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Best practices to reduce math anxiety

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Pepperdine University

Graduate School of Education and Psychology

BEST PRACTICES TO REDUCE MATH ANXIETY

A dissertation submitted in partial satisfaction
of the requirements for the degree of
Doctor of Education in Organizational Leadership

by

Karen Michelle Mitchell

October, 2018

Farzin Madjidi, Ed.D. – Dissertation Chairperson

This dissertation, written by

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under the guidance of a Faculty Committee and approved by its members, has been submitted to and accepted by the Graduate Faculty in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

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DEDICATION

I dedicate this dissertation to my husband, Pete Mitchell, who believes in me and pushes me to always be a better version of myself. You offered unending encouragement and made many sacrifices along the way to make this happen. I love you and am grateful for you.

ACKNOWLEDGMENTS

First, I would like to acknowledge my Lord and Savior, Jesus. Thank you, Lord, for your grace and wisdom and providing the strength to travel on this journey. I am grateful for the people you have brought into my life.

My husband, Pete, who has been with me every step of the way. I cannot wait to continue on this journey with you. Now it is my turn to do more of the cooking. I love you and our life together.

My two children, Josh and Amanda, who are my greatest blessings. Your encouraging words, hugs, texts, and notes brought many smiles to my face. I count it the greatest privilege to be your mom, and I was able to accomplish this because you believed in me. I love you more than you will ever know.

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VITA

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ABSTRACT

The subjects of science, technology, engineering, and math (STEM) have grown in importance because they are fundamental to the future quality of life and the ability to compete in today's global society. The demand for STEM careers is increasing; however, the United States is having difficulty meeting this demand. Society needs students who can research and think critically, so they can be proficient in STEM education and become the next generation of mathematicians, scientists, technologists, and engineers. Mathematical proficiency is of particular concern because while it is required for STEM education success, individuals find it challenging.

Both adults and children have apprehension about mathematics, and their negative attitudes toward math develop a barrier to STEM education and careers. This negative math phobia, or math anxiety, causes a decrease in math achievement. This study explored the perceptions of elementary teachers in establishing a classroom environment free of math anxiety. Specifically, this study focused on best practices that teachers incorporate in order to reduce math anxiety.

The purpose of the study was to (a) determine the strategies and practices teachers employ to reduce math anxiety, (b) determine the challenges teachers face in reducing math anxiety, (c) determine how teachers measure the success of their practices in reducing math anxiety, and (d) determine the recommendations teachers would make for future implementation of strategies in reducing math anxiety.

Chapter 1: Introduction

Background

In his book, *The World is Flat*, Friedman (2007) describes a flattening of the world because economic competition has become global and the playing field has been leveled. In this global economy, the subjects of science, technology, engineering, and math (STEM) have grown in importance because they are fundamental to our quality of life and future prosperity (Cal, 2017; Kennedy & Odell, 2014; National Mathematics Advisory Panel, 2008; Yildirim & Selvi, 2015). Instead of viewing the four subjects as independent disciplines, they are thought of as a meta-discipline and integrated together (Estapa & Tank, 2017; Kennedy & Odell, 2014). STEM education includes teaching and learning of the disciplines in all classroom settings from preschool through graduate school (Gonzalez & Kuenzi, 2012).

The purpose of STEM education is to promote and develop a STEM literate society that can compete in today's global economy. Bybee (2013) explains STEM literacy as:

- "Knowledge, attitudes, and skills to identify questions and problems in life situations, explain the natural and designed world, and draw evidence-based conclusions about STEM-related issues" (p. 101).
- "Understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry, and design" (p. 101).
- "Awareness of how STEM disciplines shape our material, intellectual, and cultural environments" (p. 101).
- "Willingness to engage in STEM-related issues and with the ideas of science, technology, engineering and mathematics as a constructive, concerned, and reflective citizen" (p. 101).

STEM Proficiency

Proficiency in STEM education is becoming increasingly important in modern society as students are expected to have the knowledge and skills for solving problems and analyzing information (National Mathematics Advisory Panel, 2008; U.S. Department of Education, 2017). Society needs students who are able to research, innovate, and think deeply, so they can participate successfully in STEM careers (U.S. National Academies Press, 2006; U.S. Department of Education, 2017). According to the U.S. Bureau of Labor Statistics, occupations in STEM fields will increase by 9 million between 2012 and 2022 (Vilorio, 2014). By 2022, software development is expected to have more than 200,000 job openings and civil engineering is expected to have more than 120,000 job openings (Vilorio, 2014). Also, by 2022, careers in mathematics are expected to increase 23% and jobs for statisticians are expected to increase by 27% (Vilorio, 2014).

While there is an increasing need and opportunity for STEM employment, the U.S. is facing an inadequacy in meeting the demand (Roehrig, Moore, Wang, & Park, 2012). The U.S. is expected to lose a fraction of its science and engineering workforce because 26% of science and engineering workers were above age 50 in 2003 (National Science Board, 2008). During the time of the decreasing workforce, growth in STEM careers will triple that of other occupations (National Science Board, 2008). In addition, there will not be as many scientists and engineers to import from overseas because they are working in their own countries, such as China, Singapore, South Korea, and Taiwan, where rapid research and development is occurring (National Science Foundation, 2007). Finally, U.S. students may not possess the competence required to successfully fill the STEM positions (National Research Council, 2011). The 2010

Executive Report by President's Council of Advisors on Science and Technology state the following:

> The success of the United States in the 21st century - its wealth and welfare - will depend on the ideas and skills of its population. These have always been the Nation's most important assets. As the world becomes increasingly technological, the value of these national assets will be determined in no small measure by the effectiveness of science, technology, engineering, and mathematics (STEM) education in the United States. STEM education will determine whether the United States will remain a leader among nations and...help produce the capable and flexible workforce needed to compete in a global marketplace. (p. vii)

Mathematical proficiency is of particular concern for achieving the necessary competence in STEM fields (National Mathematics Advisory Panel, 2008); however, there may be little interest in pursuing mathematics because individuals find it challenging (Harari, Vukovic, & Bailey, 2013). Approximately 75% of U.S. eighth graders are not proficient in math when they complete eighth grade (National Research Council, 2011). The National Assessment of Education Progress (NAEP) states that 27% of eighth graders could not correctly shade one-third of a rectangle and 45% could not solve a word problem that required dividing fractions (U.S Department of Education, 2004). Moreover, NAEP data shows that 39% of students are at or above the proficient level of math in eighth grade (U.S. Department of Education, 2007), and only 23% are at or above the proficient level by twelfth grade (U.S. Department of Education, 2005). Finally, 78% of adults cannot compute the interest paid on a loan, 71% cannot calculate miles per gallon on a trip, and 58% cannot calculate a 10% tip (Phillips, 2007). Murnane and

Levy (1996) stressed the importance of math as a skill when they explained that almost half of all seventeen-year olds cannot do math at the level needed to get a job at a modern automobile plant. The statistics are disheartening because mathematics is considered the foundational language of science, technology, and engineering (Schmidt & Houang, 2007).

Since mathematics is a foundational language, mathematical proficiency is critical for success in the subject. Factors that affect mathematical proficiency are working memory, gender, math anxiety, and mindset/self-efficacy (Dweck, 2016; Miller & Bichsel, 2004). Math anxiety is considered to be the most significant factor; however, mindset and self-efficacy are related because they are negatively related to math anxiety (Dweck, 2016).

Math and Anxiety

Regardless of cultural and economic background, two-thirds of adults in the United States fear and dislike math and recall having negative experiences with the subject, even in elementary school (Burns, 1998; Furner & Duffy, 2002). These fears and negative experiences could pose as a major impediment to future math experiences and entry in a STEM career (Ferguson, Maloney, Fugelsang, & Risko, 2015).

Research shows that in addition to adults, children have apprehension about mathematics as well (Blazer, 2011). For many children, anxiety and a negative attitude toward math are growing barriers to mathematics (Geist, 2010), and negative attitudes often develop from society's over reliance on timed tests and standardized testing (Scarpello, 2007). These attitudes about math are perpetuated by the following math myths that exist today:

- "Math is thought to be inherently difficult" (Ashcraft, 2002, p. 181).
- "Aptitude is considered far more important than effort" (Ashcraft, 2002, p. 181).

- “Being good at math is considered relatively unimportant, or even optional” (Ashcraft, 2002, p. 181).

Perceptions About Math

According to Ashcraft (2002), individuals continue to believe these myths. There is an acceptance of the idea that math is a field where a student has talent or not, such as athletics, art, or music (Stodolsky, 1985). Society would not say that about reading; however, it is said about math even though math is necessary for many of life’s functions. Students need a sufficient level of numeracy, which is the counterpart of literacy (Paulos, 1988). Math negativity and anxiety are an impediment to numeracy and create a disparity between levels of math achievement (Beilock & Maloney, 2015).

> No longer can we accept that a rigorous mathematics education is reserved for the few who will go on to be engineers for scientists. Mathematics may indeed be the “the new literacy” (Schoenfeld, 1995); at the least, it is essential for any citizen who is to be prepared for the future (National Mathematics Advisory Panel, 2008, p. 5).

Various Roles in Math Anxiety

Role of educators. Research shows there are high levels of math anxiety in many preservice elementary teachers (Gresham, 2004; Singh, Granville, & Dika, 2002; Zettle & Raines, 2002). Elementary school teachers who are higher in math anxiety affect their students negatively. At the beginning and end of the school year, Beilock, Gunderson, Ramirez, and Levine (2010) assessed first- and second-grade teachers’ levels of math anxiety and their students’ attitudes and math achievement. They discovered that when female elementary teachers are higher in math anxiety, their students have lower levels of math achievement and believe stereotypes that boys are better at math than girls (Beilock et al., 2010). The results did not indicate if the teachers' math anxiety levels affected the student's math anxiety; however, negative attitudes are related to math anxiety (Hembree, 1990).

Educators also play a key role in developing students' mindsets. Studies show the positive effects of growth mindset on students' achievement (Aronson, Fried, & Good, 2002; Blackwell, Trzesniewski, & Dweck, 2007; Boaler, 2013a, 2016), and the importance of communicating that learning takes time and is the product of effort. The most successful schools design learning practices on growth mindset messages and beliefs (Sahlberg, 2011; Stigler & Hiebert, 1999). Since teachers regularly communicate with students about their ability and learning, a need exists in order to study the best practices and strategies educators use in order to promote a growth mindset.

Role of parents. Parents' math anxiety affects their children's math anxiety in specific situations. Maloney, Ramirez, Gunderson, Levine, and Beilock (2015) assessed parents' math anxiety and the frequency of homework help they provide to their first- and second-grade children. Parents who regularly help their children with homework may pass on their frustration and dislike of math to their children. They have the ability to be positive or negative academic role models to their children.

Parents also affect their children's mindset by the words they use and how they offer praise (Dweck, 2016). By praising brains and talent, parents think they are increasing their children's confidence. However, this technique has the opposite effect because children doubt themselves when something is difficult or challenging (Dweck, 2016). The best gift parents can give their children is "to teach their children to love challenges, be intrigued by mistakes, enjoy effort, seek new strategies, and keep on learning" (Dweck, 2016, pp. 179-180).

Role of teacher education programs. Most mathematics curriculum and instructional practices are traditional in that memorization of facts is emphasized, teachers lecture, and students do not have ample opportunity to engage in experiential learning and hands-on activities (Gresham, 2004; Tobias & Weissbrod, 1980). This traditional emphasis results in the learning styles of all students not being met and an increase in math anxiety (Hodges, 1983; Sloan, Daane, & Geisen, 2001; Tobias & Weissbrod, 1980). All teacher education programs should emphasize the importance of an inviting classroom, students' learning style differences, safe environment, multiple teaching approaches, and praise for students' accomplishments in math (Gresham, 2007).

Role of STEM initiatives. Current STEM initiatives focus on math content and largely ignore affective factors such as math anxiety, self-efficacy, and growth mindset (Beilock & Maloney, 2015). Since math anxiety is a widespread phenomenon and negatively affects math performance, math attitudes, and math avoidance (Ashcraft & Kirk, 2001; Beilock & Maloney, 2015; Blazer, 2011; Hoffman, 2010), it should be addressed in present day policy initiatives. More STEM teachers and more students pursuing STEM careers would certainly be a positive result, in addition to incorporating best practices to reduce math anxiety and growth mindset.

Statement of the Problem

Individual differences in math achievement are attributed to a variety of factors (Dweck, 2016; Miller & Bichsel, 2004). First, a widely researched factor is working memory, consisting of retrieval, processing, and storage (Adams & Hitch, 1998; Ashcraft, 2002; Brainerd, 1983; Geary & Widaman, 1987; Hitch, 1978a; Hitch, 1978b). A second factor contributing to differences in math achievement is gender (Hyde, Fennema, Ryan, Frost, & Hopp, 1990; Leahey

& Guo, 2001). A third factor is math anxiety (Ashcraft, 2002; Faust, Ashcraft, & Fleck, 1996; Wu et al., 2012). The final factor known to cause differences in math achievement is mindset and self-efficacy (Dweck, 2008).

Out of the four factors, this study will primarily focus on math anxiety because research indicates it is the strongest predictor of math performance (Ashcraft, 2002; Ashcraft & Kirk, 2001; Beilock & Maloney, 2015; Hoffman, 2010; Miller & Bichsel, 2004). Mindset and self-efficacy will also be areas of interest because they have a negative relationship with math anxiety and affect math performance (Aksu, Ozkaya, Gedik, & Konyalioglu, 2016; Cooper & Robinson, 1991; Jain & Dowson, 2009; Ma & Xu, 2004;). The earlier math anxiety and mindset is addressed in students, especially elementary school age, the earlier improvements in performance may be demonstrated, the shorter the period of math avoidance, and the earlier participation in STEM may be experienced (Beilock & Maloney, 2015).

Purpose Statement

The purpose of the study was to:

- Determine the strategies and practices teachers employ to reduce math anxiety.
- Determine the challenges teachers face in reducing math anxiety.
- Determine how teachers measure the success of their practices in reducing math anxiety.
- Determine the recommendations teachers would make for future implementation of strategies in reducing math anxiety.

Research Questions

In order to discover how to increase math achievement by reducing math anxiety, the following research questions (RQ) were addressed in this study.

Research Question 1: What strategies and practices do teachers employ to reduce math anxiety?

Research Question 2: What challenges do teachers face in reducing math anxiety?

Research Question 3: How do teachers measure the success of their practices in reducing math anxiety?

Research Question 4: What recommendations would teachers make for future implementation of strategies in reducing math anxiety?

Significance of the Study

It is critical that students receive the instruction and tools they need to be successful in math (National Mathematics Advisory Panel, 2008). Teachers need to have high expectations for all students, and students need to believe they can succeed in math. Students can make significant progress when they believe their intelligence can increase through learning, effort, and persistence. The National Council of Teachers of Mathematics (NCTM) states,

> A strong foundation in mathematics, for each and every student from pre-K–12, is vital to our nation's economic stability, national security, workforce productivity, and full participation in our democratic society. Mathematical literacy is fundamental for adult numeracy, financial literacy, and everyday life (NCTM, 2017, para. 1).

