In addition to the collaborative work using real-world tasks, bibliotherapy, small-group rotations, growth mindset work, and alternative assessment options found to be effective in Phase 1, three additional practices were added in Phase 2: mathematical discourse cards, work on group dynamics, and work to tap into the innate creativity of mathematics. These strategies are outlined in Table 4.8 and further explained below, and the strategies intended for Weeks 7 and 8 but cancelled due to the pandemic are outlined in Appendix H. The omitted strategies emphasized student choice (Kohn, 1993) and creativity in mathematics (Boaler, 2016; Boaler et al., 2018).

Table 4.8 *Intervention Phase 2 Strategies and Practices*

Week	Strategies and Practices
5	<ul style="list-style-type: none"> • Collaborative group work • Bibliography – <i>I Can’t Do That, Yet: Growth Mindset</i> (Cordova, 2017) • Journaling • Mathematics discourse cards • Real-world connections/authentic tasks
6	<ul style="list-style-type: none"> • Real-world connections/authentic tasks • Collaborative group work • Small-group instruction with mathematics workshop groups • Mathematics discourse cards • Assessment choices (collaborative performance assessment or independent quiz) • Focus on Collaborating and Communicating Effectively with Participation Quiz Group Goals (Boaler, 2016)

Collaborative Group and Partner Work and Real World Connections

Collaborative group and partner work continued during Phase 2 in much the same manner as Phase 1, including the use of mathematics toolkits. Based on data from Phase 1, I selected tasks that were relatable and immediately applicable to students' lives. For example, during Weeks 5 and 6, groups and partners solved problems based on their specific interests, such as gardening, cooking, and making videos. During Week 6, collaborative groups performed tasks associated with cooking, which ultimately led to the creation of a recipe. Through these authentic scenarios, students learned to add, subtract, and multiply fractions and mixed numbers, and I also introduced strategies for collaboration and effective communication.

Collaborating and Communicating Effectively. During Phase 1, students clearly enjoyed and benefited from opportunities to collaborate, although I realized more specific guidance and practice with collaborating and communicating effectively could turn their simple groups into effective communities of practice. True communities of practice require three specific dimensions: mutual engagement, joint enterprise, and shared repertoire (Wenger, 1998). Attending to each of these dimensions reinforced students' ability to construct their understanding of mathematics content by integrating new content with their prior learning in a social context (Clements & Battista, 2009), and ensured groups would support students' development of mathematical identity, which Lutovac and Kaasila (2014) suggest is fluid and ever-changing based on experiences.

Various activities were planned to transform student groups into effective communities of practice, including a "participation quiz" for group goals (Boaler, 2015). After we discussed criteria of successful groups (See Appendix I), early in Week 6, I

checked in with groups throughout the week to see whether they were achieving their group goals. During our daily debrief sessions, I shared some of my observations. At the end of the week, we had a group discussion and students self-assessed their own participation and their group's participation in terms of these goals.

During Phase 1, students had rich discussions about the mathematics they were learning, but sometimes lacked the language to communicate clearly, and not everyone participated to the same degree. Students needed mathematical discourse support to extend their conversations and share their ideas effectively and equitably. Bennett (2014) explains, "Meaningful discourse includes an element of debate and is an interactive, dynamic, and inclusive strategy with the intent of developing particular mathematical concepts or practices" (p. 21). These meaningful opportunities for discussion within groups or with partners are "the greatest aid to understanding" (Boaler, 2016, p. 29). To enhance classroom discourse, I incorporated specific questions and sentence starters during class discussions, group conversations, and small-group work guided by Curriculum Associates (2018) Discourse Cards. These cards use questions to encourage reasoning, explaining, and critiquing; as well as reflecting and connecting, and they also use sentence starters to give students an entry point for conversations. Examples include: "I started solving the problem by...", "A place where I got stuck was...", and "One thing I like about my partner's strategy is..." (Curriculum Associates, 2018). I passed out card stacks and allowed groups to pick the question they wanted to answer or ask of another group and the sentence starter they wanted to use when sharing. I also put some cards at each group's station to guide their discussions when they worked together.

Mathematics Toolkits. During Phase 2, we continued to use mathematics toolkits to support student problem solving in collaborative group work, in small groups, and during rotations. These toolkits included a variety of mathematics manipulatives to support student thinking in our work with decimals and fractions including base ten blocks, unmarked fraction squares, 100 bead strings, 10 x 10 grids, rulers, fraction towers, and pattern blocks. As in Phase 1, students also had access to other materials to add to their toolkits as needed and were encouraged to try a variety of tools and to share how they used them.

Small-Group Instruction with Mathematics Workshop Groups

The data from Phase 1 exit slips and my teacher journal indicated that students were enjoying our new structure for small-group instruction, especially when I was able to engage more directly with their groups. During Phase 2, I continued to use small-group instruction a couple of times each week, especially when exit slip data or through self-assessment indicated students' confusion or a struggle with specific content. These groups continued to provide opportunities for collaborative problem solving in which I could directly facilitate conversations and allowed for brief moments of explicit instruction as needed.

Bibliotherapy and Growth Mindset

Bibliotherapy continued in Phase 2, as this had been such a popular activity in Phase 1. Reinforcing our work on growth mindset, I read *I Can't Do That, Yet: Growth Mindset* (Cordova, 2017), wherein the main character, Enna, has a fixed mindset about her ability to read and lacks self-confidence. In a dream of possibilities for her future self, she learns she can do challenging things, just not yet, which encourages her to continue to

try and increases her confidence. My students journaled about their connections to and reflections on the text, and willing students shared entries as we discussed how and why Enna's mindset shifted from a fixed to growth mindset. Many students admitted to connecting with Enna and feeling that they cannot do mathematics, but they also noted they were beginning to realize that not being able to do the work now does not mean that they will never understand. Students were beginning to understand the power of the word yet.

Phase 2 Daily Exit Slip Quantitative Data

As in Phase 1, students completed daily Google Form exit slips during Phase 2 to rate their confidence and perceived usefulness of each day's activities. The quantitative prompts for these exit slips stayed the same: *I felt confident in math today* and *Today's activities were helpful to me as a math learner*. Learners rated these statements as *yes*, *kind of*, *not really*, or *no*, aligned with a 4-point Likert scale, with 4 representing *yes* and 1 representing *no*. The higher the score, the higher students' self-confidence and the more useful the strategy or practice. Data were exported into a Google Sheet, coded based on the strategies and practices, and the mean scores for each question were calculated. Table 4.9 provides an overview of the mean score for each quantitative question by strategy or practice used each day, as well as the overall mean for each strategy.

The mean scores for each of the strategies and practices are very similar, with overall mean scores ranging from 3.4 to 3.8. The activities with the highest mean for both student confidence and perception of strategy usefulness were bibliotherapy and growth mindset, indicating students' special connection to these activities. Collaboration and effective communication activities were new in Phase 2, with positive results, as the

Table 4.9 Phase 2 Daily Exit Slip Responses

Strategy or Practice	I felt confident in math today.	Today's activities were helpful to me as a math learner.
Collaborative Work with Mathematics Tools	3.1	3.2
	3.2	3.2
	3.6	3.5
	3.5	3.7
	3.7	3.5
	Mean: 3.4	Mean: 3.4
Collaborating and Communicating Effectively	3.1	3.2
	3.6	3.5
	3.8	3.8
	3.7	3.5
	Mean: 3.6	Mean: 3.4
Small-Group Rotations	2.8	3.3
	3.8	3.8
	3.6	3.5
	3.5	3.7
	Mean: 3.4	Mean: 3.6
Bibliotherapy	3.8	3.8
Growth Mindset	3.8	3.8

overall mean for student confidence was 3.6 and the overall mean for perceived usefulness was 3.4 out of 4. These data indicate students' confidence with using the group goals and mathematical discourse cards enhance their communities of practice.

When compared to Phase 1 data, overall mean student confidence when using collaborative grouping with mathematics tools increased from 3.3 to 3.4 and overall mean perceived usefulness stayed the same at 3.4. Overall mean self-confidence when learning in small-group rotations stayed the same at 3.4, and the perceived usefulness of the lessons increased from 3.5 to 3.6. The overall mean for student confidence during growth mindset lessons increased from 3.3 to 3.8, and the overall mean for student perceived usefulness of the activities grew from 3.6 to 3.8. The means increased for bibliotherapy as well, from 3.2 to 3.8 for student confidence and from 3.6 to 3.8 for

perceived usefulness. These data indicate the strategies used in Phase 2 were as, or more, effective when compared to those used in Phase 1.

To determine the change in student confidence and perceived usefulness of the strategies used during this phase of intervention, the means for each question were calculated for Weeks 5 and 6 and compared in Table 4.10. Both student confidence and their perceived usefulness of the strategies used increased by 0.1 point.

For a clearer picture of the change in students' confidence and thoughts on the usefulness of the strategies, I calculated the means for each question weekly and created a line graph for each question (Figures 4.9 and 4.10). When comparing the data from the beginning of intervention to the end, the mean for confidence increased by 0.8 points from 2.8 to 3.6. The mean for the perceived usefulness of the strategies also increased from the beginning to end of intervention, from 3.1 to 3.6 or an increase of 0.5 points. These data indicate a positive shift in students' daily mathematics confidence as well as an increase in positive perceptions of mathematics activities during the two-phase intervention.