According to research, there are numerous ways to increase math achievement including equity and access, intervention, high expectations, teacher training, teacher evaluation, early childhood learning, and assessment (NCTM, 2017). This study specifically focuses on best practices to reduce math anxiety in elementary students, so math achievement is increased. The significance of this study is that by having a deeper understanding of math anxiety, self-efficacy, and growth mindset, teachers, parents, teacher education programs, and STEM initiatives can implement strategies in their practice to improve outcomes.

Significance for teachers. The results of this study can be utilized by teachers in order to underscore the importance of identifying math anxiety early (Zubrzycki, 2017) and to develop strategies to reduce it. Research shows that teacher practices have a strong influence over a student's degree of math anxiety (Geist, 2010; Scarpello, 2007). Teachers can implement best practices to help students in reducing math anxiety. Moreover, the findings can be implemented so teachers can intentionally teach growth mindset. They can model growth mindset, promote it with their students, and provide process praise so students persevere through challenging math tasks (Cimpian, Arce, Markman, & Dweck, 2007). Finally, lead and mentor teachers can create professional development courses for existing teachers about the research on math anxiety and how to spot it in students (Beilock & Maloney, 2015).

Significance for parents. The results also have significance for parents because the information can be shared with and extended to parents, and they can implement strategies in their home. Parents' attitudes toward math shape their children's attitudes toward math (Scarpello, 2007; Woodard, 2004). Parents can read the study and benefit from parent education nights at schools and childhood centers. Moreover, they can focus on expressing positive attitudes about math while in the presence of their children, even if they did not experience math success in school (Blazer, 2011).

Significance for teacher-education programs. The findings of this study will contribute to teacher-education programs. All teacher-education programs that have a STEM component - multiple subject elementary programs and single STEM subject programs - can incorporate lessons on math anxiety, so teachers understand that success in math requires not only content but also the right mindset (Beilock & Maloney, 2015). The elementary pre-service programs should not be neglected because negative math attitudes often develop when children are young.

Significance for STEM policy initiatives. This study also has significance for STEM initiatives. The federal government has developed various STEM policy initiatives in an effort to elevate U.S. students from their 27th place world ranking in math and 20th place world ranking in science (Beilock & Maloney, 2015). Specifically, President Obama launched the *Educate to Innovate* initiative in 2009, which provides funding for STEM research, programs, and training. Elements of the initiative can be expanded by incorporating this research on math anxiety and the role of fixed mindset in creating a barrier to entry into STEM fields (Beilock & Maloney, 2015).

Assumptions of the Study

There were four assumptions in this phenomenological study, and Creswell (2013) suggested assumptions should be acknowledged. Assumptions in a research study are those parts that are somewhat out of the researcher's control; however, the research would not exist without them (Leedy & Ormrod, 2010).

1. The interviewer established rapport with the participants while providing a safe environment that encouraged sharing and open reflection.
2. The participants responded to the interviewer's questions in an honest, transparent, and candid manner. Transparency was encouraged because the participants knew that their responses were anonymous and confidential and that they could withdraw from the study at any time.

3. The participants had adequate teaching experience to share insights, personal anecdotes, and observations. They have worked with numerous students and are able to determine and utilize successful math teaching strategies.
4. The participants in this study had no personal interest in influencing the study's data or analysis. There was no compensation and participation did not influence the individual's teaching positions.

Limitations of the Study

Research studies have limitations and are out of the researcher's control (Simon, 2011). It is useful to explain the limitations of a study because they highlight the potential weaknesses (Simon, 2011) and improve the credibility of the study (Ioannidis, 2007). Moreover, Brutus, Aguinis, and Wassmer (2013) believe that limitations are an important aspect of advancing research and must be disclosed and described. The researcher acknowledged the following limitations of this study.

Creswell (2014) states that researchers bring bias to a study and should clarify the bias. In this study, the researcher may have had bias in interpreting the data resulting from her prior education roles as a math tutor, elementary teacher, mentor/master teacher, and administrator. The researcher has her own knowledge and experience from teaching students across a variety of grades and abilities, training developing teachers, and evaluating teachers' instruction.

Participants were exclusively from XYZ Unified School District, so the interviewees may or may not represent the broader population of elementary math teachers. The district may have had a focus on math instruction to improve all students' math achievement or may have had additional math inservices. The results may not translate across districts, geographic areas, or socio-economic levels.

Definition of Terms

The following key terms are used in this study:

- **Anxiety:** An aversive state of worry occurring in situations when an individual perceives a threat is high (Davis, Ollendick, Nebel-Schwalm, 2008; Derakshan & Eysenck, 2009; Jarrett, Black, Rapport, Grills-Taquechel, & Ollendick, 2015).
- **Best practices**: Existing procedures, techniques, or methodology, shown by research and experience, to produce optimal results and widely-agreed effectiveness (Hargreaves & Fullan, 2012).
- **Fixed mindset**: The belief that intelligence and ability are fixed traits (Dweck, 2016).
- **Growth mindset:** The belief that intelligence can be increased, and the brain can be developed through exercise; belief that effort, curiosity, and perseverance help to become better at something (Dweck, 2016).
- **Intelligence:** The ability to acquire knowledge and skills; capacity for learning; level of intelligence is based on genes and environment (Dweck, 2016).
- **Math achievement:** The amount of basic and applied math content a student learns in a given amount of time (Miller & Bichsel, 2004).
- **Math anxiety**: Math negativity and phobia; feeling of fear, panic, apprehension, helplessness that arises when confronted with solving a math problem (Blazer, 2011; Carey, Hill, Devine, & Szücs, 2016; Stodolsky, 1985; Tobias & Weissbrod, 1980).

- **Mindset:** Implied theories about the essence of intelligent behavior; engagement, motivation; ownership (David, 2015; Dweck, 2000).
- **Self-efficacy:** Beliefs that a student holds about his or her academic capabilities to produce desired results (Bandura, 1986).
- **STEM:** A metadiscipline comprised of the four fields of science, technology, engineering, and mathematics (Kennedy & Odell, 2014; Treacy & O'Donoghue, 2014).

Summary

As society becomes more technological and data driven, it is imperative that students are well prepared to succeed in future STEM careers (English, 2016). Students' math achievement can be impeded when they suffer from math anxiety or have a fixed mindset (Blazer, 2011; Boaler, 2013a; Cavanaugh, 2007; Geist, 2010). Math anxiety can be debilitating because it undermines a student's academic performance. It also leads to avoidance, which ultimately means students may not take higher math classes, not pursue higher education, and avoid careers that are perceived as mathematically burdened (Ashcraft, 2002; Blazer, 2011; Jameson, 2014; Pletzer, Wood, Scherndl, Kerschbaum, & Nuerk, 2016; Ramirez, Gunderson, Levine, & Beilock, 2013; Wu et al., 2012). Studies also show there is a strong negative correlation between math anxiety and test scores (Chiu & Henry, 1990; Wu et al., 2012). As math anxiety increases, test scores and grades decrease. Students with a fixed mindset lose confidence and motivation when the math task becomes challenging. They believe effort will not make a difference and they are not oriented toward learning goals (Dweck, 2006).

This study explores the best practices and strategies teachers incorporate to reduce math anxiety and promote growth mindset in their students. The goal is to increase math achievement. This study also looks at the challenges teachers face and recommendations they have for future implementation of best practices. Chapters 2 and 3 provide an overview of the literature on math anxiety and mindset, summarize existing research on the topic, present the research methodology and rationale, and describe the interview and data collection procedures.

Chapter 2: Literature Review

Many people have a genuine fear of math (Burns, 1998; Furner & Duffy, 2002). This math trauma, or math anxiety, carries implications for future math success. Math anxiety and its related factors, self-efficacy and growth mindset, all play a role in math achievement (Beilock & Maloney, 2015). By developing a deeper understanding of math anxiety and its related factors, best practices can be established for reducing math anxiety. In this literature review, the initial sections focus on general anxiety in the education arena and factors affecting math achievement. The research on math anxiety and related factors are then examined in detail, all while aiming to ensure the best possible outcomes for students.

General Anxiety

Anxiety is an emotion that signals to the individual possible challenges or difficulties are involved with the situation or task at hand (Bigdeli & Bai, 2009). Moreover, anxiety is a "highly pervasive and insidious psychological phenomenon" (Bigdeli & Bai, 2009, p. 103) that negatively affects teaching and learning. Reviews of studies show that anxiety disorders are the most common disorder in youth (Albano, Chorpita, & Barlow, 2003), and that the prevalence rate ranges from 2% to 27%, depending on age and the measure used (Costello, Egger, & Angold, 2004).

There are several negative aspects associated with anxiety. Children with anxiety tend to be shyer, more socially withdrawn, less popular, and less likeable than children who are not anxious (Coplan, Girardi, Findlay, & Frohlick, 2007; Nelson, Rubin, & Fox, 2005). Parent reports of anxious children compared to those of non-anxious children detail more difficulties with the anxious children (Kashani & Orvaschel, 1990). Students who are classified as anxious by their teachers demonstrate greater difficulties and problems adjusting than their non-anxious peers (Strauss, Frame, & Forehand, 1987). The negative effects of childhood anxiety tend to persist into adulthood and may include adult anxiety disorders, mood disorders, and substance abuse problems (Kendall, Safford, Flannery-Schroeder, & Webb, 2004; Woodward & Fergusson, 2001). Several aspects related to school such as peers, school work, homework, teachers, and tests are correlated with anxiety (Barrett & Heubeck, 2000).

Schools are often imbued with anxiety since there are several types of educational anxiety including separation anxiety, general anxiety, math anxiety, English as a second language anxiety, test anxiety, and performance anxiety (Bigdeli & Bai, 2009; Mychailyszyn, Mendez, & Kendall, 2010). Anxiety causes interference with attention, memory, processing, and inductive reasoning (Bigdeli & Bai, 2009; Ellis, 1990; Jarrett, Wolff, Davis, Cowart, & Ollendick, 2016). Elevated anxiety creates a state of arousal where attention is focused on the perceived threat, which impairs the ability to focus on learning (Wood, 2006). Since there is a negative relationship between childhood anxiety and academic achievement (Jarrett et al., 2015), it would be particularly beneficial to help teachers understand the nature of anxiety and to best assist their students in overcoming it (Beilock & Maloney, 2015; Bigdeli & Bai, 2009). Training in a teacher education program would provide the necessary knowledge for teachers so they could incorporate anxiety awareness into the curriculum. Once a student understands anxiety, she can attend to it instead of letting it proliferate. When anxiety is experienced before a learning situation such as a test, presentation, or debate, the student can use the anxiety as a trigger to accept the challenge and perform at a higher level. On the contrary, when anxiety permeates and is experienced relentlessly, especially during a demanding task, it can be seriously damaging to the student's learning ability and impairs performance (Bigdeli & Bai, 2009; Chansky & Kendall, 1997; Derakshan & Eysenck, 2009).

Davis et al. (2008) conducted a study by comparing the cognitive impairment of children with anxiety disorders to the cognitive impairment of children without significant anxiety. The study participants were 161 children with a mean age of 10.56 referred by schools, physicians, and mental health professionals (Davis et al., 2008). The researchers administered three assessments to the children: *The Wechsler Intelligence Scale for Children - Third Edition* to measure ability (IQ)*, The Wechsler Individual Achievement Test - First Edition* to measure academic achievement, and *The Anxiety Disorders Interview Schedule* to assess psychopathology. The parents took the parent version of *The Anxiety Disorders Interview Schedule*. The researchers found a statistically significant influence of anxiety on ability and achievement; although, the effects were only observed on the overall composite score, not individual achievement scores (Davis et al., 2008). This study did not indicate any causal direction as it is undetermined if children with lower IQ scores are predisposed to develop anxiety disorders or if children with anxiety disorders are predisposed to experience deficits in IQ over time. In the first situation, a child with lower ability may have a more difficult time persevering through stress or solving life problems. In the second scenario, a child with an anxiety disorder may achieve less because of the pervasive worry that impedes focus (Davis et al., 2008). Overall, anxiety disorders impact psychological functioning and their impact on children needs to be recognized.

In a similar study, Ialongo, Edelsohn, Werthamer-Larsson, Crockett, and Kellam (1996) examined anxiety, depression, and cognition in a sample of 1,197 first-grade children from 19 Baltimore public elementary schools. The children were selected from school-based intervention groups that targeted early learning and aggression. The participants completed the following assessments: *Revised Children's Manifest Anxiety Scale* to measure the level of anxiety and

Children's Depression Inventory to measure symptoms associated with depression. The researchers and trained interviewers administered the *Teacher Observation of Classroom Adaptation - Revised* where the teachers answered questions regarding the student's ability to adapt to classroom demands. All classmates completed the *Peer Assessment Instrument* where the researcher read a description such as *plays alone a lot* or *your best friends* and the students circled the child who best fit the description. Finally, scores from the standardized test *California Achievement Test* were used (Ialongo et al., 1996). The researchers specifically studied the degree of social and cognitive impairment on the children with only anxious symptoms, only depressive symptoms, and comorbid anxious and depressive symptoms. First, boys who were only anxious or only depressed showed significantly greater impairment in social and cognitive functioning than boys who were neither anxious nor depressed. Girls who were only anxious or only depressed showed little social and cognitive impairment when compared to girls who were neither anxious nor depressed (Ialongo et al., 1996). Second, the researchers compared anxious symptoms to depressive symptoms. Boys who only showed depressive symptoms showed very slight social and cognitive impairment over boys who only showed anxious symptoms. There was no difference between the two in girls (Ialongo et al., 1996). Third, the researchers compared comorbid symptoms. There was limited evidence that boys with comorbid status had greater social and cognitive impairment than boys with only anxious or only depressive symptoms. For girls, the cognitive and social impairment were apparent when using the standardized achievement test and the teacher ratings of shy behavior (Ialongo et al., 1996). The researchers shared that further research was warranted in order to explain the different outcomes by gender. Although the degree of social and cognitive impairment varied across situations and gender, the researchers felt it was still worth recognizing because early achievement is linked to future educational and occupational success and psychological well-being (Ialongo et al., 1996).

In two of their previous studies, Ialongo, Edelsohn, Werthamer-Larsson, Crockett, & Kellam (1994, 1995), discovered that first grade children in the top quartile of anxiety were eight times more likely to be in the lowest quartile of reading achievement and two and a half times more likely to be in the lowest quartile of math achievement. The researchers also reported that anxiety in first grade was a strong predictor of anxiety in fifth grade (Ialongo et al., 1995). Finally, Ialongo et al. (1995) proposed that anxiety in school-age children continues through the years if left untreated.

General education anxiety impedes students' future success in school. Depending on the severity of the anxiety, it can affect students in a variety of ways as explained above. One aspect that general anxiety affects is overall math achievement.

Math Achievement

Individual differences in math achievement are attributed to a variety of factors (Dweck, 2016; Miller & Bichsel, 2004). First, a widely researched factor is working memory, consisting of retrieval, processing, and storage (Adams & Hitch, 1998; Ashcraft, 2005; Baddeley, 2000; Brainerd, 1983; Engle, 2002; Geary & Widaman, 1987; Hitch, 1978a; Hitch, 1978b). Hitch (1978a, 1978b), one of the earliest researchers who studied the relationship of working memory on math performance, found that the number of mathematical errors students made increased as the number of operations held in working memory increased, as the answers needed be to written in reverse order (hundreds, tens, ones), and as the number of operations that had to be executed within working memory increased. Specifically, Hitch's results demonstrated that working memory was overwhelmed by holding more information in memory, holding the information for a longer time, and executing more operations in memory (Ashcraft, 1995). Students who are more competent in the working memory processes perform better overall on mathematics achievement tests (Miller & Bichsel, 2004).

A second factor used to account for discrepancies in math ability is gender. Throughout the years, researchers have often debated if the findings demonstrating that males have an advantage in math courses are inherent or if it is the influence of sex-based stereotypes (Hyde, Fennema, & Ryan et al., 1990; Leahey & Guo, 2001). Benbow (1988) found large gender differences showing a male advantage that emerged as early as middle school. When Leahey and Guo (2001) studied large, national samples, they found no gender differences among middle school students; however, they found slight gender differences among high school students in the areas of general math, reasoning, and geometry.

A third factor found to create low math achievement is math anxiety (Ashcraft, 2002; Faust et al., 1996; Wu et al., 2012). Research shows performance differences were more prominent when difficult arithmetic problems were tested (Ashcraft & Faust, 1994; Faust et al., 1996). High-math anxiety individuals had difficulty solving two-column addition problems due to the regrouping operation (Ashcraft & Faust, 1994), and it took them three times as long to complete the problems than the low-math anxiety individuals (Faust et. al., 1996). According to documented literature, there is a significant relationship between math anxiety and math achievement, and math anxiety has long-term damaging consequences (Ashcraft & Kirk, 2001; Faust et al., 1996; Hembree, 1990). Specifically, math anxiety "disrupts the ongoing, task-relevant activities of working memory, slowing down performance and degrading its accuracy" (Ashcraft & Kirk, 2001, p. 236). Math anxious individuals worry about solving a math problem and the worries occupy their thinking resources that are needed for the present math task at hand.

Math anxious individuals are focusing on two tasks at once - attending to their worries and solving the problem - so their performance suffers (Beilock & Maloney, 2015).

Neuroscientific data from functional magnetic resonance imaging (fMRI) were used to analyze the differences of brain activity between children with high math anxiety and children with low math anxiety while they completed math problems (Young, Wu, & Menon, 2012). The children with high math anxiety had more activation in brain regions associated with negative emotions and had less activation in brain regions associated with working memory. The scientific data confirm that math anxiety disrupts working memory and interferes with the math task at hand (Young et al., 2012).

Math anxiety is not only limited to decreasing math performance in academic settings. It has been identified with poor drug calculations in nursing (McMullan, Jones, & Lea, 2012), reduced teaching self-efficacy in teachers (Swars, Daane, & Giesen, 2006), and unsound financial planning (McKenna & Nickols, 1988). This study primarily focused on math anxiety because research indicates it is the strongest predictor of math performance (Ashcraft, 2002; Ashcraft & Kirk, 2001; Beilock & Maloney, 2015; Hoffman, 2010; Miller & Bichsel, 2004).

Finally, mindset and self-efficacy account for differences in math performance. Low achievement stems from students who believe that math ability is a fixed trait or mindset (Dweck, 2008). Good, Aronson, and Inzlich (2003) studied a group of seventh grade students who were not performing well in math. One group served as a control group and the second group had growth mindset intervention. The growth mindset group met with math mentors in November and January and had e-mail correspondence throughout the year. There was no improvement in the control group; however, the growth mindset group had a 4.5-point gain in their mathematics achievement test scores (Good et al., 2003). Poor math performance also results when students have no self-efficacious beliefs. Regardless of how hard the student works, she believes her grade will not improve because she has no influence over her achievement (Bandura, 1986; Usher & Pajares, 2009).

Understanding Math Anxiety

Definition of math anxiety. Math anxiety is referred to as math negativity and math phobia; although, math anxiety is the commonly used term (Ferguson et al., 2015). It is defined as negative emotions and a state of discomfort that interfere with the solving of math problems (Blazer, 2011; Carey et al., 2016; Stodolsky, 1985). Math anxiety is more than just disliking math, and 93% of Americans indicate they experience math anxiety to some degree (Blazer, 2011). Tobias, a pioneer in the study of math anxiety, described it as "the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematics problem" (Tobias & Weissbrod, 1980, p. 64). Buckley and Ribordy (1982) define math anxiety as "an inconceivable dread of mathematics that can interfere with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations" (p. 1). Characteristics of math anxiety include avoidance, lack of perseverance, rigidness, and resistance (Kulkin, 2016). Math anxiety is a trait anxiety as opposed to a state anxiety because it is a persevering part of an individual's personality and extends across all situations (Elliot & Dweck, 2013; Miller & Bichsel, 2004).

Math anxiety is studied to see if it is related to other important characteristics. Even though math anxiety is related to other forms of anxiety explained previously, such as test anxiety, separation anxiety, and general anxiety, research shows that it is its own phenomenon (Ashcraft, 2002; Devine, Fawcett, Szücs, Dowker, 2012; Hembree, 1990; Kazelskis et al., 2000; Mychailyszyn et al., 2010). The interrelationship between math anxiety and test anxiety is a 0.52

correlation; however, intercorrelations provide support that math anxiety is its own phenomenon. Intercorrelations between assessments of math anxiety range from 0.50 to 0.70, but intercorrelations of math anxiety to other forms of anxiety range from 0.30 to 0.50 (Ashcraft, 2002). When Faust, Ashcraft, and Fleck (1996) studied a group of highly math-anxious individuals performing math tasks of increasing difficulty, they found physiological evidence of increasing reactivity such as changes in heart rate. When the same individuals performed verbal tasks of increasing difficulty, there was hardly any increase in their reactivity. Participants with low math anxiety showed negligible increases during either the math or verbal task. Next, the characteristic of overall intelligence is found to be weakly related to math anxiety with a small correlation of -0.17 (Ashcraft, 2002). Finally, in the relationship between gender and math anxiety, anxiety is found to be somewhat higher in women than men (Ashcraft, 2002).

The first math anxiety measurement scale was development by Richardson and Suinn in 1972. Titled the *Mathematics Anxiety Rating Scale* (MARS), the tool asks participants to rate themselves on levels of anxiety they would feel in various situations such as calculating a restaurant bill and taking a math test (a representing “not at all” anxious and 5 representing “very much” anxious). An example of one item on the 98-item scale is, “Adding two three-digit numbers while someone looks over your shoulder” (Richardson & Suinn, 1972, p. 552). Scores range from 98 to 490 and elevated scores on the MARS represent high math anxiety. The authors first used the MARS on a group of 397 undergraduate students. The Pearson product-moment correlation coefficient was found to be 0.85, which indicates that the MARS is reliable and valid (Richardson & Suinn, 1972). Ten years later, Richardson and Suinn revised the MARS, which resulted in a shorter version known as the *Mathematics Anxiety Rating Scale for Adolescents* (MARS-A, Abidin, Alwi, & Jaafar, 2010). Then in 1988, Suinn, Taylor, and

Edwards developed the *Mathematics Anxiety Rating Scale for Elementary School Students* (MARS-E, Wu et al., 2012). Other measures have been developed over the years without determining validity; however, the MARS tests appear to be the educational standard for measuring math anxiety due to their reliability and validity (Ashcraft, 2002).

Although the MARS tests were accepted as standard assessments, a practical need emerged for a shorter assessment, so the *Abbreviated Math Anxiety Scale* (AMAS) was developed by Hopko, Mahadevan, Bare, and Hunt in 2003 for adolescents and adults (see Table 1). The AMAS was created with a two-factor analysis: learning math anxiety and math evaluation anxiety. The AMAS is a nine-item inventory including specific items such as, "listening to a lecture in mathematics class," "starting a new chapter in a mathematics book," and "being given a 'pop quiz' in a mathematics class" (Hopko et al., 2003, p. 180). Participants rank each item on a five-point scale from one representing "low anxiety" to five representing "high anxiety." Scores range from 9 to 45 and higher scores represent higher levels of math anxiety (Hopko et al., 2003). Upon testing the reliability and validity of the measure, Hopko et al. (2003) found that internal consistency, external validity, and test-retest reliability were strong.

A team of researchers desired the ease of administering the shorter assessment; however, they needed a scale suitable for children as young as eight years old. Carey, Hill, Devine, and Szücs (2017) adapted the AMAS to use with British children aged 8-13 years old. They used British vocabulary (maths for math) and named the scale the *Modified Abbreviated Math Anxiety Scale* (mAMAS (see Table 2). The mAMAS was found to be both a valid and reliable for measuring math anxiety in children and adolescents (Carey et al., 2017).

Table 1

Abbreviated Mathematics Anxiety Scale (AMAS)

Item	**Low Anxiety**	**Some Anxiety**	**Moderate Anxiety**	**Quite a bit of Anxiety**	**High Anxiety**
Having to use the tables in the back of a mathematics book.					
Thinking about an upcoming mathematics test one day before.					
Watching a teacher work an algebraic equation on the blackboard.					
Taking an examination in a mathematics course.					
Being given a homework assignment of many difficult problems which is due the next class meeting.					
Listening to a lecture in mathematics class.					
Listening to another student explain a mathematics formula.					
Being given a "pop" quiz in a mathematics class.					
Starting a new chapter in a mathematics book.					

Note. From "The Abbreviated Math Anxiety Scale (AMAS): Construction, Validity, and Reliability," by D. R. Hopko, R. Mahadevan, R. L. Bare, and M. K. Hunt, 2003, *Assessment*, *10*(2), p. 180. Copyright 2003 by the authors. Adapted with permission.

Table 2

Modified Abbreviated Mathematics Anxiety Scale (mAMAS)

Item	Low Anxiety	Some Anxiety	Moderate Anxiety	Quite a bit of Anxiety	High Anxiety
Having to complete a worksheet by yourself.					
Thinking about a maths test the day before you take it.					
Watching the teacher work out a maths problem on the board.					
Taking a maths test.					
Being given maths homework with lots of difficult questions that you have to hand in the next day.					
Listening to the teacher talk for a long time in					(continued)

Item	Low Anxiety	Some Anxiety	Moderate Anxiety	Quite a bit of Anxiety	High Anxiety
maths.					
Listening to another child in your class explain a maths problem.					
Finding out that you are going to have a surprise maths quiz when you start your maths lesson.					
Starting a new topic in maths.					

Note. From "The Modified Abbreviated Math Anxiety Scale: A Valid and Reliable Instrument for Use with Children," by E. Carey, F. Hill, A. Devine, and D. Szücs, 2017, *Frontiers in Psychology*, *8*, p. 3. Copyright 2017 by the Authors. Adapted with permission.

Nature of math anxiety. Math anxiety has been studied primarily in sixth graders through adults (Harari et al., 2013), and researchers have observed a range of symptoms. Physiological symptoms of math anxiety include increased heart rate, lightheadedness, increased perspiration, clammy hands, and upset stomach (Blazer, 2011; Kirkland, 2016). Psychological indicators include an inability to concentrate, feelings of helplessness, and worry of not being able to cope during a math lesson. Behavioral symptoms include avoidance of math classes, not studying regularly, and procrastinating on math homework until the last minute (Blazer, 2011; Kirkland, 2016).

Harari et al. (2013) describe four dimensions that make up the nature of math anxiety. First, numerical anxiety involves using math in life and academic situations. Second, math test anxiety is related to testing and evaluation in math. Third, worry is the negative cognitions and concerns about math. Finally, negative reactions are the feelings of tension and unpleasant physiological reactions to math. To date, there is no single assessment of math anxiety that will assess all four dimensions simultaneously, so researchers have used multiple assessments and observations in order to determine the symptoms and dimensions of math anxiety (Harari et al., 2013).

Since math anxiety has been primarily studied in children starting in sixth grade, Harari et al. (2013) wanted to study three dimensions of math anxiety in first-grade children: numerical anxiety, negative reactions, and worry; they did not feel math test anxiety would be an age-level appropriate dimension. The researchers wanted to determine if math anxiety was multidimensional in younger children just as it is in older children and adults. They studied 106 ethnically and linguistically diverse children using the numerical questions from the original 26 question MARS-E. They also used a five-item, researcher-developed, Likert-scale survey including statements such as, "I think math is fun" and "I think math is easy" (Harari et al., 2013). The researchers determined that numerical anxiety, worry, and negative reactions were all dimensions of math anxiety in young children. In another study of first and second grade children, math anxiety served as a negative predictor of the use of problem solving strategies (Ramirez, Chang, Maloney, Levine, & Beilock, 2016). Gierl and Bisanz (1995) studied the level of math anxiety in third and sixth grade children. They found that most children had low levels of math anxiety; however, there were some children who possessed high levels of math anxiety and negative attitudes toward math. This finding indicates that math anxiety not only exists in adolescents through adults, but in younger children as well. Older students from sixth grade and up experience greater levels of math anxiety (Lent, Brown, & Larkin, 1984; Meeks, 1997). Specifically, Chin (2009) determined high levels of math anxiety in 4% of elementary-aged children.

Development of math anxiety. Math anxiety is a multifaceted phenomenon and is likely influenced by a combination of cognitive factors, biological/behavioral factors, cultural stereotypes, and environmental/social sources (Ashcraft & Krause, 2007; Beilock & Maloney, 2015; Casad, Hale, & Wachs, 2015; Harari et al., 2013, see Figure 1).