Table 4.10 *Phase 2 Quantitative Data Weekly Mean Scores*

Week	I felt confident in math today.	Today's activities were helpful to me as a math learner.
5	3.5	3.5
6	3.6	3.6
Change	+ 0.1	+0.1

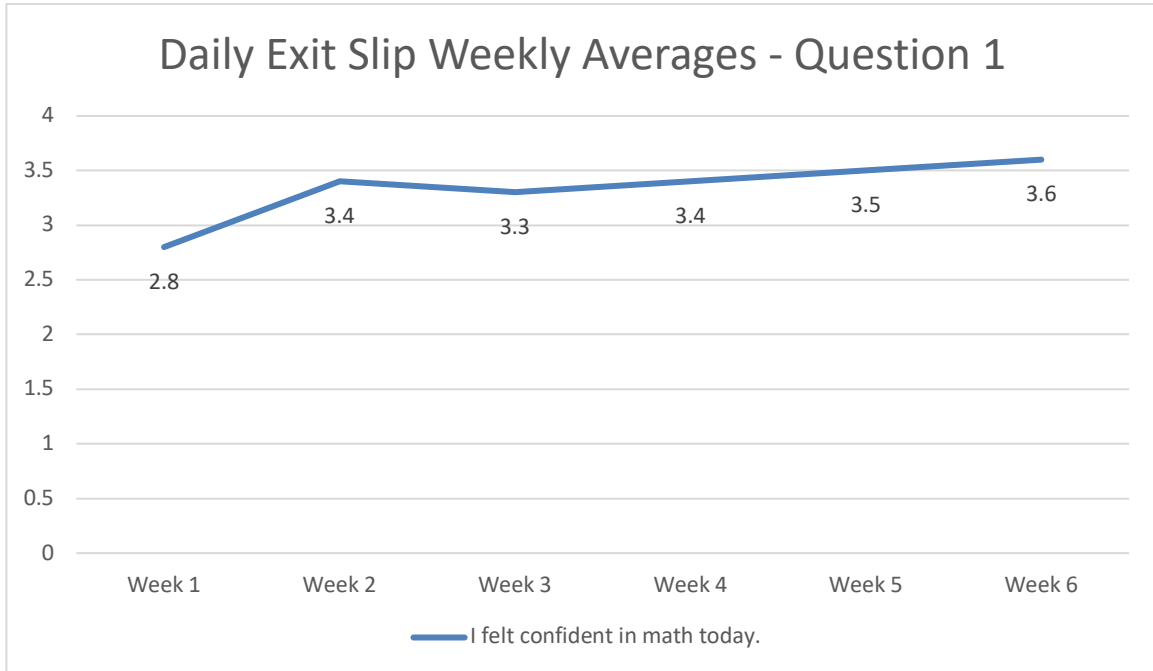


Figure 4.9 Daily Exit Slip Weekly Mean for Question 1

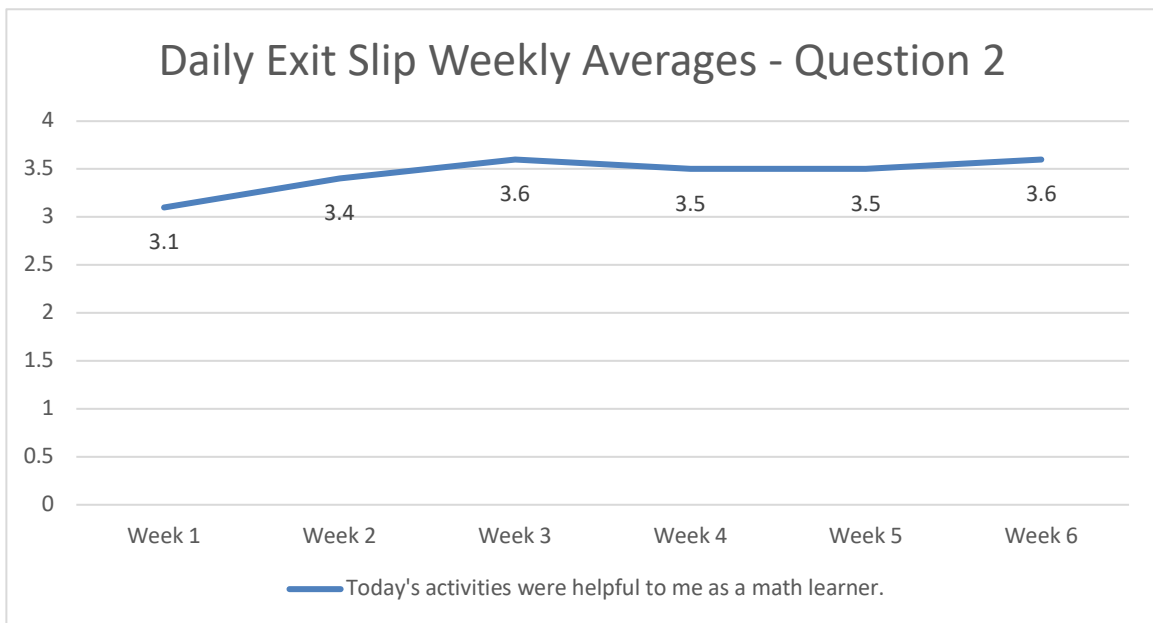


Figure 4.10 Daily Exit Slip Weekly Mean for Question 2

Phase 2 Daily Exit Slip Qualitative Data

As in phase 1, daily exit slips also provided qualitative data from the third question, which was open-ended: *Reflect on today's math lesson. Be sure to share your feelings about the math we learned, the activity we did, and your participation in our math learning community.* Responses were exported into a Google Sheet, coded for each strategy and practice, and later coded for the emerging themes. These qualitative data expanded my understanding of the data collected from the Likert-style questions. Table 4.11 shares the themes that emerged from data analysis.

The qualitative data enhanced my understanding of students' quantitative responses. Students most commonly reported their participation in a positive light on

Table 4.11 Phase 2 Daily Exit Slips Themes

Strategy or Practice	Emergent Themes
Collaborative Work with Mathematics Tools	<ul style="list-style-type: none">• Appreciate working with groups and realizing that others have worries or get confused, too• Shift from confusion to participation• Participation most when working with collaborative groups• Working with groups is fun• Enjoyed the tasks with connections to cooking/baking, especially knowing we were going to actually bake together
Collaborating and Communicating Effectively	<ul style="list-style-type: none">• Mixed reviews initially on mathematics discourse cards, improved attitudes after continued use• Enjoyed the group goals to set boundaries for group
Small-Group Rotations	<ul style="list-style-type: none">• Some students are recognizing that they prefer small group to collaborative group work• Working with teacher is helpful
Bibliotherapy	<ul style="list-style-type: none">• Power of YET!• Perseverance• Enjoyed journaling and discussing the book
Growth Mindset	<ul style="list-style-type: none">• Power of YET!• Persevering through tough days leads to confidence and a sense of pride when students have a breakthrough

days in which they were engaged in collaborative group work. Moreover, the exit slip data revealed a key factor behind students' appreciation of group work: struggling alongside one another and realizing that others have worries or get confused, too. One student said, "It feels good to know that we can do it together and work through our confusedness." Students have begun to notice their own shift from confusion to participation as they realize they have a support system. A student reported, "At some points, I wanted to cry but I did not. I had my group and we just pushed through."

The qualitative exit slip data also revealed students' excitement about the real-world tasks in Phase 2. Comments about the cooking task were all positive. For example, "Today in math I really liked how we got to work with our table group on the project. My participation was really good and we didn't get off track. We are really excited to make Sprinkle Chow." Another student said, "I really liked this activity because it kept me going through the math because we get to make sprinkle chow. I also felt good with participation because I helped my group and got each one right." Students were motivated to participate when the task was authentic, rather than abstract and unrelatable.

Some students still struggled with collaborative group work, however. One student noted, "What we learned today was challenging. I think I could do better. So I'll try." Although the student struggled with the mathematics lesson for the day, he realized he could give more effort. Some students noted their frustration with the challenge of working with fractions with unlike denominators, especially when working with groups without one-on-one teacher support. One student confided, "I hated everything about math and you didn't help me." While collaborative grouping helps many students feel

comfortable participating and encourages engagement, some students still crave more direct teacher support and explicit instruction.

Similarly, initial student reactions to the Mathematics Discourse Cards were mixed. One student said, “I liked using the cards because when we finished, it was easier to talk so you can be ready to share,” whereas another reported, “I did not like using the cards today. I like to choose my own starters.” This variance explains the lower quantitative data on this day, with scores of 3.1 for confidence and 3.2 for perceived usefulness, lower than the overall average of 3.6 for confidence and 3.4 for perceived usefulness.

However, later in the week and during the following week, students’ attitudes shifted to embrace the use of these cards. One student reported, “The activity in general was great! We got to talk in our groups and discuss certain problems. I think I participated a lot today in math because I was confident on what I was going to say.” Another shared, “I liked the cards because I did not feel shy if I got the answer wrong.” These cards deepened their mathematical discussions by giving students useful questions to ask one another and a place to start when sharing their ideas.

Students also appreciated the use of group goals, including giving everyone in the group equal time to talk, listening to one another, and taking ownership to participate in the community. When these behaviors were modeled and then required for group participation, students responded positively. One student said, “I liked what we did in math today. I enjoyed it and did well. I participated good with my group.” Another stated, “I liked this because we had a good conversation with our new goals.” These data indicate students’ positive reception of these new parameters for more effective groups.

Students' continued to enjoy small-group instruction in Phase 2, as evident in comments like, "I was happy I got to work with you. It helped me understand more." and "It was fun working in groups today! I liked doing the stations because I played math games and did Math War." One interesting takeaway was that some students have started to realize they prefer small-group instruction over collaborative groups because they need more structure. One student reported, "I liked how I was in a group with you because you were right there if I needed help." Another student said, "When it is hard and I don't know what I'm doing I don't try as much if you aren't with me." These data exhibit students' metacognition and self-reflection to think about what they really need as mathematics learners. Some learners feel more confident when they have more access to me than what they may have if I am facilitating collaborative groups.

As was the case in Phase 1, bibliotherapy and work on growth mindset were very popular with students during Phase 2. Students made strong connections between the story and their own lives and noted the power of the word "yet" and their own ability to persevere. After reading, journaling about, and discussing *I Can't Do That, Yet: Growth Mindset* (Cordova, 2017), one student said, "I loved the book. I think we should always have a growth mindset of I can't do it...yet." Another shared, "I liked how we wrote about the book. I think it helped me and other math learners." Students' verbalized reactions to this activity echoed the quantitative data, as the mean for both confidence and perceived usefulness for this strategy was 3.8 out of 4.

Not only did this explicit work with growth mindset yield positive benefits, but the data also indicated students' development of a growth mindset across activities. One student said, "I finally understand how to do these problems and I just feel so good about

myself now that I got through the hard parts of understanding these types of math problems!” Another student said, “The beginning was tricky. I participated well and...I ended up fine.” One student simply said, “I’m persevering!” These data indicate positive shifts in students’ mindset toward mathematics and toward themselves as learners.

Phase 2 Teacher Journal Data

During Phase 2, I continued using my teacher journal to collect qualitative data on classroom happenings, student responses, and my reactions. As before, the physical notes were transcribed and elaborated upon in a digital journal. These data were coded based on the specific strategy or practice observed, and the emerging themes were coded during data analysis. The most common themes are included in Table 4.12.

The data from my journal deepened my understanding of the quantitative data and other qualitative data collected during Phase 2. While some themes stayed consistent from Phase 1, additional insights emerged. One major takeaway was that students were showing more persistence and perseverance. During collaborative work with mathematics toolkits, I noticed students realizing the value in sticking with a task and not giving up. In one entry, I recorded a student saying, “I liked my partner’s strategy of not giving up. We all worked together as a team and we had a hard time at first but we didn’t give up and kept trying to solve. We didn’t get the answer right, yet...but it felt good not to give up.” This demonstrates the tremendous shift in this particular student’s mindset and also indicates her confidence when working with a group.

The theme of persistence was also salient during Phase 2. I noted this happening in small groups and during our work on growth mindset, too. After one small group, I recorded, “Sabrina asked to stay for two small groups with me today because she still did

Table 4.12 Phase 2 Teacher Journal Themes

Strategy or Practice	Emergent Themes
Collaborative work with Mathematics Tools	<ul style="list-style-type: none">• Students realizing the value in persisting• Allows me to check in with each group multiple times• Students are taking more responsibility for the discussion and their participation
Collaborating and Communicating Effectively	<ul style="list-style-type: none">• Respectfully disagreeing• Increased engagement in terms of body language, discussion, and willingness to share the “air space”• Discourse Cards lead to stronger use of mathematics vocabulary• Students questioning one another
Small-Group Rotations	<ul style="list-style-type: none">• Struggling students feel excitement when they make progress in small groups• Allows me lengthier time with groups, but does not allow me to meet with each student every day• Persistence – sticking with a problem longer before giving up, or not giving up at all
Bibliotherapy	<ul style="list-style-type: none">• Positive body language during the read aloud, students leaning forward, smiling, and engaged• Students willingly shared journal entries about the text• Can push through challenges to understand, just takes time
Growth Mindset	<ul style="list-style-type: none">• Persistence• Perseverance• The power of YET!

not understand after the first group. By the end, she had an Aha! moment. She was so proud that she did not give up.” Her perseverance paid off for her and she admitted to feeling more confident than she ever had because she did not cry or give up. This indicates a shift in her identity as a mathematics learner. She realized she was no longer a quitter, but instead someone who persists. Throughout our work on growth mindset, students referred to the power of the word “yet” and demonstrated perseverance and persistence.

Data from my journal also point to the benefits of our work on effective cooperation and communication. Echoing qualitative data from student exit slips, I noted that at first, “Students had very mixed opinions on the Discourse Cards today. One group could not come up with an answer to any of the questions and argued over which sentence starters to use.” However, in the same entry I noted, “Group 3 begged for more cards so they could keep talking about the math. This group really focused on how to respectfully disagree with one another.” The theme of respectfully disagreeing surfaced in several journal entries. Students took this aspect of being a more effective group very seriously, and their tone and words were kinder than ever before.

The use of the Discourse Cards helped students incorporate more mathematical vocabulary in their discussions. I noted in my journal, “Students are using more precise math vocabulary thanks to the use of the Discourse Cards and their attitudes are more consistently positive when using these cards now that we have had some practice with them.” The same was true for the use of the group goals. On the day these were introduced, I noted, “The kids in group 5 are not buying the group goals. Jaden’s arms stayed crossed while his group worked and he did not participate.” On the following day, however, I said, “There is more buy in with the group goals today. Each group shared different ideas about how these goals were keeping them accountable. Even Jaden said he liked the goals to tell him what he should do.” I also noted that students were more willing to share the “air space” and work together after implementing the group goals.

My journal entries about bibliotherapy mirrored the quantitative and qualitative data from students. I noted students’ body language was positive when I read aloud: “The students all scooted in closer when I told them we were going to read a story today. Many

students leaned in as I read and smiled when they were able to make connections to the text.” I also noted that students willingly shared their journals after we read the text and had great discussion about how they are realizing that it is okay not to be able to do new things. The power of adding the word “yet” continued to come up in this discussion.

My journal entries also highlighted my own participation in this phase and how these strategies were impacting my role in the classroom. I noted that the collaborative group work allowed me the opportunity to check in with each group of students, in turn allowing me to touch base with each student more frequently. I wrote, “I am really enjoying facilitating the collaborative group work because I am able to hear their great conversations, but also let the students engage in some productive struggle.” Another theme in my journal was the benefit of small groups and spending more time with each group. After one day’s lesson, I recorded, “I’m glad we had small group today. Some kids needed a longer time to work with me so that I could do some explicit modeling with them.” These data indicate the benefits of mixing up the structures used in the mathematics classroom based on students’ day-to-day needs.

Interpretation of Phase 2

Even though this phase of intervention was abbreviated due to the COVID-19 school closure, the data yielded valuable information to help answer all three research questions. The first research question asks: How does negative mathematical identity and/or math anxiety impact my students? Data from exit slips and my teacher journal indicated that while collectively, students’ confidence was on the rise, some students still had negative experiences with mathematics and negative feelings about themselves as mathematicians. Some students still reported getting upset and crying during mathematics

or not trying because they did not understand, particularly when working with specific mathematics content like fraction operations with unlike denominators. This indicates that negative mathematical identity can impede students' participation in mathematics class.

The second research question asks: What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced? During Phase 2, activities intentionally addressed the negative mathematical identity-supporting practices identified from pre-intervention data. Because students felt most negatively about independent work, assessments, and being called on when they are unprepared or do not know the answer, during Phase 2, collaborative group work and small-group instruction replaced independent group work. Students also got to choose an assessment type, though they did not get to take this assessment due to the school closure. Lastly, students were consistently engaged in small-group conversations and made use of sentence starters. Further, bibliotherapy and growth mindset work continued in an effort to replace practices contributing to the development of negative mathematical identity.

Through analysis of the Phase 2 data, it is clear the strategies had positive effects on student confidence and were also perceived to be useful. All Phase 2 strategies had overall means well above average for student confidence and usefulness. The qualitative exit slip data correlated with the quantitative data, indicating overall positive reactions. Consequently, I believe these practices can replace the use of frequent independent work, traditional assessments, and cold-calling students, which students indicated as negative, often anxiety-inducing, experiences. Based on the qualitative Phase 2 data, which show

that sometimes students prefer one small group to collaborative problem-solving and vice versa, a balance of these two strategies may best support the needs of my students.

The increase in student self-confidence indicated by exit slip and teacher journal data was also a positive outcome. Similarly, the increase in student perception of usefulness of the strategies employed during this phase was encouraging. These data point to a positive shift in mindset and confidence in my students. It is important to consider this trend in light of the third research question: How do constructivist-aligned strategies affect mathematical identity in fifth-grade students? The quantitative and qualitative data suggest constructivist-aligned strategies increase student self-efficacy. As the increase in confidence was evident across the data, I concluded that strategies like collaborative group work with the use of mathematics toolkits, small-group instruction with rotations, bibliotherapy, a growth mindset focus, and work on effective collaboration and communication are effective practices to foster positive mathematical identity.

Post-Intervention Data

As my district pivoted to remote learning for the remainder of the school year, post-intervention data were collected virtually, approximately four weeks after Phase 2.

Post-Intervention Researcher-Created Survey

The 10 question post-intervention researcher-created survey was administered through Google Forms. All 23 participants rated six statements on their attitudes toward mathematics and four statements on their mathematics learning preferences, and the answer choices of *always*, *often*, *sometimes*, and *never* corresponded with a 4-point Likert scale. Through Google Classroom, students could use the Read Aloud Chrome extension. The results of this survey, by item, are presented in Table 4.13.

Table 4.13 *Post-Intervention Researcher-Created Survey Responses*

	Item	Always 4	Often 3	Sometimes 2	Never 1	Mean	Mode
Attitudes and Beliefs	1. I like math.	6 (26.1%)	7 (30%)	8 (33.8%)	2 (8.7%)	2.7	2
	2. I think math is useful to my daily life.	9 (39.1%)	5 (21.7%)	7 (30.4%)	2 (8.7%)	2.9	4
	3. I think math will be important to my future.	14 (60.9%)	2 (8.7%)	7 (30.4%)	0 (0%)	3.3	4
	4. I feel confident during math class.	6 (26.1%)	8 (34.8%)	7 (30.4%)	2 (8.7%)	2.8	3
	5. I feel confident during math assessments.	4 (17.4%)	11 (47.8%)	3 (13%)	5 (21.7%)	2.6	3
	6. I can use my problem-solving skills to figure out challenging problems.	8 (34.8%)	8 (34.8%)	4 (17.4%)	3 (13%)	2.9	4 & 3
Learning Preferences	7. I like to learn math by practicing independently	5 (21.7%)	3 (13%)	5 (21.7%)	10 (43.5%)	2.1	1
	8. I like to learn math in small groups.	14 (60.9%)	2 (8.7%)	6 (26.1%)	1 (4.3%)	3.3	4
	9. I like to learn math by collaborating with others.	10 (43.5%)	7 (30.4%)	5 (21.7%)	1 (4.3%)	3.1	4
	10. I like to learn math by working with my teacher.	15 (65.2%)	5 (21.7%)	2 (8.7%)	1 (4.3%)	3.5	4

For the first six statements, each student's score was calculated out of a total of 24 possible points to determine an overall attitudes and beliefs score. Students scoring less than 12 points, or 50% of the total points, were noted (See Figure 4.11). Twenty-one of the 23 participants (91.3%) scored 12 or higher while 2 students (8.7%) scored lower than 12. As compared to the pre-intervention data, the percentage of students scoring 12 or higher increased by 4.3%. Conversely, the percentage of participants scoring less than 12 points decreased from 13% to about 9%. These data indicate an overall positive shift in students' attitudes and beliefs about mathematics and themselves as mathematics learners.