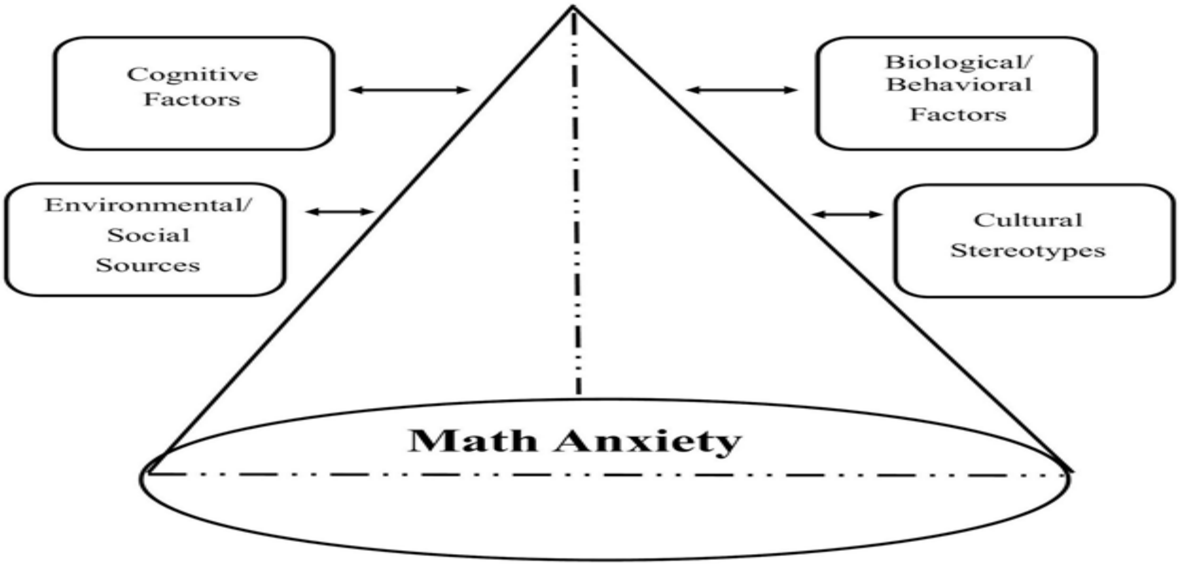


Figure 1. Math anxiety is a multifaceted phenomenon consisting of a combination of factors.

Cognitive factors. Maloney, Risko, Ansari, and Fugelsang (2010) found that individuals with high math anxiety do not process numbers in the same way as individuals with low math anxiety. Maloney et al. (2010) showed a display of one to nine squares to a group of students with high math anxiety and a group of students with low math anxiety and asked them to count the number of squares. The groups performed equally well when they were asked to count one to four squares. When they were asked to count five or more squares, the high math anxiety group was slower and less accurate. High math anxiety individuals have been found to have difficulties counting simple objects. Since counting is a foundational skill for higher math, they may experience difficulty when learning advanced math (Geary, 1993).

Individuals with high math anxiety also have difficulties with number sense (Beilock & Maloney, 2015; Dehaene, 2011). Number sense involves an understanding of numbers including their magnitude, relationships, and numerical distance effect (Dehaene, 2011). Individuals with a small numerical distance effect are able to quickly compare both far (11 and 98) and close number pairs (4 and 4.5), which means they have a precise mental number line. Individuals with a large numerical distance effect struggle when they compare close number pairs relative to far number pairs, which means they have a non-precise mental number line (Holloway & Ansari, 2008; 2009). Maloney, Ansari, and Fugelsang (2011) studied numerical distance effect between individuals with high math anxiety and individuals with low math anxiety. They found that high-math-anxiety individuals have a higher numerical distance effect and a less precise mental number line that low-math-anxiety individuals. A less developed number sense is detrimental when learning advanced math.

Another foundational cognitive skill for math is spatial ability, which is the ability to transform symbolic information and identify spatial relationships among objects and in space (Gardner, 1983). By studying individuals with math anxiety, Maloney, Waechter, Risko, and Fugelsang (2012) determined that a link exists between math anxiety and spatial ability. Math anxiety was negatively related to perceived spatial ability (Maloney et al., 2012). Moreover, Ferguson et al. (2015) found individuals with high math anxiety report having a poor sense of direction and perform worse on large-scale spatial skill tests. Maloney's team of researchers concluded that individuals with high math anxiety struggled on tasks involving counting ability, number sense, and spatial ability that are foundational to math. Having difficulty in math will likely cause math anxiety, which creates an avoidance of future math learning and then more anxiety. According to Maloney and Beilock (2012), this avoidance and anxiety cause a vicious cycle to emerge.

Biological/behavioral factors. In addition to cognitive factors, there are biological and behavioral factors that influence math anxiety. Individuals who have a biological predisposition toward anxiety may be more at risk of developing math anxiety (Ashcraft & Krause, 2007;

Harari et al., 2013). Behavioral factors also include low self-esteem, inability to handle frustration, self-efficacy, shyness, and intimidation (Blazer, 2011; Jain & Dowson, 2009). Individuals with low self-efficacy show low levels of academic performance, motivation, and attitudes (Valentine, DuBois, & Cooper, 2004; Zimmerman, 2000).

Cultural stereotypes. Cultural stereotypes about gender and math exist, specifically that men and boys are superior in math (Casad et al., 2015; Jameson, 2014) and that math-related fields are masculine domains (Gutbezahl, 1995; Halpern et al., 2007). After Hyde, Fennema, and Lamon (1990) conducted a meta-analysis of 100 studies, they found the gender difference in math to be negligible. Males performed slightly better in problem solving and females had an advantage in computation. They found slight gender differences in adolescence in algebra and geometry, but the differences were not statistically significant (Hyde, Fennema, et al., 1990). Although there are no significant gender differences in math achievement, research shows there are definite gender differences in math anxiety levels (Jameson, 2014). Middle school girls reported math anxiety levels 20% higher than middle school boys (Meece, Wigfield, & Eccles, 1990). In their meta-analysis, Hyde, Fennema, et al. (1990) found women report that they experience higher levels of math anxiety than men. Ma and Xu (2004) also found significant findings regarding gender when they studied 3116 seventh grade through twelfth grade students. Prior low math achievement caused high math anxiety for boys across all grades seventh through twelfth. Conversely, prior low math achievement caused high math anxiety for girls only at critical transitions (elementary to junior high and junior high to high school (Ma & Xu, 2004). Overall, math anxiety was more stable in the girls than boys. It is believed that self-efficacy affects perceived math ability (Meece et al., 1990). Girls' levels of math self-efficacy are lower than boys and directly affects their levels of math anxiety. In boys, their levels of math self-efficacy their perceptions of the importance of math, which in turn affected their levels of math anxiety (Meece et al., 1990).

Environmental/social factors. Environmental factors include negative classroom experiences, such as poorly written textbooks, an emphasis on drill and practice without understanding, poor instructional methods, and reliance on timed tests (Blazer, 2011; Ruff & Boes, 2014). In addition, parents, teachers, and peers are all social factors that may contribute to an individual developing math anxiety (Casad et al., 2015). Parents may hold the gender stereotype that sons have a stronger math ability than daughters. As a result, parents may expect their daughters to perform more poorly in math, which may contribute to greater math anxiety for girls (Casad et al., 2015). Teachers can also reinforce gender stereotypes. An interesting study by Beilock et al. (2010) indicated that female teachers with math anxiety affected the math anxiety level of their female students but not the males.

A study with second grade students examined the relationship of parents' math anxiety to their children's math anxiety but found no effects (Jameson, 2014). A more recent study by Maloney et al. (2015) found parents' math anxiety affected children's math anxiety. They assessed the math anxiety and math achievement of first and second grade children at the beginning and end of the school year. They also assessed the parents' math anxiety levels and degree to which they helped with homework. When parents had high math anxiety and frequently helped with homework, their children's level of math anxiety increased and math achievement decreased. When the high math anxiety parents did not help or rarely helped their children with homework, they did not affect the math anxiety level of their children (Maloney et al., 2015). Sparks' (2015) findings confirmed this observation when he discovered that students whose parents reported high levels of math anxiety made significantly less progress in math over the course of the school year and were more likely to become anxious themselves only if the parents tried to help with homework. When parents have math anxiety, they often express negative attitudes about math, believe math is not useful, and have low math self-efficacy (Hembree, 1990). If parents express these ideas, it can certainly be destructive and demotivating for their children (Gunderson, Ramirez, Levine, & Beilock, 2012; Maloney et al., 2015; Yee & Eccles, 1998). Parents' math anxiety transfers to their children; therefore, children are more susceptible to math anxiety when their parent exhibits math anxiety (Soni & Kumari, 2017). The impact of parents' math anxiety as a socializing agent of children's math anxiety is an area for future research (Casad et al., 2015).

Past negative experiences with math; such as skill deficits, low self-confidence and motivation in math, hostile teachers, and teachers with math anxiety; all set the conditions for development of math anxiety (Harari et al., 2013; Hembree, 1990; Jameson, 2014). When these negative experiences are left unchecked, students develop a negative math perception, which causes a performance spiral into math anxiety (Jameson, 2014). Harari et al. (2013) and Ashcraft (2002) explained that math anxiety stems from internalization of consistent negative feedback as a result of repeated failure to complete complex mathematical problems, such as percentages and algebra, as opposed to whole number operations. In general, math anxiety is more evident beginning in sixth grade since the curriculum is more complex and children have had more opportunity to internalize the negative feedback (Ashcraft & Krause, 2007).

Relationship of math anxiety to math performance. Despite analyzing the development and correlations of math anxiety explained above, one critical question in the study of math anxiety remains: Does poor math performance elicit math anxiety or does math anxiety cause poor math performance? Carey et al. (2016) analyzed this question by reviewing the two possible causal directions between math anxiety and math performance.

The deficit theory. The Deficit Theory states that poor performance leads to higher anxiety about a situation in the future (Carey et al., 2016, see Figure 2). Therefore, deficits in math performance lead to math anxiety. The Deficit Theory is supported by studies of children with mathematical learning disabilities because they have disproportionately high levels of math anxiety when compared to typically developing children (Carey et al., 2016). The Deficit Theory is also supported by longitudinal studies. In one longitudinal study of adolescents in the United States, there were significant correlations between academic performance in one year and the level of math anxiety the following year. The correlations were far weaker between math anxiety the first year and academic performance the following year (Ma & Xu, 2004). In another longitudinal study, the researchers found math ability in one year was moderately correlated with math anxiety the following year (Meece et al., 1990).

Figure 2. Deficit theory model. From "The Relationship between Maths Anxiety and Maths Performance," by University of Cambridge, 2017, *Centre for Neuroscience in Education*, Retrieved from https://www.cne.psychol.cam.ac.uk/the-relationship-between-maths-anxiety-and-maths-performance. Copyright 2017 by University of Cambridge. Reprinted with permission.

The debilitating anxiety model. The Debilitating Anxiety Model explains that math anxiety leads individuals to avoid math-related situations (see Figure 3). This theory supports math anxiety leads to poor math performance (Carey et al., 2016) and is supported by various research. For example, Hembree (1990) shared evidence that adolescents experiencing math anxiety avoid math situations and learning opportunities. Ashcraft and Faust (1994) found that adults with high math anxiety spend less time processing mathematical problems by rushing through the problems and having little accuracy, and they are less likely to enroll in future mathematics courses (Hembree, 1990). The Debilitating Anxiety Model is also supported by research that manipulates anxiety levels and observes changes in math performance. For example, when students write about their math anxiety and emotions prior to a math test, their performance increases (Park, Ramirez, & Beilock, 2014). Moreover, math anxiety has less of an effect on math performance when the math test or activity is not timed (Faust et al., 1996).

Figure 3. Debilitating anxiety model. From "The Relationship between Maths Anxiety and Maths Performance," by University of Cambridge, 2017, *Centre for Neuroscience in Education*, Retrieved from https://www.cne.psychol.cam.ac.uk/the-relationship-between-maths-anxiety-and-maths-performance. Copyright 2017 by University of Cambridge. Reprinted with permission.

Carey et al. (2016) believe that the data are conflicting because some research supports the Deficit Theory and other research supports the Debilitating Anxiety Model. Carey et al. (2016) propose the Reciprocal Theory which explains that there is a bidirectional relationship between math anxiety and math performance (see Figure 4). The two factors can influence one another in a vicious cycle (Carey et al., 2016). One study in Singapore demonstrates that previous math performance may affect a student's math anxiety and the level of math anxiety then affects future achievement (Luo et al., 2014). More research is needed in this area so the relationship between math anxiety and math performance is better understood.

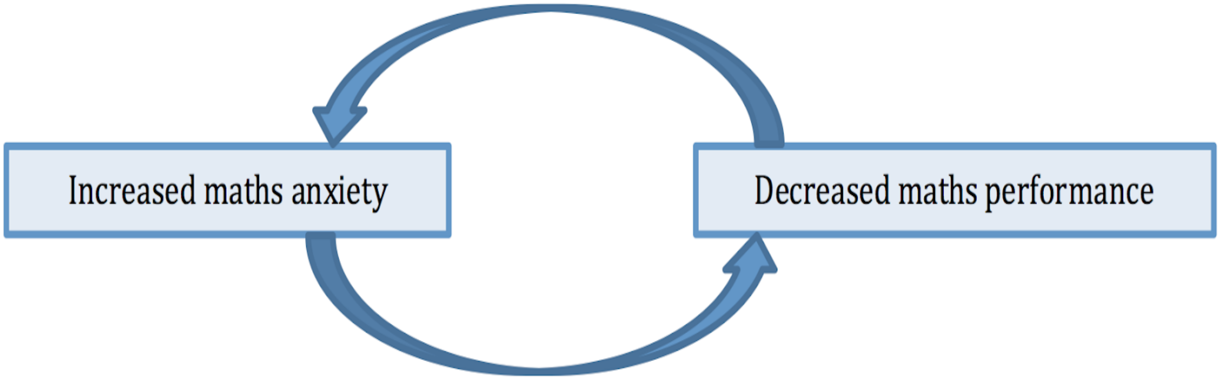


Figure 4. Reciprocal model. From "The Relationship between Maths Anxiety and Maths Performance," by University of Cambridge, 2017, *Centre for Neuroscience in Education*, Retrieved from https://www.cne.psychol.cam.ac.uk/the-relationship-between-maths-anxiety-and-maths-performance. Copyright 2017 by University of Cambridge. Reprinted with permission.

Consequences of Math Anxiety

Math anxiety is a serious obstacle for children across all grade levels and it causes negative consequences. First, math anxiety leads to an avoidance of math and the earlier the onset of the anxiety, the longer the period of subject avoidance (Hembree, 1990). Students take fewer elective math courses in high school and college and drop out of advanced mathematics courses prematurely, which leads to fewer careers in math. It can also mean students are ineligible for advanced education due to insufficient math proficiency and lack of required math prerequisites (Ashcraft, 2002; Blazer, 2011; Jameson, 2014; Pletzer et al., 2016; Ramirez et al., 2013; Wu et al., 2012). Students often dislike mathematics if they are becoming elementary teachers (Hembree, 1990; Ho et al., 2000; Ma, 1999; Ma & Xu, 2003). Yang Lin, Durbin, and Rancer (2016) studied the math anxiety of a group of undergraduate students in a communications research methods course. The researchers reported that communications was a preferred major over business for many of the students because the students wanted to avoid math classes whenever possible. Second, math anxiety creates a negative attitude toward math. Students participate less in math class, enjoy math less, and are less likely to see the value of learning math (Ashcraft, 2002; Harari et al., 2013; Jameson, 2014; Pletzer et al., 2016; Ramirez et al., 2013; Wu et al., 2012). Third, math anxiety causes negative self-perceptions about one's math abilities. Students have decreased self confidence in their own ability to understand math. Moreover, they falsely believe that they do not have the efficacy to succeed in math (Ashcraft, 2002; Hembree, 1990; Jameson, 2014; Pletzer et al., 2016; Ramirez et al., 2013; Wu et al., 2012). The correlations between math anxiety, motivation, and math self-confidence are highly negative, ranging from -0.47 to -0.82 (Ashcraft, 2002).