The class average was also calculated (See Figure 4.12). The average score for these first six questions was 17.3 out of 24, an increase of 1.4 points, and 13 participants (57%) scored at or above the class average, while the remaining ten students (43%) scored below the class average. When compared to the pre-intervention data, the percentage of students scoring above the class average increased from 43% to 57%. Not only does these data show an increase in the overall class average from pre- to post-intervention, but they also indicate a positive shift in overall student attitudes and beliefs.

To evaluate the overall difference between the pre- and post-intervention scores on the Attitudes and Beliefs section of the researcher-created survey, I conducted a paired *t*-test which "compares the same group under two different conditions" and yields "a *t*-statistic that is used to draw conclusions about whether the difference between the two group means is statistically significant" (Ivankova, 2015, p. 228). A two-tailed paired *t*-test yielded a *t* of 1.85 and a *p*-value of 0.78. At a significance level of 0.05, this *p* value

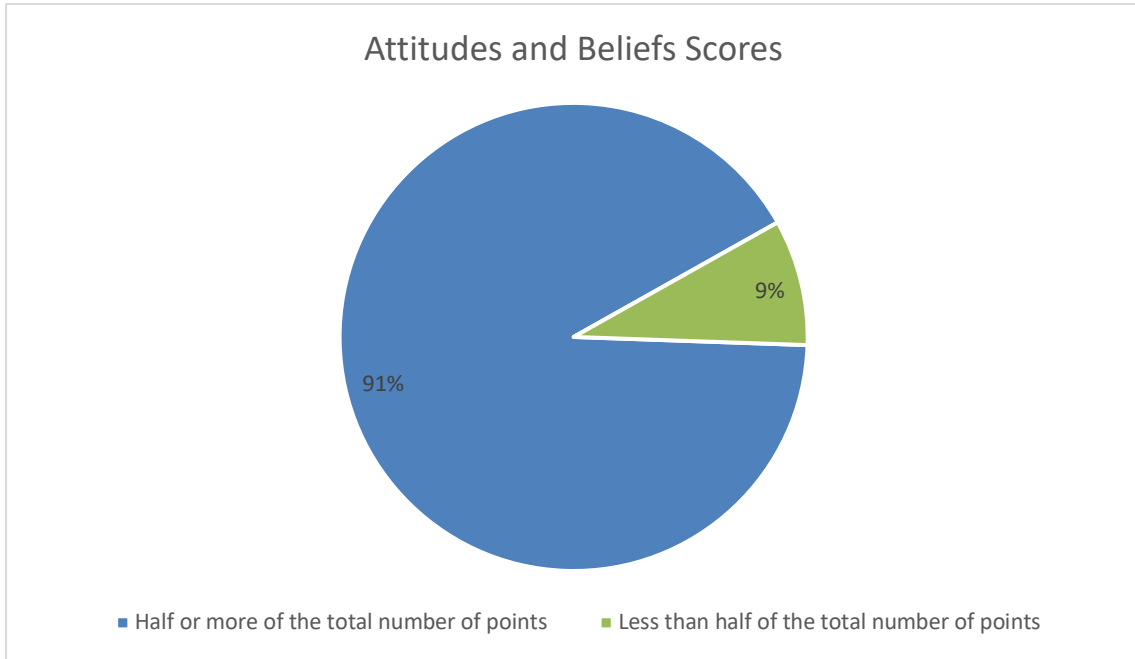


Figure 4.11 Visual Representation of Scores above 12 on the Attitudes and Beliefs Statements in the Post-Intervention Researcher-Created Survey

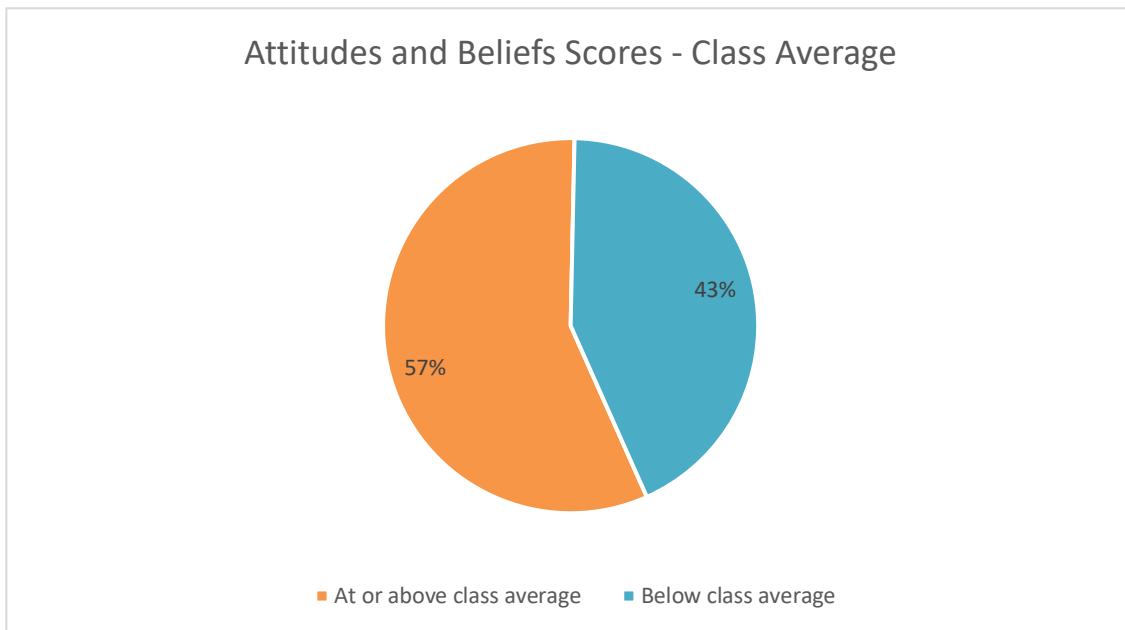


Figure 4.12 Visual Representation of Scores in Relation to the Class Average on the Attitudes and Beliefs Statements in the Post-Intervention Researcher-Created Survey

indicates no statistical significance between the overall pre- and post-intervention scores of students on the researcher-created survey.

Nevertheless, the results from this section provided insight into how students' attitudes and beliefs about mathematics shifted during the intervention, as 26.4% of students reported always liking mathematics, an increase of 12.4% from the pre-intervention survey data. Similarly, 26.1 % indicated always feeling confident during mathematics class, a 9.1% increase from the pre-intervention survey. Interestingly, only 8.7% of students indicated never feeling confident in mathematics class, a decrease of 8.7% from the pre-intervention survey. In terms of confidence when taking mathematics assessments, 65.2% of students indicated always or often feeling confident during mathematics assessments, a 26.1% increase from pre-intervention. The percentage of students reporting never feeling confident during mathematics assessments also decreased from 30.4% to 21.7%. Nearly 70% of participants reported always or often feeling confident to use problem-solving skills to solve challenging problems, while only 13% of students reported never feeling confident. Compared to pre-intervention data, students' always or often feeling confident as problem solvers increased by 26.2%. While these data show quite an increase in confidence, the percentage of students reporting never feeling confident as problem solvers also increased from 8.7% in the pre-intervention data to 13% during the post-intervention data. Still, data on students' attitudes toward mathematics and their confidence in mathematics class, during assessments, and as problem solvers show a significant increase in overall confidence and positive attitude toward mathematics from pre- to post-intervention.

When considering student perception of mathematics as useful to daily life, 60.8% of respondents found mathematics to always or often be useful in their daily life, while 8.7% reported never believing mathematics to be useful in daily life. As compared to the pre-intervention survey data, students' perception of mathematics as always or often useful increased 8.7%, while students' perception of mathematics as never useful to their daily lives stayed the same. This suggests the positive relationship between students' perceptions of mathematics as useful day to day with the use of authentic, real-world mathematics tasks in class. Interestingly, in the post-intervention survey, 69.6% of students recognized the value of mathematics in their future, a decrease from 78.2%. While the gap between students' recognition of the day-to-day application and usefulness of mathematics to their future closed from pre- to post-intervention, the decrease in perceived application of mathematics in the future is a curious shift.

Just as there were shifts in student attitudes and beliefs from pre- to post-intervention, there were also shifts in students' learning preferences. Post-intervention survey data from questions 7-10 provided information about students' learning preferences in the mathematics classroom. Nearly 35% of students reported always or often enjoying learning mathematics through independent work, an increase of 4.3 percent from pre-intervention data. Of the 23 respondents, 69.6% reported always or often enjoying learning mathematics in small groups, a decrease of 21.7%. In terms of collaborating with others to learn mathematics, 73.9% reported always or often enjoying learning mathematics through collaboration, a decrease of 13%. Nearly 87% of students always or often found working with the teacher to learn mathematics enjoyable, an

increase of 4.3%. It is interesting to note that one student reported never liking to learn mathematics through any of these structures.

Post-Intervention Semi-Structured Interviews

To further explain the post-intervention quantitative data, I conducted semi-structured interviews. As with the survey, school closure impacted data collection. Interviews were conducted online via Google Meet and were recorded and transcribed. The same six students were interviewed post-intervention and will be referred to using the same pseudonyms. Data collected from these interviews deepened my understanding of students' experiences with the intervention and their shifting perspectives, as well as illuminated the shifting quantitative data from the researcher-created survey. As these students were initially selected for interviews based on their low MASYC-R and pre-intervention researcher-created survey scores, post-intervention interviews also allowed me to compare their specific shifts in mathematical identity and self-efficacy.

Student responses to question 1, *How does math make you feel?*, included a range of reactions. Three of the six participants reported mixed feelings. Blaire noted, "It makes me feel nervous sometimes because I don't understand and it makes me scared." When prompted to share what particularly makes her nervous about mathematics, she noted division as a specific point of anxiety, particularly when working independently. Haleigh also noted feeling nervous sometimes, but stated, "Sometimes it makes me feel good because math is usually hard for me and if we're doing a unit that is really easy, it makes me feel better to do math." Katie found that her feelings change, depending on the day and if she has been anxious or upset about outside things that day. Jaden's response was unequivocally negative as he said that mathematics makes him mad. When asked to explain, he attributed his anger to the hard work. The remaining students' responses

demonstrated shifts in their feelings toward mathematics. Sabrina said, “Well, it used to make me feel really upset when I struggled but when we started doing those different things it made me feel better.” When asked to elaborate, she immediately responded, “Working in groups!” Similarly, Zoe said, “It makes me feel a lot better than it did. Sometimes when I get a question wrong, it’s not as bad as it was.” When I asked if she felt there was a real difference in how she feels about mathematics, she happily replied, “Yes!” As compared to students’ pre-intervention interview responses, these did not mention any negative physical reactions associated with mathematics. The positive responses from Sabrina and Zoe help explain the increase in positive survey responses as well.

The second interview question was a follow-up to the first and asked: *What makes you most _____ [student response to previous question] when doing math?* When asked why working with groups helped her feel better about mathematics, Sabrina noted how everyone can pitch in and help one another. Zoe found that she feels better about mathematics because she got to work in groups but also noted, “that was helpful but now I kind of like to challenge myself to do it by myself to see how I get it.” This shift in perspective helps explain the increase in student preference for independent learning. Haleigh found that when she gets nervous in mathematics it is usually because “we have to do math in our head or if we’re rounding or estimating.” Interestingly, a couple of students mentioned that new concepts make them nervous at first and can seem hard just because they are new.

The third question asked: *What kind of math lessons do you like most/least?* All six students noted a preference for working in groups. Sabrina also mentioned small-

group rotations, and Haleigh spoke of using mathematics tools with her group was her favorite. Blaire added, “I like the lessons where we do them in groups so we can see what everybody else thinks.” Katie stated, “I love groups but sometimes I don’t, I like to do things independently and I like to draw what’s happening and I like to interact.” As compared to the pre-intervention interviews, while collaboration is still a favorite for students, a few are beginning to realize they sometimes enjoy the challenge of working independently. Haleigh found, “I like working by myself if I feel confident enough to do it or if we’re doing an easy unit and we’re doing fun math games that you have to do by yourself.” These data correlate with the quantitative data, which showed an increase in student enjoyment of learning mathematics independently. The lessons students reported liking least included mathematics assessments, working independently, and lessons that do not provide choice. Jaden mentioned not liking fractions or decimals. Zoe said, “The math lessons I like the least are probably when we don’t have the option to work by ourselves, like we have to work by ourselves. I like the option of when we can work with a partner.”

Interview question four, *How do you learn math best?*, yielded mixed responses. Three of the six students feel they learn best in collaborative groups. Katie noted that she learns best when she can work one-on-one with the teacher. Two students found they learn best in small groups with the teacher. As compared to pre-intervention data, Jaden’s preferences switched from small group or one-on-one with the teacher to collaborative group work. Katie stayed consistent with her preference to work one-on-one with me.

The fifth interview question was: *What was your worst math experience?* Haleigh was unable to think of an experience she would call her worst. This is a shift from the

pre-intervention interview when she cited any time she had to do mathematics in her head or estimate. Zoe found she could not think of a specific worst experience but mentioned that our daily number routine is not her favorite. Sabrina noted that her worst experience was any time she had to work with decimals or fractions. Just as she mentioned in her pre-intervention interview, Blaire found that her worst experience is “when I was really not understanding, and I didn’t talk to the teacher and a quiz came and I was really stuck.” Similarly, Katie found that her worst experience was in her third-grade class when they had mathematics homework and a mathematics test every Friday. Jaden said, “My worst math experience? That’s kind of hard because all of them was the worst.” This indicates an attitude shift from the pre-intervention interview when Jaden found that his worst mathematics experience was when he made a poor mathematics grade. Interestingly, no interviewee mentioned grades during any of the post-intervention interviews.

As assessment came up repeatedly throughout interviews, I asked follow-up questions about students’ feelings and the particular shifts during the intervention. When Katie mentioned taking mathematics tests every week in third grade as her worst mathematics experience, I reminded her that she mentioned that tests made her nervous in our first interview and asked if she could give feedback on the collaborative group assessment that we used during the first phase of intervention. She responded, “I felt better about working with a group. But, then again, sometimes I just like to do something on my own.” When asked to explain, she noted that sometimes group projects like the collaborative performance assessment can be chaotic and loud. When Haleigh mentioned assessments as her worst mathematics experience, I asked how she felt about the

collaborative performance assessment. She responded, “I liked doing the poster. I was really happy that we didn’t have to do the assessment because doing a poster is easier and you can be more creative.” When I followed up with Blaire about her worst experience being unprepared for a quiz or test, I asked her if mathematics assessments make her nervous and scared or if tests in general make her feel scared. She found her anxiety is more related to the assessments than the mathematics itself. These data confirm and further explain the data collected during the intervention, as well as the 25.9% increase in student confidence about mathematics assessments noted in the post-intervention survey data.

Question six asked: *What was your best math experience?* Two students mentioned moments when they already have some background knowledge about the content. Jaden said that our multiplication unit was his favorite because he felt good at it. Sabrina found her best mathematics experience was working with her group because they help her when she’s upset or confused. Zoe stated her best mathematics experiences are “probably when I raise my hand and I got the question wrong and I didn’t feel bad about it.” When asked if she felt that had improved, she said, “It’s gotten better at me not feeling like that. But if we’ve learned it a lot and then I get the question wrong, then I feel kind of bad...I feel like oh, I should know that.” Haleigh recounted a specific memory, “Well, one of the best experiences that I had was when you let us work with the tools and there was this bead string and I knew how to use it. It just made me happy knowing how to use it and knowing what to do with it.”

The last interview question was: *Is there anything else you want to share?* The only student who shared wanted to report changes she felt she has made since the

intervention. Zoe said, “The changes I noticed was when...you’re teaching in front of the SMARTboard, I raise my hand more to participate and if I don’t know something, I kind of wait instead of being like, ‘Oh, I don’t know that.’ I wait and see if my friends will help me understand.” This indicates a shift in her mindset as she is becoming more confident and comfortable with making mistakes.

Several themes were noted across the interview data. All students indicated a strong affinity for working in collaborative groups, yet some found as their confidence grows, they want to try to do mathematics more independently, which explains the curious trend in the quantitative data. Another takeaway was that students enjoy having choices in terms of assessments and in how they will learn mathematics. The feedback provided on the use of alternative assessment supported the quantitative data. Interview data also supported the finding that students’ overall confidence and attitudes have become more positive.

Post-Intervention Data Interpretations

The post-intervention data collected from the researcher-created survey and semi-structured interviews provided interesting insight into the value of the intervention strategies implemented in response to the third research question: How do constructivist-aligned instructional strategies affect mathematical identity in fifth-grade students? The data collected in the researcher-created survey indicated positive changes in students’ attitudes and beliefs about mathematics and themselves as mathematics learners. These data indicate students’ overall beliefs have shifted in a positive direction. The data revealed an interesting trend in students’ learning preferences for mathematics: while the majority of students still much prefer learning mathematics by working with the teacher,

in small groups, or collaboratively, there was an increase in students enjoying learning mathematics independently. Based on the qualitative data gathered in the semi-structured interviews, this increase in students' preferences for independent learning may be related to their increase in confidence to try things on their own, especially if they feel comfortable with the content.

The qualitative data also indicated that the alternative assessment used during the first phase of intervention was very well received. This correlates both with the Phase 1 exit slip data and the quantitative post-intervention data, which showed a 26.1% increase in confidence during mathematics assessments. Another interesting finding from the qualitative data is that students did not mention grading during the post-intervention interviews. Grades were mentioned several times during the pre-intervention data, yet as assessment practices shifted to more student-centered strategies, students' focus on negative feelings related to assessment decreased.

Mathematical identity refers to the attitudes and beliefs about one's own ability to effectively achieve and participate in mathematical situations (Pipere & Mičule, 2014). The data gathered at the beginning of this study uncovered that some students in my mathematics class had negative mathematics attitudes and beliefs about themselves as mathematics learners, indicating a negative mathematical identity, some to the point of math anxiety. The use of strategies like independent work, traditional assessments, and cold-calling on students to answer questions and share were identified as specific areas that may be contributing to the development of students' negative mathematical identity. The two-phase intervention replaced these strategies with a variety of research-based, constructivist-aligned practices, including the development of communities of practice

through collaborative group work with the use of mathematics toolkits, small-group instruction with rotations, bibliotherapy, a focus on growth mindset, and alternative assessment. Based on the data collected during both phases of intervention and post-intervention, on average, students' self-confidence and beliefs about the discipline of mathematics shifted in a more positive direction. To this end, I can conclude that the strategies used during the intervention were effective in helping students develop a more positive mathematical identity.

Conclusion

This chapter shared the results of a convergent parallel mixed-methods action research study conducted to investigate the impact of constructivist-aligned instructional practices on students' development of mathematical identity. Baseline data from the MASYC-R and a researcher-created survey established students' experience with math anxiety and their attitudes and beliefs about mathematics, in concert with semi-structured interviews with a subset of participants. Pre-intervention data uncovered that many students in my class experienced low self-efficacy and negative mathematical identity and indicated several instructional practices that were contributing factors.