Fourth, math anxiety lowers math competence and achievement and reduces students' working memory. While studying high school students, Wu et al. (2012) found math anxiety was negatively correlated (-0.31) with term grades, final exam grades, and tests of math aptitude. Math anxiety was also negatively correlated with the total mathematics score of the SAT (Stanford Achievement Test). Chiu and Henry (1990) found that fifth, sixth, and eighth graders had levels of math anxiety that significantly negatively correlated with semester math grades. In order to determine if poor test performance was a result of low competence versus heightened math anxiety, Ashcraft, Kirk, and Hopko (1998) administered a standard math achievement test to students with low, medium, or high math anxiety. The researchers scored the test line-by-line to analyze by difficulty. They found no math-anxiety effects on the first half of the test, which had whole-number arithmetic problems. Anxiety effects were noted on the second half of the test, which had more difficult problems, including mixed fractions, percentages, solving for unknowns, and factoring. There was a strong negative correlation between accuracy and math anxiety. Therefore, students with high levels of math anxiety did not have an overall deficit in math competence (Ashcraft et al., 1998). The higher-level arithmetic was where the competence and anxiety relationship was observed.

In an earlier research study, Ashcraft and Faust (1994) found that math anxiety had minimal effects on performance with single-digit addition and multiplication problems. They did find an effect of math anxiety on arithmetic problems including two-column addition or multiplication problems. Students with high levels of math anxiety completed the task, but they sacrificed considerable accuracy. This behavior resembles the avoidance of individuals with high math anxiety, and it shows that the addition problems with regrouping were more difficult for those individuals. Certainly, math anxiety causes lower math performance regardless of actual math ability.

Reducing Math Anxiety

Teacher strategies. Since researchers have found teachers have a profound effect on students' math anxiety, addressing it at the teacher level may be an effective starting point in reducing it in young children and improving overall math achievement (Geist, 2010; Ramirez et al., 2013). Teachers should use the following techniques in order to lessen students' math anxiety (Blazer, 2011). First, teachers should develop strong skills and a positive attitude toward math (Blazer, 2011). As explained above, teachers with math anxiety or negative views of math contribute to math anxiety in their students (Sparks, 2015). By being positive and participating in math skills' training, teachers can counteract the negativity.

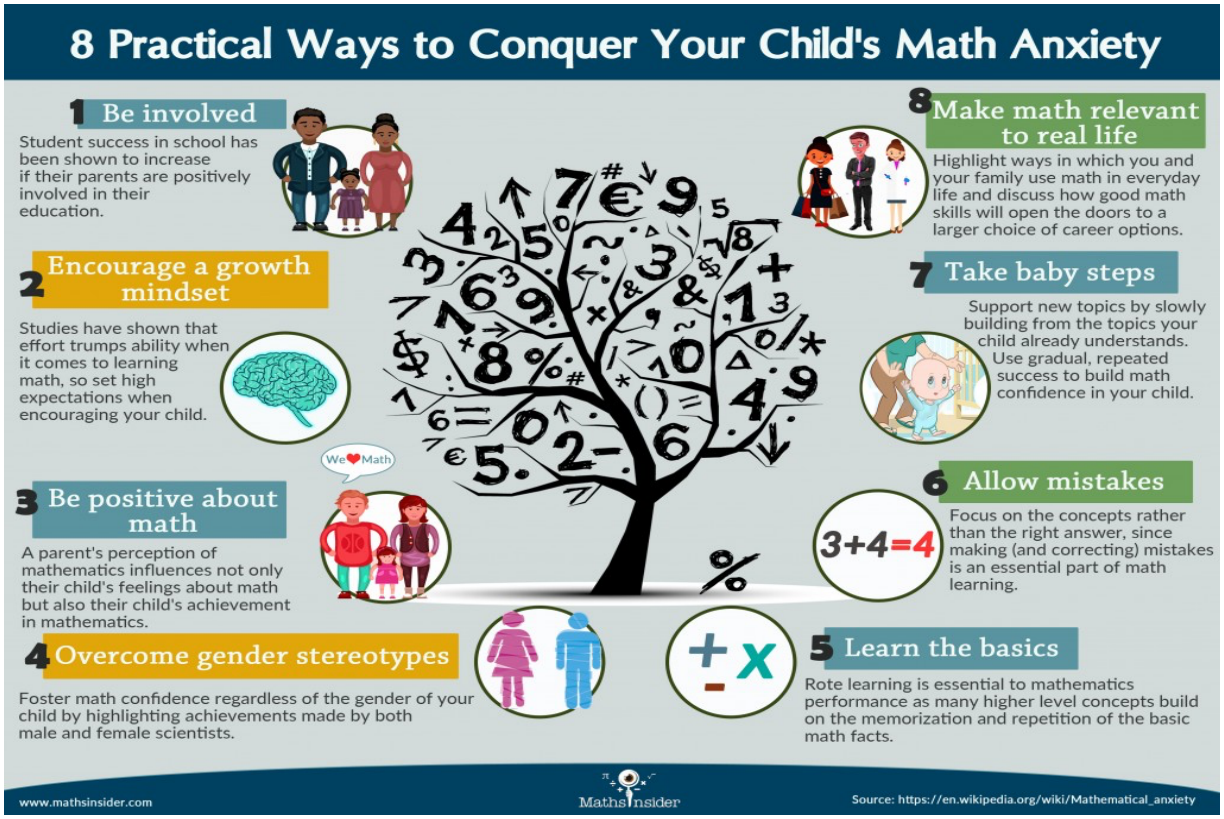
Second, teachers are encouraged to relate math to real life (Blazer, 2011). By making connections to everyday life, students are able to view math as an important and useful tool (Geist, 2010; Jackson, 2008). In addition, teachers should encourage critical thinking and active learning (Blazer, 2011), and remove the emphasis on memorization and drill and practice, which increase math anxiety (Geist, 2010). It also encourages teachers to incorporate games and hands-on activities into math lessons. Furthermore, there should be less emphasis on correct answers and computational speed (Blazer, 2011). Timed tests often increase math anxiety. By focusing on the process, students may feel less anxious. In math, there is usually one right answer, but there may be more than one way to obtain the correct answer. Instruction should balance the speed and correct answer emphasis with the process (Geist, 2010; Jackson, 2008). Teachers should praise student progress in mathematics (Gresham, 2007). All students need to feel supported.

In addition, teachers should vary their instruction to include cooperative learning groups, manipulatives, and technology in the classroom (Blazer, 2011). These are all ways of decreasing math anxiety because students have the opportunity to exchange ideas, justify answers, understand abstract ideas, and receive instant feedback (Woodard, 2004). Furthermore, teachers should place an emphasis on differences in students' learning styles, respect all learning styles, and work to meet all students' needs (Geist, 2010; Gresham, 2007). Moreover, teachers should avoid putting students in embarrassing situations (Blazer, 2011). The atmosphere cultivated in the classroom should be one of a safe, secure, and inviting place (Gresham, 2007). Students should not feel threatened when they are called upon and expected to give an oral answer or solve a problem on the board. They should be allowed alternative methods in order to decrease their math anxiety (Ashcraft et al., 2007; Woodard, 2004). Finally, teachers should incorporate a variety of assessments in addition to traditional and standardized tests (Blazer, 2011). Alternative assessments include observation, demonstration, projects, journals, oral questioning, portfolios, and performance tasks (Woodard, 2004).

Parent strategies. While the significance of parents' attitudes on their children's attitude toward math warrants additional research, studies have found that parents still have an influence. In order to prevent or reduce their children's math anxiety, parents should not express negative attitudes about math (Blazer, 2011). Parents may pass their negative attitudes toward math to their children by modeling negative math behaviors. Parents need to conquer their own math fears and avoid passing them onto their children (Geist, 2010; Sparks, 2011).

In addition, parents should have realistic expectations and monitor their children's math progress (Blazer, 2011). When parents have unrealistic expectations, it increases a child's math anxiety. Parents should follow their child's progress by communicating with the teacher, helping with homework as needed, and reviewing tests and quizzes. Moreover, parents should allow mistakes (Boaler, 2016). Making mistakes is a critical part of the math learning. Further, parents should provide support and encourage a growth mindset. Encouragement in math strongly influences children's attitudes toward math (Blazer, 2011). It is critical for parents to let children know they believe they can succeed at math. Parents should believe and model a growth mindset. Finally, parents should demonstrate positive uses for math (Blazer, 2011), which help children understand the value of learning math. Sports, hobbies, home repairs, cooking, bills, shopping, and checkbooks are all practical ways to demonstrate math positively (see Figure 5).

Student strategies. Ramirez et al. (2016) believe that addressing math anxiety at the teacher and parent level is even more effective when combined with student level interventions (Blazer, 2011). In order to overcome math anxiety, researchers recommend that students practice math problems every day (Cavanaugh, 2007). Second, students should use good study techniques that match their individual learning style (Blazer, 2011). For example, visual learners learn best through pictures, diagrams, and visuals; auditory learners learn best through lectures and discussions; and kinesthetic learners learn best through hands-on learning. Third, students should engage in a focusing breathing technique prior to completing a math task or math test (Brunye et al., 2013).



8 Practical Ways to Conquer Your Child's Math Anxiety

1 Be involved

Student success in school has been shown to increase if their parents are positively involved in their education.

2 Encourage a growth mindset

Studies have shown that effort trumps ability when it comes to learning math, so set high expectations when encouraging your child.

3 Be positive about math

A parent's perception of mathematics influences not only their child's feelings about math but also their child's achievement in mathematics.

4 Overcome gender stereotypes

Foster math confidence regardless of the gender of your child by highlighting achievements made by both male and female scientists.

5 Learn the basics

Rote learning is essential to mathematics performance as many higher level concepts build on the memorization and repetition of the basic math facts.

6 Allow mistakes

Focus on the concepts rather than the right answer, since making (and correcting) mistakes is an essential part of math learning.

7 Take baby steps

Support new topics by slowly building from the topics your child already understands. Use gradual, repeated success to build math confidence in your child.

8 Make math relevant to real life

Highlight ways in which you and your family use math in everyday life and discuss how good math skills will open the doors to a larger choice of career options.

www.mathsinsider.com

Source: https://en.wikipedia.org/wiki/Mathematical_anxiety

Figure 5. Eight practical ways to conquer your child's math anxiety.   from "8 Practical Ways to Conquer Your Child's Math Anxiety," by Caroline Mukisa, 2005, *MathsInsider*, Retrieved from http://www.mathsinsider.com/conquer-math-anxiety/. Copyright 2005 by MathsInsider. Reprinted with permission.

Students need to learn to not rely solely on memory (Blazer, 2011). It is important for students to understand a mathematical concept. If students do not understand a concept and merely memorize a set of procedures, their memory may fail them, or they may not be able to apply the procedures to a new problem. In addition, students should focus on past successes and ask for help when needed (Blazer, 2011). By focusing on past successes, students will build their confidence, which counteracts math anxiety. Students should always ask for extra help when needed, whether it is the classroom teacher, tutor, parent, older sibling, or another teacher.

Finally, students may find expressive writing helpful before an upcoming math test. Park et al. (2014) compared individual's performance on math ability tests before and after an expressive writing exercise where they wrote for five to ten minutes about their feelings on the upcoming math test. The expressive writing led to an increase in math performance for the individuals with the greatest math anxiety (Park et al., 2014). Ramirez and Beilock (2011) had highly math anxious students write about their worries and feelings before their final exam. The writing helped increase their final exam scores from B- to B+ (Ramirez & Beilock, 2011).

School and district strategies. There are strategies that can be implemented in schools and partnerships that can be developed between home and school that decrease math anxiety. First, schools should provide parents workshops on ways to bolster number sense and spatial abilities in young children (Maloney & Beilock, 2012). By targeting some of the precursors of math anxiety, math anxiety can be reduced overall. Schools can also provide homework tools such as math worksheets, iPad applications, and websites so parents are better prepared to help with homework (Beilock & Maloney, 2015). Schools and districts should also provide professional development courses on the research on math anxiety for established teachers (Beilock & Maloney, 2015). Another intervention is to have schools employ professional school counselors who are uniquely trained to help students cope with math anxiety (Ruff & Boes, 2014; Soni & Kumari, 2017).

Teacher education strategies. In teacher education math methods courses, there are effective ways to teach the material in order to decrease the math anxiety of pre-service teachers (Battista, 1986). When a math methods course is focused on how children learn mathematical concepts, the math anxiety levels of pre-service teachers decrease. When a math methods course is focused on how to teach a specific concept, the math anxiety levels of pre-service teachers do not improve (Tooke & Lindstrom, 1998). By simply framing the course differently, teachers' math anxiety decreases, which leads to greater math outcomes for students. Further, reflective notebooks should be used by pre-service teachers in their mathematics course (Salinas, 2004). The notebooks are used to write about perspectives on learning and math anxiety. Pre-service teachers who incorporated this strategy reported that they were able to monitor their own learning, share feelings, write questions, and express their concern and confusion (Salinas, 2004).

Understanding Self-Efficacy

Definition of self-efficacy. Self-efficacy is the belief students hold about their academic abilities (Bandura, 1986). An important feature of self-efficacy is understanding that it refers to the perceptions a student has about his ability as opposed to his actual ability. Students with self-efficacy are effortful and able to perform at a high level, and when related to math, self-efficacy may diminish math anxiety (Jain & Dowson, 2009; Pajares & Graham, 1999; Shores & Shannon, 2007). There is a positive correlation of .38 between self-efficacy and mathematics performance (Stajkovic & Luthans, 1998). This correlation approximates the average negative correlation of -.34 between anxiety and math performance (Hembree, 1990; Ma, 1999), and may mitigate the negative correlation.

Nature of self-efficacy. Students with higher levels of self-efficacy put forth more effort, persevere, attempt challenging problems, and incorporate wise problem-solving strategies (Hoffman, 2010; Pajares, 1996; Pajares & Graham, 1999). They believe they are more competent, which leads to their levels of higher self-efficacy. Students who perceive they are less competent in math do not perform as well because their lower performance expectations influence learning (Hoffman, 2010).