A two-phase intervention incorporated various constructivist-aligned instructional strategies and practices in hopes of improving students' mathematical identity. Data were collected through daily exit slips and a teacher journal, and Phase 1 data informed the design of Phase 2. As illustrated above, data collected during intervention and post-intervention indicate a positive impact on students' confidence and beliefs about mathematics and themselves as mathematics learners. While some students still reported mixed feelings about mathematics, there was an increase in student confidence from pre-

intervention to post-intervention. In relation to the research questions, the findings suggest constructivist-aligned instructional strategies and practices can increase student self-efficacy and aid in the development of a more positive mathematical identity. The information gathered through Ivankova's (2015) mixed-methods framework for action research have provided integral insight for me to support my students as they develop their mathematical identities. Further, the findings of this action research study will inform and improve my practice as a mathematics teacher.

CHAPTER 5

IMPLICATIONS

This chapter provides a brief summary of my Problem of Practice, research questions, and study design before discussing the implications of the study findings. Reflections on action research methodology, transferability, limitations, and future research inform the provided action plan.

This convergent parallel mixed-methods study was conducted to address a problem of practice in my fifth-grade classroom. Through this study, I aimed to determine the extent to which my students experienced negative mathematical identity or math anxiety, the classroom practices that may have contributed to students' development of negative mathematical identity, and ways to replace those practices. Further, the study was conducted to evaluate the effects of constructivist-aligned instructional strategies on my fifth-grade students' development of mathematical identity. Constructivist learning theory (Dewey, 1897; Piaget, 1976; Vygotsky, 1978), identity theory (Erikson, 1968; 1970), particularly mathematical identity, and communities of practice (Wenger, 1988) provided the theoretical framework for this work.

As a teacher who suffered with math anxiety for much of my educational career, I recognized the signs of math anxiety and negative mathematical identity in my students and hoped to determine if the curse of this debilitating phenomenon could be reversed to help students experience math mental health (Tobias, 1991). Further, I realized that adequately preparing all students for success in our constantly evolving world in which

STEM skills are highly regarded in the workforce, it was important to help students overcome negative attitudes toward mathematics to develop a positive mathematical identity. As research indicates negative mathematical attitudes and math anxiety can begin early and have long-lasting impacts (Foley et al, 2017; Geist, 2010, 2015; Soni & Kumari, 2015; Tobias, 1991), so this action research study had the potential to impact the equitable opportunity for success of the study participants, as well as and my future students, and to inform the practices of other mathematics educators and teacher educators.

Following Ivankova's (2015) framework for mixed-methods action research, which includes diagnosing, reconnaissance, planning, action, evaluation, and monitoring phases of action, I identified a problem of practice and conducted a literature review to inform the study design. Pre-intervention data were collected through the use of the MASYC-R and a researcher-created survey and semi-structured interviews, which informed a two-phase intervention carried out in the daily mathematics block in my classroom. This intervention included the use of constructivist-aligned instructional strategies and practices that promoted student-centered instruction and the development of a mathematical community of practice within the classroom. Strategies included the use of collaborative group work with mathematics tool kits, bibliotherapy, small-group work, alternative assessments, growth mindset work, and a focus on effective communication and collaboration. During the intervention cycles, data were collected through a Google Form exit slip and a teacher journal. While the intervention was cut short due to school closure during the COVID-19 pandemic, post-intervention data were collected virtually in the form of the researcher-created survey and semi-structured

interviews to evaluate the impact of intervention. The following research questions guided the data collection and were focused on how I could positively impact the development of my students' mathematical identity:

- 1) How does negative mathematical identity and/or math anxiety impact my students?
- 2) What classroom practices contribute to the development of negative mathematical identity and how can those practices be replaced?
- 3) How do constructivist-aligned instructional strategies affect mathematical identity in fifth-grade students?

From the quantitative and qualitative pre-intervention data, I confirmed that many of my students were experiencing math anxiety and negative mathematical identity as 39% of students reported increased negative reactions to mathematics, 43% indicated less than average numerical confidence and 82% indicated higher than average worry about mathematics on the MASYC-R. Additionally, less than half of the class reported feeling confidence in mathematics and only 39.1% of students reported confidence during mathematics assessments, while nearly 60% indicated rarely feeling confident in mathematics on a researcher-created survey. As described in Chapter 4, these data were echoed in semi-structured interview data as participants reported mixed feelings about mathematics, some indicating negative physical reactions to the discipline.

Data collected prior to and during the intervention revealed classroom practices that students associated with negative feelings or anxiety, including tests, independent work, and feeling unprepared when called on to share answers. These data also pointed to strategies with which students felt most confident, including collaboration and small-

group rotations. After further research on constructivist-aligned mathematics practices, I employed a two-phase intervention using strategies such as mathematics autobiography posters, collaborative group work with mathematics toolkits, bibliotherapy, small group rotations, growth mindset activities, authentic assessment, and a focus on effective collaboration and communication. Daily exit slip data indicated above average incidence of self-confidence and perceived usefulness of strategies and an increase in student confidence across the phases. This increase in student self-confidence and evidence of strengthening communities of practice were also echoed in my teacher journal

Post-intervention data collected from a quantitative researcher-created survey and semi-structured interviews revealed a positive shift in students' attitudes toward and beliefs about mathematics with an overall 14% increase in students' scoring above average on this section of the survey. Interestingly, post-intervention data on students' mathematics learning preferences showed an increase in preference for learning mathematics independently, which was explained in semi-structured interviews as students noted their willingness to try mathematics independently when their confidence was higher. Interview data reiterated the survey findings that overall confidence and sense of identity were more positive post-intervention.

Based on my experiences with these learners, it was surprising to note that students' pre-intervention responses were not more negative. This could be due to my positionality in that some students may have wanted to give answers to the survey questions that they thought I, as their teacher, would want to hear. However, interview data allowed me to note specific examples of students' low self-efficacy and negative attitudes and understand the depths of my students' experiences with negative

mathematical identity. This illustrates the value of mixed methods action research as I was able to better understand students' experiences by using both qualitative and quantitative data. Further, as an action researcher, I was able to use my own experience with my students to discern changes from pre-and post-intervention that a traditional researcher might not detect.

Implications

Reflecting on the findings of this study, the themes of student voice and choice continued to surface. In my effort to mitigate the impacts of negative attitudes and anxiety and support positive mathematical identity development, I found that prioritizing students' voices through the surveys and exit slips, as well as in the rich conversations held throughout the intervention phases, instilled confidence in my students. Further, by providing students with choice, their comfort levels rose, allowing them to develop their confidence and leverage their voices. These implications have the potential to impact my own practice and that of other mathematics educators and can lead to important changes for colleges and universities as they strengthen the mathematics course requirements for preservice teachers.

Mathematics teachers and teacher educators might be especially interested in the value of bibliotherapy, which influenced students' attitudes and self-efficacy. Daily exit slip data and my teacher journal from both phases indicated this strategy was especially impactful yielding rich discussions, powerful connections, and shifting students' attitudes. As such, mathematics teachers should consider incorporating bibliotherapy as part of their regular classroom routine to help foster conversations about students' feelings and perceptions about mathematics. Through this strategy, students are able to

make connections with characters and discuss their own thoughts. Furner (2017b) notes that when using bibliotherapy, the follow-up discussion is critical, as it allows students to voice their thinking and provides space for students to connect with their peers over shared experiences, which in turn, strengthens the community of practice.

Teacher educators also may benefit from the inclusion of bibliotherapy in their teacher preparation programs. While many programs include courses that promote the use of children's literature across content areas to teach concepts, these programs should consider implementing bibliotherapy to address the fears and anxieties of teacher candidates, which is well documented in the literature as I discussed in Chapter 2. Further, these programs should consider providing instruction on how to use bibliotherapy in the classroom to prepare mathematics teachers who are sensitive and proactive in their work to support students' developing mathematical identities.

Another interesting finding from this study was the post-intervention increase in students' preference for independent learning. While post-intervention data still indicated students' preferences for collaborative and small-group learning opportunities, there was a 4.3% increase in students' reporting always or almost always enjoying learning mathematics independently. This finding was explained during semi-structured interviews when students found themselves more willing and interested in working independently as their confidence with mathematics grew. This valuable information supports the need for teacher flexibility and reiterates the importance of allowing students the opportunity to voice their preferences and giving students choices in how they work. As Kohn (1993) finds, "the entire constructivist tradition is predicated on the idea of student autonomy," (p. 13) in which students find learning to be in their control. When

provided with collective and individual choices about what learning looks like for them, students are empowered to find their confidence as mathematics learners. Based on these findings, teachers should provide space for student autonomy to choose how they learn and how they show what they have learned in the mathematics classroom. These implications extend to teacher preparation programs, as well, and indicate a need for teacher candidates to learn student-centered, constructivist-aligned instructional strategies that will allow them to feel comfortable providing their students with autonomy as mathematics learners.

Implications for assessment practices can also be gleaned from my study's findings. Pre-intervention data noted a lack of confidence about mathematics assessments and a negative focus on mathematics grades. Post-intervention survey data indicated a 26.1% increase in student confidence during mathematics assessments and grades were not mentioned at all in post-intervention semi-structured interviews. Further, qualitative data showed students' positive reactions to having choice in how they are assessed, confirming Kohn's (1993) assertion that choice increases psychological benefits. These data suggest providing students with alternative assessment options and giving students choice in how they will be assessed increases their confidence. Based on these data, it is clear that traditional paper-pencil tests should not be the only means for mathematics assessment. In her work on assessment for learning, Boaler (2016) pinpoints a variety of strategies for shifting assessment to a focus on learning: self-assessment, peer assessment, reflection time, jigsaw groups, exit tickets, online forms, doodling, student-written questions and tests, and diagnostic comments. Mathematics teachers should explore various options for how to assess student content mastery and give students

choices in how they showcase what they have learned. Teacher preparation programs should also consider these findings as they guide future teachers in developing a toolbox of assessment practices.