Self-efficacy has a negative correlation to math anxiety, and students with high math anxiety believe they are less competent in math (Hoffman, 2010; Jain & Dowson, 2009; Ma & Xu, 2004). Math anxiety interferes with a student's ability to say, "I can" do mathematics (Gresham, 2007). To overcome math anxiety, high self-efficacy and working memory ability are necessary (Hoffman, 2010). Moreover, research indicates that self-efficacy, math anxiety, and working memory play a role in problem-solving accuracy (Ashcraft & Kirk, 2001; Cooper & Robinson, 1991; Hembree, 1990). Hoffman (2010) found that individuals with math anxiety were more successful when solving problems that they perceived as easier. When the problems increased in difficulty, the individuals struggled when attempting to find the solution. The anxiety was present in both situations; however, self-efficacy appeared to be the prevailing variable because it compensated for anxiety when the problems were perceived as easier. Self-efficacy can help to intercept anxiety before it is cultivated.

Development of self-efficacy. Bandura (1997) asserts that an individual's self-efficacy beliefs come from four sources: mastery experience, vicarious experience, social persuasions, and emotional and physiological states. Mastery experience is the most powerful source and represents an individual's interpretation of her personal accomplishments. For example, when a student completes a particularly difficult math assignment and experiences success in overcoming the task, there is a boost to self-efficacy (Bandura, 1997; Usher & Pajares, 2009). Vicarious experience represents an individual's observations of others and comparisons of herself to them. Students compare themselves to peers, classmates, and adults and gauge their performance and academic abilities against others (Usher & Pajares, 2009). If a student sees a classmate solve a challenging math problem, then she may believe she can tackle the problem as well. Social persuasions are the third source of self-efficacy. Self-efficacy is the encouragement a student receives from parents, teachers, and peers that bolsters the student's confidence in her academic abilities (Bandura, 1997; Usher & Pajares, 2009). Finally, self-efficacy beliefs are shaped by the emotional and physiological states of anxiety, stress, fatigue, and mood (Bandura, 1997). Strong emotions to school tasks trigger expected success or failure. High math anxiety can undermine self-efficacy. In general, increasing a student's emotional well-being and decreasing a negative physiological state such as high math anxiety will strengthen self-efficacy (Usher & Pajares, 2009).

Relationship of self-efficacy to math anxiety and math performance. Previous research regarding psychological factors in math focuses on the relationship between (a) self-efficacy (independent variable) and math performance (dependent variable), and (b) math anxiety (independent variable) and math performance (dependent variable). Self-efficacy is related to superior performance and the correlation has been shown in several studies (Akin & Kurbanoglu, 2011; Jain & Dowson, 2009; Pajares & Graham, 1999; Shores & Shannon, 2007). As explained previously, math anxiety is a key affective variable and is linked to decreased math achievement (Ashcraft, 2002; Hembree, 1990; Maloney et al., 2015; Ramirez et al., 2013). Very few studies have focused on math anxiety as the dependent variable; however, when those studies focused on math anxiety as the dependent variable, they looked at instructional variables such as teacher instruction and textbook (Furner & Duffy, 2002; Jackson & Leffingwell, 1999). In Jain and Dowson's (2009) research study, they intentionally focused on psychological variables, specifically self-efficacy, that may reduce math anxiety. Their results indicated that self-efficacy was negatively related to math anxiety. Jain and Dowson (2009) proposed that self-efficacy is a "key motivational variable impacting outcomes" (p. 246). Aksu et al.'s (2016) study confirmed this concept when they found self-efficacy has a negative relationship with anxiety, and they shared that self-efficacy was a predictor of math anxiety. Math anxiety and self-efficacy go hand-in-hand and affect math achievement in an opposite manner (Akin & Kurbanoglu, 2011; Cooper & Robinson, 1991). According to Bandura (1977), self-efficacy is an extremely important factor influencing math anxiety.

Understanding Mindset

The brain and math. New technologies allow scientists to watch brain activity while children and adults are working on math. Through brain scanning, scientists have been able to prove that brains have plasticity; they are able to grow and change within periods of time (Maguire, Woollett, & Spiers, 2006; Woollett & Maguire, 2011). One brain study had people work on a ten-minute exercise every day for three weeks (Karni et al., 1998). Those individuals who worked on the exercise daily experienced brain changes. Effort changes the brain because the brain forms new connections (Blackwell et al., 2007; Boaler, 2013a). If the brain is able to change from short daily exercises, it can certainly change from continued math instruction. Brain research establishes that everyone can be successful in math with the right teaching and communication (Boaler, 2016). Students need to believe in themselves and believe that they are able to learn math.

Brain research also shows that brains grow when mistakes are made. Psychologist Jason Moser found this growth by studying people's brains as they made mistakes (Moser, Schroder, Heeter, Moran, & Lee, 2011). When a mistake is made, the brain has two responses. The first is increased electrical activity when there is a conflict between the correct answer and the error. Growth happens whether or not the person is aware she made a mistake. The second is a brain signal that reflects conscious attention to mistakes. This brain signal happens when the person is aware an error has been made. Moser et al. (2011) compared these brain responses from people with growth and fixed mindsets and found two significant results. First, people's brains had more electrical activity when mistakes were made than when their answers were correct. Second, brain activity was greater for participants with a growth mindset than a fixed mindset. The brains of growth mindset individuals lit up more than the brains of fixed mindset individuals (Moser et al., 2011) (see Figure 6).

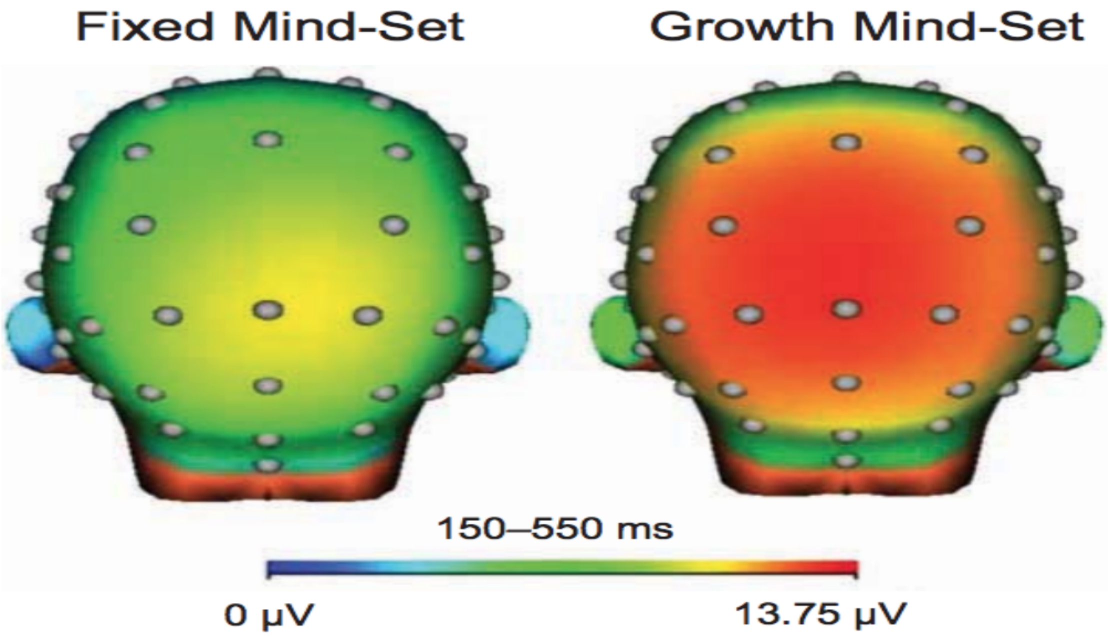
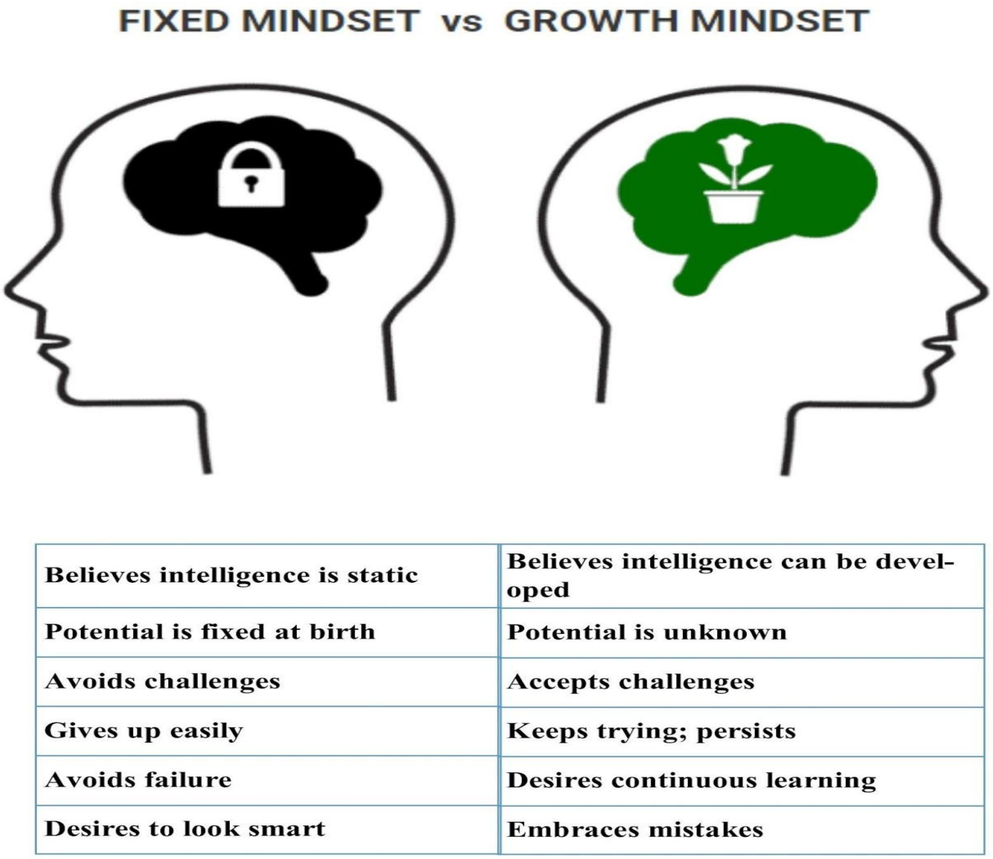


Figure 6. Brain activity in individuals with a fixed and a growth mindset. From "Mind Your Errors: Evidence for a Neural Mechanism Linking Growth Mind Set to Adaptive Post Error Adjustments," by J. S. Moser, H. S. Schroder, C. Heeter, T. P. Moran, and Y. Lee, 2011, *Psychological Science, 22*(12), p. 1487. Copyright 2011 by SAGE Publications. Reprinted with permission.

Definition of mindset. Carol Dweck (2016), Stanford University psychologist, defines mindset as a self-perception or self-theory that people hold about themselves. It is the degree to which individuals view the nature of their intelligent behavior. Students with a fixed mindset believe that their qualities and traits are carved in stone and cannot be practiced or developed. They believe success does not depend on their effort to learn; rather, their success depends on the level of innate ability they have. They are reluctant to take on challenges and are fearful of making mistakes. Students with a growth mindset believe that effort or training can change their qualities and traits. They attribute success to learning and view mistakes as opportunities to develop. They are confident that when they put forth extra effort they will learn the skill or knowledge, thereby improving their performance (Dweck, 2016) (see Figure 7).



Believes intelligence is static	**Believes intelligence can be developed**
Potential is fixed at birth	**Potential is unknown**
Avoids challenges	**Accepts challenges**
Gives up easily	**Keeps trying; persists**
Avoids failure	**Desires continuous learning**
Desires to look smart	**Embraces mistakes**

Figure 7. Fixed mindset versus growth mindset. From "Fixed Mindset vs. Growth Mindset," by The Peak Performance Center, 2005, *The Peak Performance Center*, Retrieved from http://thepeakperformancecenter.com/development-series/mental-conditioning/mindsets/fixed-mindset-vs-growth-mindset/. Copyright 2007 by The Peak Performance Center. Adapted with permission.

Nature of mindset. There is a growing body of evidence that students' mindsets play a principal role in their school achievement; moreover, mindsets are found to have a significant effect on math and science achievement (Boaler, 2013b; Dweck, 2008). Dweck's research classifies about 40% of students with a growth mindset and about 40% of students with a fixed mindset. About 20% of students show mixed profiles (Boaler, 2013b; Dweck, 2008). Students with a growth mindset perform at higher levels in school, and mindsets predict math achievement over time. The differences in math grades can be attributed to several factors. First, students with a growth mindset are more oriented toward learning goals, whereas students with a fixed mindset are more focused on validating their intelligence (Blackwell et al., 2007). Second, students with a growth mindset show a stronger belief in the potential of effort; however, students with a fixed mindset believe that effort will be ineffective for them (Dweck, 2008). Finally, those with a growth mindset stand strong in the face of setbacks, such as putting forth greater effort. When individuals with a fixed mindset face challenges, they tend to employ negative strategies, such as withdrawal and cheating (Dweck, 2008).

Development of mindset. Mindsets are often formed at an early age and are influenced by adults' feedback. When teachers believe that math intelligence is fixed, they often respond to students who scored low on a test with comments such as, "Not everyone has math talent – some people are 'math people' and some aren't" (Dweck, 2008, p. 8). On the other hand, when teachers have a growth mindset and believe that math intelligence is acquirable, they give more support to students and provide concrete feedback such as changing study strategies, working with a tutor, and practicing with challenging math problems (Dweck, 2008). This finding demonstrates how adults create self-fulfilling prophecies because when teachers believe in fixed mindset, only the students that tend to achieve at a high level are those with high ability. When teachers have a growth mindset, a broader range of students do well (Rheinberg, Vollmeyer, & Rollett, 2000). Research shows that praising students for their intelligence makes students think their abilities are fixed, makes them avoid challenging tasks, makes them lose confidence and motivation when the task becomes hard, and impairs their performance on difficult problems (Dweck, 2008). Process praise for effort or strategy, on the other hand, leads students to seek and thrive on challenges (Dweck, 2008). An example of process praise is, "I see that you tried several different strategies to solve that math problem. You stuck with it and were able to solve using guess and check."

Relationship of mindset to math performance. Mindsets play a key role in math achievement. Students with a fixed mindset are at a significant disadvantage in math because they believe that their mathematics ability is a fixed trait. Students with a growth mindset perform at a higher level in math because they believe their abilities can be developed (Dweck, 2008). This observation was illustrated in a study by Blackwell et al. (2007) when they followed 373 students entering seventh grade. The researchers assessed the students' mindsets and monitored their math grades for the next two years. The results were dramatic. The achievement of students with a fixed mindset stayed constant over the two years while the achievement of students with a growth mindset increased (Blackwell et al., 2007; Boaler, 2016) (see Figure 8). During middle school, students' beliefs about their intelligence played a significant role in their math performance. According to Blackwell et al. (2007), students put forth more effort and persistence when they believed their intelligence could increase.

Additional data suggest that a growth mindset leads to high math achievement. The Program for International Student Assessment (PISA) team administers international tests every four years and shares the data around the world. In the last set of tests, the United States ranked 36th out of 65 countries (PISA, 2012). Indeed, this statistic is alarming and speaks to the need for reform in mathematics teaching and learning (Boaler, 2016). PISA also surveys students on their beliefs about math and their mindsets. The data shows that the highest achieving math students are those who have a growth mindset. They scored over 65 points higher on the PISA math test, which is equivalent to more than a year of mathematics.

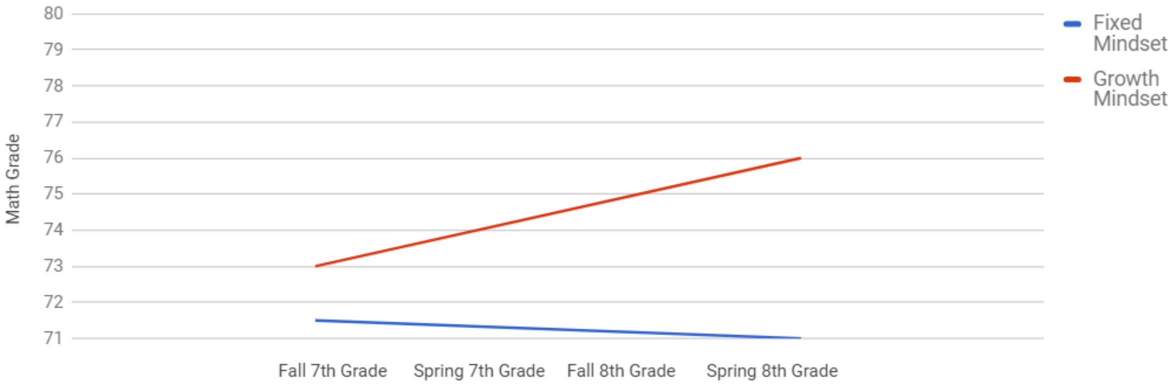


Figure 8. Students with growth mindset outperform students with fixed mindset in math. From "Implicit Theories of Intelligence Predict Achievement Across an Adolescent Transition: A Longitudinal Study and an Intervention," by L. Blackwell, K. Tzesniewski, and C. S. Dweck, 2007, *Child Development, 78*(1), p. 251. Copyright 2007 by John Wiley and Sons. Adapted with permission.

Consequences of Mindset

Mindsets also play a key role in the underachievement of women in math. The data from two recent research studies illustrate this finding. First, Dar-Nimrod and Heine (2006) provided one of two explanations of the gender difference in math achievement to college females before they attempted a challenging math task. One group was told that the gender difference was based on genetics, which is more of a fixed mindset orientation. The second group was told that the gender difference was based on different experiences males and females face, which is more of a growth mindset orientation. The females in the fixed mindset group performed far lower on the math task than the females in the growth mindset group (Dar-Nimrod & Heine, 2006).

In a second study, Dweck (2008) followed several hundred females in a university calculus class and studied how mindsets influenced their sense of belonging in math, their math grades, and their desire to pursue math in the future. Females with a growth mindset were not affected by negative stereotypes of women in math. They felt they belonged in the higher math classes, they earned high grades, and they intended to continue higher math courses (Dweck, 2008). Females with a fixed mindset were affected by negative stereotypes about women in the field of mathematics. Their math grade decreased over the course of the semester and they questioned if they should pursue further advanced math courses (Dweck, 2008). Dweck explains that "a fixed mindset contributes to this eroding sense of belonging, whereas a growth mindset protects women's beliefs that they are full and accepted members of the math community" (Dweck, 2008, p. 5).

Changing Mindset

Changing the mindsets of students can have significant impact on their grades, test scores, and overall math achievement (Dweck, 2008). In the second part of Blackwell et al.'s (2007) research study explained previously, the researchers implemented growth mindset workshops with the seventh graders. One group participated in eight study skills workshops with growth mindset training. The students were taught about the brain as a muscle and how the brain forms new synapses when new information is learned. The control group participated in the eight study skills workshops, but they received no growth mindset training. The control groups' math grades continued to decline, and the growth mindset groups' math grades improved right after the intervention and continued the upward climb toward higher achievement (Blackwell et al., 2007, see Figure 9).

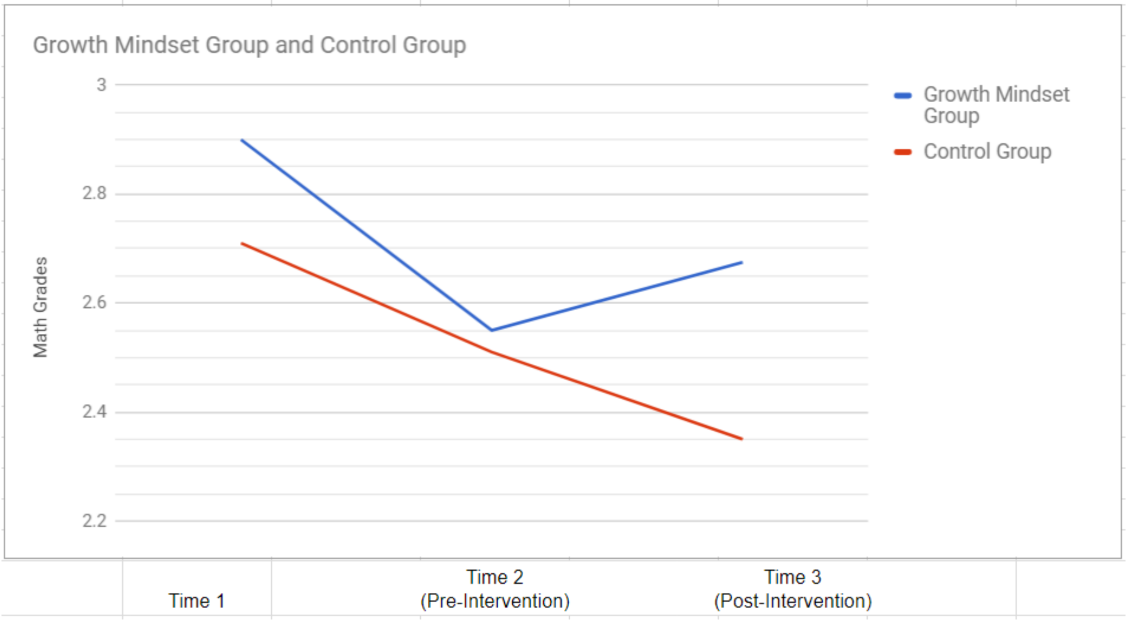


Figure 9. A growth mindset intervention. From "Implicit Theories of Intelligence Predict Achievement Across an Adolescent Transition: A Longitudinal Study and an Intervention," by L. Blackwell, K. Tzesniewski, and C. S. Dweck, 2007, *Child Development, 78*(1), p. 257. Copyright 2007 by John Wiley and Sons. Adapted with permission.

The students' teachers in Blackwell et al.'s study (2007) were questioned since they were blind as to whether the students were in the control group or the growth mindset group. The teachers observed that during the course of the two years, three times as many students in the growth mindset group displayed significant changes in their motivation. Specifically, 27% of the students in the growth mindset group demonstrated an increase in motivation compared to 9% of the students in the control group (Blackwell et al., 2007). The research reviewed clearly demonstrates that changing a student's mindset from a fixed mindset to a growth mindset has a significant impact on a student's math achievement. In order for the changes to endure, it would be beneficial to continue environmental support in the way of teachers modeling a growth mindset and using effective teaching strategies and parents supporting a growth mindset. This concept will be explored further in the subsequent section (see Figure 10).

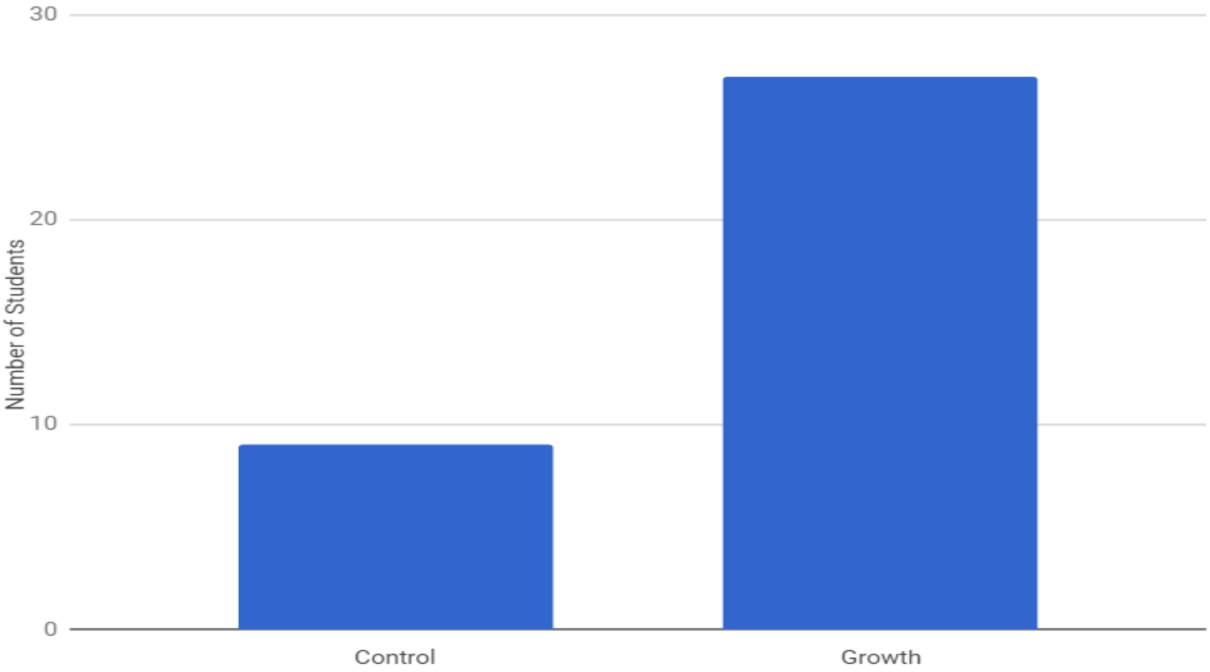


Figure 10. A 7th grade growth mindset intervention. From "Implicit Theories of Intelligence Predict Achievement Across an Adolescent Transition: A Longitudinal Study and an Intervention," by L. Blackwell, K. Tzesniewski, and C. S. Dweck, 2007, *Child Development, 78*(1), p. 255. Copyright 2007 by John Wiley and Sons. Adapted with permission.

Role of teachers and parents. Many parents and teachers want to make children feel good about themselves in math. When a child is excelling in math, parents and teachers praise the child's talent or intelligence. However, process praise is more valuable than intelligence praise. When a child is struggling in math, some parents may try to relieve their child by saying, "You're not a math person," or "You're like me. I was never good at math either." Both of these strategies promote a fixed mindset (Dweck, 2008). Dweck (2008) conducted a study where they asked adult participants to act as teachers in order to give feedback to seventh grade students who earned 65% on a recent math test. At the beginning of the study, the teachers read an imaginary scientific article. Half of the teachers read that math intelligence is fixed and the other half learned that math intelligence is acquirable. Teachers from the fixed group comforted the students and explained that not everyone is a math person. Teachers from the growth mindset group gave more encouragement and support and shared strategies for improvement. Moreover, teachers from the fixed group favored boys over girls and gave them more strategies for improvement (Dweck, 2008). This finding provides an example of how adults' mindsets influence students' mindsets. Both parents and teachers have the power to model growth mindset.

Increasing Growth Mindset

Teacher strategies. Teachers have the profound ability to impact students. First, they can convey a growth mindset by teaching students about brain plasticity and the view that the brain becomes smarter when exercised (Dweck 2008). When teachers introduce a new math concept, they can remind students that the new skill is developed and mastered through practice and hard work because the brain is making new connections. Teachers can illustrate this concept by sharing the examples of people who have made great contributions (Ericsson, Charness, Feltovich, & Hoffman, 2006). Innate talent does not automatically propel an individual to genius status. Success is often achieved through dedication, self-improvement, hard work, and persistence. Next, teachers can promote a growth mindset by encouraging students to learn from their mistakes (Boaler, 2016; Dweck, 2008). When a student makes a mistake, her brain sparks and grows (Boaler, 2016; Moser et al., 2011). Mistakes have a double benefit because they encourage learning and cause brain growth. Some teachers provide extra points when students attempt challenging problems and make mistakes versus only providing points for correct answers. Third, teachers can encourage a growth mindset by providing process praise over intelligence praise (Dweck, 2008). Process praise focuses on effort, perseverance, and improvement, as opposed to intelligence praise focusing on the person or final outcome. An example of process praise is, “Everyone learns in a different way. Let’s keep trying to find the way that works for you” (Dweck, 2008, p. 14).

As a summary, Boaler (2016) suggests seven messages that teachers can post and teach in their math classrooms:

1. Everyone can learn math to the highest levels.
2. Mistakes are valuable.
3. Questions are really important.
4. Math is about creativity and making sense.
5. Math is about connections and communicating.
6. Depth is more important than speed.
7. Math class is about learning not performing (p. 277).

Parent strategies. Similar to teacher strategies, parents have the power to influence their children in the area of mindset. First, parents should recognize their own mindset and be aware of the messages they send through their words. Parents can focus on positive growth messages instead of making comments such as, “I’m not good at math” or “You got my math gene.” Second, parents can model learning from failure. When parents make mistakes in their own lives, they can talk positively about the mistakes and model the process for their children. Third, parents can support the productive struggle of their children. When a child is struggling with a challenging math homework problem, parents should give the child time with the problem. The child’s brain makes new connections through the effort put forth. Finally, parents can praise the process by providing process praise to their children. Praising the child’s effort instead of the child’s intellect acts as a constructive growth mindset message.

Teacher education program strategies. Teachers with fixed and growth mindsets create self-fulfilling prophecies. When teachers have a fixed mindset, students with high ability perform well in their class but other students do not perform as well. When teachers have a growth mindset, students with a wide range of abilities do well (Rheinberg et al., 2000). Training must exist to change the teachers' fixed mindsets. Dweck (2008) recommends that all teacher education programs include the following four components: (a) brain plasticity findings showing that the brain is capable of changing, (b) idea that dedication and perseverance bring students long-term success, (c) difference between process praise and intelligence praise and practice using process praise statements, and (d) training on how to effectively challenge students of all ability levels.

Another recommendation is to share the research on ability grouping with pre-service teachers. The research indicates that ability grouping has a negative impact on the achievement of students in the low and middle groups and does not improve the achievement of students in the high group (Boaler, 2013b). Students' beliefs about their own potential changes to match the group in which they are placed. Ability grouping is based on fixed mindset beliefs and is generally practiced by teachers with fixed mindsets. Students in mixed ability groups show significant increases in achievement (Burris, Heubert, & Levin, 2006). Mixed ability grouping is based on growth mindset beliefs.