To achieve NCTM's (2000) expectation of equitable mathematics education by equal access for all students, mathematics teachers must ensure that fear and anxiety do not serve as gatekeepers for all students' success. My findings indicate the value of constructivist-aligned practices in the mathematics classroom to mitigate the impacts of math anxiety and aid in the development of positive mathematical identity. While opponents of constructivist teaching cite the time it takes to prepare for and implement constructivist practices (HRDevelopmentInfo, 2020), I found that the time I invested in planning for and implementing these practices was worthwhile and fit into my scheduled planning and math blocks. The benefits of this time investment were clear in my students' responses, as well. I found that when instruction is student-centered, student voices are valued and true communities of practice develop that reinforce positive mathematical identity. By teaching mathematics in a way that prioritizes student voice and provides choice, educators set the stage for equal access for all learners.

Reflection on Methodology

The use of a convergent parallel mixed-methods action research methodology allowed me to flexibly investigate a problem of practice in my own classroom by gathering both qualitative and quantitative data in a two-phase study. Flexibility and cycles of action are hallmarks of action research methodology (Dick, 2015; Herr & Anderson, 2015) and allowed me to investigate a multi-faceted problem faced by my students. Using Ivankova's (2015) mixed-methods framework of six phases of action, I

was able to diagnose a problem in my setting, gather reconnaissance through a detailed literature review, design and plan a study, take action by intervening in two phases, and evaluate and monitor the impacts of the intervention.

As action research is cyclical, I was able to move through these steps in phases to gather the most accurate and helpful data to learn answers to my research questions and ultimately, to help my students and improve my practice. This focus on improving practice is another hallmark of action research (Herr & Anderson, 2015), which made this a perfect fit for my study. The constructivist nature of action research (Efron & Ravid, 2013) also aligned with the theoretical framework of this study.

The collection of both quantitative and qualitative data during these cycles allowed me to see the full picture of the problem of practice as well as fully explore the research questions. The use of multiple data sources allowed for triangulation of the data to richly describe and interpret the data to answer my research questions and identify implications of the study.

Transferability

Transferability is the degree to which study findings apply to other contexts and settings, which is important in action research so that readers can identify the investigated problem and research setting and compare to their own contexts (Ivankova, 2015). Lincoln and Guba (1985) posit transferability must be determined outside of the investigator by someone seeking to apply the findings to their own context, but describe the investigator's role as "providing sufficient descriptive data to make such similarity judgements possible" (p. 298). As such, I have used a mixed-methods methodology, which enhances transferability. Further, I provided a detailed description of the research

setting and the study participants and used rich description of the abundant data to aid readers in making transferability judgements (Ivankova, 2015; Lincoln & Guba, 1985). While the goal of action research is focused on the improvement of practice rather than the construction of new knowledge (Townsend, 2014), the findings of this study have the potential to inform practices outside of the research setting. It is my hope that other educators who have identified similar problems of practice within their classrooms and schools will be able to use this study to inform potential shifts in their instructional practices, including the use of collaborative group work, mathematics toolkits with mathematics manipulatives, small-group rotations, alternative assessments, bibliotherapy, growth mindset work, and explicit work on effective collaboration and communication in mathematics communities of practice.

Limitations

As I mentioned earlier, action research is fluid, dynamic, and flexible (Efron & Ravid, 2013). This flexibility was key given the limitations experienced during this study, the most significant of which was the closure of schools due to the COVID-19 pandemic. School closure shortened the second phase of intervention, leading to a relatively short intervention period of six weeks. Additionally, while figuring out the logistics of where we would return to school or continue remote learning, four weeks passed between the second phase of intervention and the collection of post-intervention data. This passing time could have impacted students' responses to survey questions or semi-structured interview questions.

Action researchers must consider the dual role of practitioner and scholar and be mindful that conducting research not affect the quality of practice (Efron & Ravid, 2013).

Conducting intervention lessons while staying on track with the grade-level long-range plans also created limitations. Some intervention activities, like bibliotherapy, were completed in addition to teaching the mathematics content, which required striking a balance between the goals of the study and the grade-level standards. Also, scheduling intervention activities so that all participants could participate proved challenging when working around the schedule of our Title I interventionist. Despite these limitations, the study yielded beneficial results for my students and me.

Future Research

As evidenced in the literature reviewed in Chapter 2, math anxiety and negative mathematical identity are prevalent concerns that impact students' equitable opportunity for future success. In an action research study similar to my own, Ruff and Boes (2014) investigated the impacts of math anxiety on the achievement of fifth-grade students. As guidance counselors, they used small-group lessons on self-talk, expressing feelings, reducing stress, self-advocacy, changing thought patterns, study skills, self-evaluation, and celebration of success to mitigate the negative impacts of math anxiety, in hopes of increasing student achievement. The researchers found this counseling intervention to be moderately effective. Based on these findings and the findings of my study, I believe it would be interesting as a classroom teacher to partner with the guidance department to design an integrated intervention that pairs mathematics instructional practices with social emotional work, aiming to not only to increase students' self-efficacy and promote positive mathematical identity, but also investigate the impact this intervention could have on student achievement.

In her work with adult learners, Tobias (1991) partnered with mathematics educators and counselors to create a Math Anxiety Clinic in which specific techniques were used to aid in the mitigation of math anxiety and the development of math mental health, with much success. This partnership with mental health professionals and content experts yielded many positive results for participants. Tobias noted, “Millions of adults are blocked from professional and technical job opportunities because they fear or perform poorly in mathematics. Most of these adults are brain-capable of learning more mathematics. Theirs is not a failure of intellect, but of nerve” (p.91). To continue the work of providing all learners equal access to mathematics content, further research should be conducted on how a partnership with classroom teachers and counseling departments could begin at the elementary level to mitigate the impacts of math anxiety and negative mathematical identity early.

As mentioned in the literature review, research indicates that the reported achievement gap associated with gender has closed, yet many females still have negative attitudes toward mathematics that may impact their future success (Ramirez et al., 2013). While gender was not a focus of this study, it was interesting to note that of the six students selected for semi-structured interviews based on evidence of math anxiety and/or negative self-efficacy, five were female, which indicates a much higher incidence of negative mathematical identity in my female students when compared to males. Further research should be conducted to identify the specific impact of constructivist-aligned instructional strategies based on gender.

Another avenue of future research arose out of this study’s limitations. In light of the COVID-19 pandemic and the shift to remote learning, I wondered how these

constructivist practices could be applied to a remote or online learning scenario. As such, future research should investigate appropriate use of constructivist-aligned instructional strategies in a remote learning environment, specifically how to develop effective communities of practice when working online with elementary-aged students.

Action Plan

As action research is defined by cycles of action (Dick, 2015; Herr & Anderson, 2015), I plan to continue this work next year. Based on the findings of this study, I concluded that constructivist-aligned instructional practices support the development of positive mathematical identity and help to mitigate the impacts of math anxiety and negative attitudes toward mathematics; thus, I will continue to implement these strategies and practices in my classroom in the coming school year. As suggested above, I hope to collaborate with the school guidance counselor to develop interventions that address mathematical identity, math anxiety, and social emotional learning for impact on mathematics achievement. I also plan to share these findings with my grade-level team and support them as they make shifts to their practices as well. As the grade-level mathematics liaison, the person responsible for creating and disseminating mathematics lesson plans for my team, I will specifically design constructivist-aligned mathematics lessons for use by the grade-level team.

Specific future instructional shifts include providing more choice for students, particularly in terms of how they show they have mastered a concept. I hope to give students more voice through the use of formative assessment. While I have always used a variety of formative assessment tools in my classroom, including exit slips, I learned through this study the importance of using formative assessments that measure students'

confidence and leave space for them to share their thoughts on the activities used in the class. As such, I plan to overhaul my formative assessment practices to incorporate weekly exit slips for students to rate their confidence and share their thoughts on the mathematics, the lesson structures, and assessment. I believe that giving students this opportunity to share their feelings will ultimately make them feel more empowered to advocate for themselves as learners.

I also plan to share the results of the study with the faculty of my school and with the leadership at other elementary schools within the district. Through this presentation, elementary mathematics teachers and school leadership will be able to gain insight into the impact of constructivist instructional practices on the development of students' mathematical identities, potentially opening the conversation in their own contexts and school settings. Additionally, I hope to share these findings at professional conferences and at the next Elementary Advisory Board meeting at my alma mater, in hopes of partnering with their faculty and preservice teachers for future action research.

Conclusion

Herr and Anderson (2015) find that action researchers “study their own contexts because they want the research to make a difference in their own setting” (p. 2). As someone who silently suffered with math anxiety into adulthood, suspecting my students were also impacted by this phenomenon prompted this study in hopes of making a difference in my classroom, with my students, and for my students. The findings of this convergent parallel mixed-methods action research study confirmed my students were suffering with low mathematics confidence and negative mathematical identity, some to the point of anxiety. Students associated independent work, mathematics assessments,

and being called on to answer questions when they felt unprepared with these negative attitudes. Study findings indicated the use of constructivist-aligned, student-centered instructional strategies, with a focus on student collaboration and the development of a strong community of practice, increased students' confidence and helped students develop more positive mathematical identities. Based on these findings, I concluded prioritizing student voice and choice is critical in creating learning environments in which students develop positive mathematical identity. These findings will continue to influence my teaching practices in the future in hopes of reversing the curse of math anxiety and negative mathematical identity by providing a learning environment in which students can find a love for mathematics that will prepare them for future success.

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APPENDIX A

MATH ANXIETY SCALE FOR YOUNG CHILDREN – REVISED

VERSION (Ganley & McGraw, 2016)

Negative Reactions

Read each statement below and circle your response using the provided scale.

Likert Scale: 4 – Yes, 3 – Kind of, 2 – Not really, 1 – No

1. Math gives me a stomachache.

4 3 2 1

2. When it is time for math my head hurts.

4 3 2 1

3. I am scared in math class.

4 3 2 1

4. My heart starts to beat fast if I have to do math in my head.

4 3 2 1

Numerical Confidence

Read each statement below and circle your response using the provided scale.

Likert Scale: 4 – A lot better, 3 – A little better, 2 – A little worse, 1 – A lot worse

5. I like doing math problems on the board in front of the class.

4 3 2 1

6. I like to raise my hand in math class.

4 3 2 1

7. I like being called on in math class.

4 3 2 1

Worry

Read each statement below and circle your response using the provided scale.

Likert Scale: 4 – Always, 3 – Often, 2 – Sometimes, 1 - Never

8. I get nervous about making a mistake in math.

4 3 2 1

9. When the teacher calls on me to tell my answer to the class, I get nervous.

4 3 2 1

10. I get worried before I take a math test.

4 3 2 1

11. I get nervous when my teacher is about to teach something new in math.

4 3 2 1

12. I get worried when I don't understand something in math.

4 3 2 1

13. I feel nervous when I am doing math.

4 3 2 1

APPENDIX B
RESEARCHER-CREATED SURVEY

Read each statement below and circle your response using the provided scale.

Likert Scale: 4 – Always, 3 – Often, 2 – Sometimes, 1 – Never

1. I like math.

4 3 2 1

2. I think math is useful to my daily life.

4 3 2 1

3. I think math will be important to my future.

4 3 2 1

4. I feel confident during math class.

4 3 2 1

5. I feel confident during math assessments.

4 3 2 1

6. I can use my problem-solving skills to figure out challenging problems.

4 3 2 1

7. I like to learn math by practicing independently.

4 3 2 1

8. I like to learn math in small groups.

4 3 2

9. I like to learn math by collaborating with others.

4 3 2 1

10. I like to learn math by working with my teacher.

4 3 2 1

APPENDIX C

SEMI-STRUCTURED INTERVIEW PROTOCOL

The following interview questions will be used as a basis for semi-structured interviews with study participants.

1. How does math make you feel?
2. What makes you most _____ [emotion mentioned in previous answer] when doing math?
3. What kind of math lessons do you like most/least? Why?
4. How do you learn math best?
5. What was your best math experience?
6. What was your worst math experience?
7. Is there anything else you want to share?

APPENDIX D

GOOGLE FORM EXIT SLIP

Likert Scale: 4 – Yes, 3 – Kind of, 2 – Not really, 1 – No

1. I felt confident in math today.

4 3 2 1

2. Today's math activities were helpful for me as a math learner.

4 3 2 1

Open-Ended Response:

Reflect on today's math lesson. Be sure to share your feelings about the math we learned, the activity we did, and your participation.

APPENDIX E

INFORMED CONSENT LETTER

Dear families,

As many of you know, I am currently enrolled in the University of South Carolina as a doctoral student studying Curriculum and Instruction. In the coming weeks, I will be conducting an action research study to investigate the impact of specific instructional strategies and techniques on students' experiences with math and their development of a mathematical identity. When I was a student, I struggled with negative mathematical identity to the point of math anxiety. I know from my own experience how difficult this struggle can be and how much of life can be impacted by these negative beliefs and anxiety. It is my hope that through this study, I will be able to identify the specific impact of math instructional strategies on students' beliefs about themselves as math learners in order to help students develop a positive mathematical identity, particularly before they begin their middle school careers next year. As part of this study, I am inviting your student to take part in my study by providing feedback on their experiences with math through surveys and daily exit slips using Google forms. Based on the information students provide, I will invite some students to participate in brief interviews. The study will take place entirely during school hours.

If you consent to your student's participation in my research study, the following can be expected:

1. Your student will be asked to complete the Math Anxiety Scale for Young Children-Revised survey as well as a researcher-created survey.
2. Your student may be invited to participate in a one-on-one, video-recorded interview with me to elaborate on the survey responses.
3. Your student will be observed during daily math lessons.
4. Your student will be asked to complete daily exit slips using Google Forms to give feedback on the day's math instructional practices and experiences.

Throughout the study, participants' confidentiality will be maintained. Pseudonyms will be used to de-identify students. All study data will be stored electronically on a password-protected computer and using a password-protected Google account. As the researcher, I will be the only person with access to student-specific data.

Participation in this research study is completely voluntary. Should you consent for your child to participate in this study, you and your student reserve the right to withdraw from the study at any point without penalty.

If you have any questions about the study or your child's participation in the study, please do not hesitate to reach out via email at ledbetterj@fortmillschools.org.

Thank you,

Jennifer J. Ledbetter

Student Name: _____

_____ Yes, I give consent for my child to participate in surveys and/or interviews.

_____ No, I do not wish for my child to participate in surveys and/or interviews.

Guardian Signature

Date

APPENDIX F

COLLABORATIVE PERFORMANCE ASSESSMENT TASK

Teacher for the Day

Task: Your fifth grade teacher has asked for your help. A teacher friend who teaches at Sunny Grove Elementary School has a fifth grade class that is having difficulty with multiplying and dividing decimals. Your teacher knows that you are an expert at multiplying and dividing decimals.

With your group, create a presentation that addresses the following items:

1. How to multiply decimals with concrete area models and drawings
2. How to divide decimals with concrete area models and drawings
3. How and why we estimate when multiplying and dividing numbers

Your presentation should include **examples** and **visual models** to help the fifth grade class Sunny Grove Elementary School have a clear understanding of how to work with decimals. Remember, your presentation needs to have **multiple representations using pictures, numbers, and/or words**. Be prepared to give a practice presentation to your classmates.



Task modified from Georgia Department of Education's Georgia Standards of Excellence Curriculum Frameworks found at <https://www.georgiastandards.org/Georgia-Standards/Frameworks/5th-Math-Unit-3.pdf>

APPENDIX G

COLLABORATIVE PERFORMANCE ASSESSMENT TASK RUBRIC

Teacher for the Day Performance Task Single-Point Rubric

<p>Math Standard 5.NSBT.7: Add, subtract, multiply, and divide decimal numbers to hundredths using concrete area models and drawings.</p> <p>Math Process Standard 3: Use critical thinking skills to justify mathematical reasoning and critique the reasoning of others.</p> <p>Math Process Standard 4: Connect mathematical ideas and real-world situations through modeling.</p> <p>Math Process Standard: 6: Communicate mathematically and approach mathematical situations with precision.</p>		
Working Toward Proficiency Areas that need work	Proficient Meeting standard goals	Beyond Expectations Evidence of exceeding standards
	<p>I can explain how and why to estimate when multiplying decimals. Explanation is accurate and provides an example of estimation with decimal multiplication. Score: ____/12</p>	
	<p>I can multiply decimals by whole numbers. Presentation accurately shows the multiplication of a decimal by a whole number. Score: ____/12</p>	
	<p>I can multiply decimals by decimals. Presentation accurately shows the multiplication of a decimal by a decimal. Score: ____/12</p>	

	<p>I can explain decimal multiplication using concrete area models or drawings. Presentation includes accurate pictures or models (10 x 10 grids, area models, base 10 drawings) to match decimal multiplication Score: ____/12</p>	
	<p>I can explain how and why to estimate when dividing decimals. Explanation is accurate and provides an example of estimation with decimal division. Score: ____/12</p>	
	<p>I can divide decimals by whole numbers. Presentation accurately shows the division of a decimal by a whole number. Score: ____/12</p>	
	<p>I can divide whole numbers by a decimal Presentation accurately shows the division of a whole number by a decimal. Score: ____/12</p>	
	<p>I can explain decimal division using concrete area models or drawings. Presentation includes accurate pictures or models (10 x 10 grids, area models, base 10 drawings) to match decimal division Score: ____/12</p>	
	<p>Presentation is neat, organized, and is visually appealing. Score: ____/4</p>	

APPENDIX H

INTERVENTION PHASE 2 STRATEGIES AND PRACTICES NOT IMPLEMENTED DUE TO SCHOOL CLOSURE

Week	Strategies and Practices
7	<ul style="list-style-type: none"> • Alternative assessment with student choice (Kohn, 1993) in independent Google Form assessment or performance assessment to be completed independently, with a partner, or in a small group • Collaborative group work • Small-group instruction with math workshop groups • Math discourse cards • Real-world connections/authentic tasks • Participation Quiz Mathematical Goals (Boaler, 2016) • Bibliotherapy - <i>The Dot</i> (Reynolds, 2003) • Creative Mathematics - Understanding Fraction Multiplication Visually (Boaler et al., 2018) <ul style="list-style-type: none"> ○ Fractions in a Pan (Visualize) ○ Pieces and Parts (Play) ○ The Sum of the Parts (Investigate)
8	<ul style="list-style-type: none"> • Collaborative group work • Small group instruction with math workshop groups • Math discourse cards • Real-world connections/authentic tasks • Bibliotherapy – <i>Thanks for the Feedback, I Think</i> (Cook, 2013) • Creative Mathematics - What Does it Mean to Divide Fractions? (Boaler et al., 2018) <ul style="list-style-type: none"> ○ Creating Cards (Visualize) ○ Cuisenaire Trains (Play)

APPENDIX I

GROUP GOALS

Group Goals

Looking for:

- Leaning in and working in the middle of the table/workspace
- Equal talk time
- Sticking together
- Listening to each other
- Asking each other questions
- Taking ownership to participate in the community

Group Mathematical Goals

Your group is successful if you are:

- Recognizing patterns and describing them
- Justifying your thinking and using multiple ways to represent the math
- Making connections between different math models or strategies
- Using words, drawings, numbers, and color to clearly communicate your ideas
- Explaining your ideas clear to your community members and your teachers
- Asking questions to ensure you understand the thinking of others in your community
- Asking questions that push the group to go deeper
- Organizing a presentation so that people outside your group can understand your group's thinking

Remember, no one is good at all of these things, but everyone is good at something. You will need all of your group members to be successful at each day's task.

Adapted from Carlos Cabana as cited in Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages, and innovative thinking*. San Francisco, CA: Jossey-Bass.