Parachutes and Decimals Case Study

Margaret Kulkin is a Washington State certified teacher and fellow in School's Out Washington. She taught fifth grade and is the founder of Northwest K-8 Learning Support. Kulkin strongly believes that all students need to make a "meaningful connection to math" (Kulkin, 2016, p. 28). Furthermore, she promotes a focus on mastery goals rather than performance. When the focus is on mastery, "success is defined by improvement, value is placed on effort and the process of learning, satisfaction is gained from working hard and learning something new" (Furner & Gonzalez-DeHass, 2011, p. 236). Students apply problem-solving strategies to real world situations. Performance, on the other hand, creates competition, memorization, and acquisition of skills.

Kulkin (2016) had the opportunity of working with Terry, a sixth-grader who loved speed and sports. Terry needed to work on decimals, so Kulkin designed activities that appealed to Terry's interests while involving decimal calculations and averages. In the first activity, Terry used a variety of materials to design two parachutes tied to Lego men. Kulkin dropped the parachutes from a high stool while Terry used a stopwatch to time the drops to the nearest thousandth of a second. He then calculated average drop time for both parachutes. In a second math investigation, Terry explored decimals by playing virtual baseball. He hit a ball thrown by a virtual pitcher and recorded the reaction time to the nearest hundredth of a second. He also found the average. Kulkin witnessed Terry's focus shift from performance to mastery and his level of anxiety decreased. Terry's description of math changed from "a scary movie" (Kulkin, 2016, p. 32) to "a book with many surprises" (Kulkin, 2016, p. 32).

Summary

It is beneficial to study math anxiety within the context of the types of general education anxiety and overall math achievement. Original researchers believed that math anxiety was a specific type of test anxiety, but math anxiety is now believed to be its own entity (Tobias & Weissbrod, 1980). Math anxiety is the biggest predictor of math achievement, even when considering working memory, gender, mindset, and self-efficacy (Ashcraft, 2002; Ashcraft & Kirk, 2001; Beilock & Maloney, 2015; Hoffman, 2010; Miller & Bichsel, 2004). Most of the research on math anxiety is with adolescents through adults (Harari et al., 2013). After conducting several studies on younger elementary students, researchers have demonstrated that math anxiety also exists among younger students (Chin, 2009; Ramirez et al., 2016). Studying these younger students is an area that could benefit from further research.

Math anxiety is believed to be related to self-efficacy and mindset (Dweck, 2016; Jain & Dowson, 2009; Miller & Bichsel, 2004). Self-efficacy and math anxiety are negatively correlated (Hoffman, 2010; Jain & Dowson, 2009; Ma & Xu, 2004). When an individual is struggling in math and has low self-efficacy, the struggle often leads to math anxiety. The field of Mindset was also reviewed since having a fixed mindset contributes to math anxiety (Boaler, 2016). In contrast, growth mindset has the potential to change a student's performance and make a significant difference in the student's ability to learn (Dweck, 2008).

In order to reduce math anxiety, a variety of strategies were reviewed from a teacher, parent, student, school, and teacher education perspective. Since promoting growth mindset is another way to reduce math anxiety, specific strategies for increasing it were reviewed. The final section of the literature review was a case study in which the teacher incorporated several of the strategies in order to reduce math anxiety and model a growth mindset.

Chapter 3: Research Design and Methodology

Introduction

The purpose of this qualitative research study was to determine the best practices incorporated and challenges faced by teachers in reducing math anxiety. This chapter explains the nature of qualitative research, as well as the strengths, weaknesses, and assumptions of the qualitative approach. The specific methodology is described, which is a phenomenological design. Moreover, the analysis unit, population, and sample are all detailed, in addition to participant selection and human subject consideration. A key component of phenomenological design is interviews, and the interview protocol and process is explained in detail. A discussion of the reliability, validity, and researcher bias of the study follows. Finally, this chapter provides a description of the data analysis.

Re-Statement of Research Questions

This chapter describes the research methods that were applied to achieve the objectives of this study, which is to primarily answer these four research questions:

Research Question 1: What strategies and practices do teachers employ to reduce math anxiety?

Research Question 2: What challenges do teachers face in reducing math anxiety?

Research Question 3: How do teachers measure the success of their practices in reducing math anxiety?

Research Question 4: What recommendations would teachers make for future implementation of strategies in reducing math anxiety?

Nature of the Study

The nature of this study is qualitative. Creswell (2013) defined qualitative research as an approach that "begins with assumptions and the use of interpretive/theoretical frameworks that inform the study of research problems addressing the meaning individuals or groups ascribe to a social or human problem" (p. 44). Qualitative research is an inquiry-based approach, and it shares common characteristics (Creswell, 2013; Creswell, 2014). First, the researcher collects data in a natural setting where the participants experience the issue or problem being studied. Instead of having participants complete instruments such as surveys, the researcher gathers information by talking to participants directly (Creswell, 2013; Hatch 2002; Marshall & Rossman, 2010). Second, the researcher is the key instrument and gathers data by observing behavior, examining documents, and interviewing participants (Creswell, 2013; Hatch, 2002). In addition, qualitative research involves multiple forms of data such as interviews, observations, and documents (Creswell, 2013; Marshall & Rossman, 2010). It also involves both inductive and deductive logic (Creswell, 2013; Hatch, 2002; Marshall & Rossman, 2010). Another important aspect of qualitative research is that it is highly focused on learning the meaning the participants have about the issue, rather than the meaning from the literature (Creswell, 2013; Hatch, 2002). It is emergent because the research plan may change depending on the data collection (Creswell, 2013; Marshall & Rossman, 2010). Moreover, qualitative research is reflexive because the researcher emanates her background and how it affects her interpretation of the study (Creswell, 2013; Horsburgh, 2003; Wolcott, 2010). Finally, it is holistic by providing a complex picture and multiple perspectives (Creswell, 2013; Creswell, 2014; Hatch, 2002; Marshall & Rossman, 2010).

Strengths. As with all types of research, there are strengths and weaknesses with qualitative inquiry. When conducted properly, qualitative research allows issues or phenomena to be studied in detail and in depth (Anderson, 2010). Much of the data are collected through observations and interviews, which act as a strength. Interviews allow for flexibility in the process, and the researcher is able to redirect and ask additional questions at a moment's notice (Anderson, 2010; Cal, 2017; Creswell, 2014). The researcher also has flexibility with the research design, which can be revised as new information is obtained (Anderson, 2010; Cal, 2017). In addition, human subjects have the opportunity to share their personal reality and experience (Creswell, 2014). The data collected from the participants is often more compelling and powerful than quantitative data (Anderson, 2010). Nuances and subtleties about the participants or topic may be discovered that could be missed with other forms of inquiry (Anderson, 2010). A final strength is that conclusions from the research study are generalized to other settings (Anderson, 2010).

Weaknesses. Qualitative research also has several weaknesses or limitations. Sometimes, it is not as well respected and understood as quantitative research in scientific circles (Anderson, 2010). In addition, the quality of the research may be influenced by the researcher's personal biases and the researcher's observing and interviewing skills (Anderson, 2010; Creswell, 2014; Horsburgh, 2003). Moreover, the presence of the researcher may affect the participants' responses (Anderson, 2010; Creswell, 2014; Horsburgh, 2003). The participants may not be equally articulate and may differ in their degree of openness (Anderson, 2010; Creswell, 2010). Another challenge of qualitative research is presenting certain findings due to anonymity and confidentiality (Anderson, 2010; Creswell, 2014). Analysis and interpretation are more time consuming in qualitative research because of the volume of data (Anderson, 2010).

Assumptions. There are four philosophical assumptions of qualitative studies: ontological, epistemological, axiological, and methodological (Creswell, 2010). The ontological assumption relates to the nature of reality because there are multiple realities in qualitative research (Creswell, 2010). The researcher studies various individuals who all have their own realities, and the readers of the research have their own realities. With this qualitative study, it is the goal of the researcher to report the multiple perspectives across all participants (Moustakas, 1994). The epistemological assumption is characterized by how knowledge is known (Creswell, 2010). In qualitative research, the researcher gains knowledge through the participants and their subjective experiences. The closer the researcher is to the participants, the more she knows what she knows through first-hand information. In this study, the researcher is able to rely on quotes and subjective experiences of the participants by interviewing and collaborating with them. Guba and Lincoln (1988) describe it as minimizing the "distance" (p. 94) or "objective separateness" (p. 94) between the researcher and participant. The axiological assumption relates to the role of values in a study (Creswell, 2010). All researchers have values, but qualitative studies are unique because the researchers make their values and biases known. When a researcher interprets the data in a given study, it is shaped by the researcher's own experiences (Denzin & Lincoln, 2011). In this study, the researcher shares her bias as an educator and how it influences her interpretation of the data. With the methodological assumption, the process of research is detailed (Creswell, 2010). Qualitative research is inductive and emerging because the researcher develops her questions from the ground up as opposed to developing all questions from a theory. The researcher may add questions or modify existing procedures as she moves through the interview and data collection process. In this study, the researcher has some follow-up questions designed and may ask additional ones as the participants share information during the interviews.

Methodology

This study specifically utilized a phenomenological approach, which is one of five approaches to qualitative research: narrative study, phenomenology, grounded theory, ethnography, and case study (Creswell, 2013). A phenomenological study "describes the common meaning for several individuals of their lived experiences of a concept or a phenomenon" (Creswell, 2013, p. 76). The goal of phenomenological research is to gather accounts from people who have experienced the phenomenon in question (Giorgi, 1997; Moustakas, 1994). Giorgi (1997) wrote,

> The turn to others is chosen in order to avoid the possible objection of bias, and the natural attitude is utilized because, practically, one cannot expect all of the persons in the whole world to be phenomenological and thus be capable of assuming the attitude of the reduction. (p. 243)

Phenomenological research is used when the desired goal is to create meaning out of a phenomenon. Adams and van Manen (2017) explain that,

> [Phenomenology] promises fascinating insights into the meaningfulness of everyday life and professional practice. Phenomenology calls us to wonder, reflect, and draw nearer to joy, love, loss, contact, care, and all manner of deeply human meanings. It grants inceptual understandings of the nature of being and becoming human in our increasingly commercial, distracted, and conflicted world. (p. 781)

A phenomenological approach was best suited for this study because knowledge was gained about the best practices for reducing math anxiety, which ultimately increase mathematical proficiency and achievement. The knowledge was gained through a series of semi-structured interviews with elementary teachers. The researcher transcribed all interviews and found the common themes throughout the data. This method supported the primary goal of phenomenological research to "synthesize multiple reported experiences to a description or definition that expresses a universal theme" (Cal, 2017, p. 96).

Structured process of phenomenology. Giorgi (2009) and Moustakas (1994) detailed specific procedures for conducting phenomenological research, which Creswell (2013) organized into a list of seven steps: (a) the researcher determines if the research question is best answered using a phenomenological approach; (b) the phenomenon of interest to study is selected, in this case, math anxiety; (c) the researcher explains the assumptions of the phenomenological approach and how she brackets out her own experiences; (d) data are collected in the form of observations, interviews, and journals from individuals who have experienced the phenomena; (e) the researcher analyzes the data by highlighting common statements to group them into meaningful themes; (f) the researcher uses the significant themes to write a "textural description" (Creswell, 2013, p. 82) of what the participants experienced and a "structural description" (Creswell, 2013, p. 82) of how the participants experienced the phenomenon; and (g) the researcher writes a composite description that focuses on the "essence of the phenomenon" (Creswell, 2013, p. 82), or the common experiences of the participants.

Appropriateness of phenomenology methodology. The phenomenological approach was best applied to this study because the research benefited from the teacher participants' lived experiences of working with students who have math anxiety. The participants shared strategies they have successfully utilized and challenges they have encountered. As a result, the researcher created a composite description of what the participants experienced and how they experienced it (Creswell, 2013; Englander, 2012).

There are strengths of phenomenology that support using the phenomenological approach for this study. Specifically, this phenomenological study provided an in-depth understanding of the individual phenomena of math anxiety, and the researcher had the flexibility to redirect and ask follow-up questions during the interview process. The result is a rich array of data gathered from the experiences of the teacher participants (Anderson, 2010).

Although the phenomenological approach is considered the best approach for this study, there are three weaknesses to address. First, it can be difficult to prevent researcher bias. Second, there can be difficulty in ensuring pure bracketing, which can interfere in the interpretation of the data. Third, there can be a variety of responses based on the participant's ability to articulate. This study mitigated these weaknesses in the following ways. First, the researcher biases were clearly explained. Next, the researcher bracketed personal experiences as an educator and administrator, so they did not interfere with the interpretation of the data (Creswell, 2013). Finally, the questions were given to the participants in advance, and the researcher asked an ice breaker question at the beginning of the interview to build rapport.

Research Design

A research design is a framework that "serves as a bridge between research questions and the execution or implementation of the research" (Durrheim, 2006, p. 34).

Analysis unit. The analysis unit for this research study was a teacher identified as such:

1. An elementary teacher who teaches first through sixth grade at an elementary school in the XYZ Unified School District,
2. A teacher with at least three years of teaching experience,
3. A teacher who possesses a California teaching credential.

Population. The population was all first through sixth grade elementary teachers in the XYZ Unified School District. There are a total of 23 elementary schools in the district. The elementary schools are kindergarten through sixth grade and have about 14 to 22 teachers.

Sample size. Sample size is an important decision in the data collection process and there are various opinions in the research. A general guideline for qualitative research is to study a few individuals in order to collect specific details about each individual (Creswell, 2013). The purpose of qualitative research is to illuminate the particular as opposed to generalizing the information (Pinnegar & Daynes, 2007). For phenomenological studies, researchers recommend three to 25 subjects (Dukes, 1984; Polkinghorne, 1989; Riemen, 1986). According to Moustakas (1994) and Creswell (2013), sample sizes in phenomenological studies should be from three or four individuals to ten to 15 so the researcher can effectively explore the phenomenon with "a group of individuals who have all experienced the phenomenon" (Creswell, 2013, p. 78). Guetterman (2015) analyzed 11 phenomenological studies and found that the mean sample size was 15 in the field of education and 25 in the field of health sciences, with a broad range of eight to 52 subjects. Several of the 11 studies discussed saturation and defined saturation as, "sufficient quality, completeness, and amount of information in addition to no evidence of new themes in the interviews" (Guetterman, 2015, p. 10). Specifically, Martins (2008) interviewed 15 participants until she reached saturation. She felt she reached saturation after 12 interviews but conducted an additional three interviews to ensure no new themes emerged. Guest, Bunce, and Johnson (2006) administered an experiment to study saturation and found 12 interviews were optimal for saturation. Kvale stated (1992), "To the common question 'How many interview subjects do I need?', the answer is simply, 'Interview so many subjects that you find out what you need to know,'" (p. 165). Given that there is research supporting smaller sample sizes (Creswell, 2013; Dukes, 1984; Moustakas, 1994; Polkinghorne, 1989; Riemen, 1986) and that saturation is consistently found between 12 and 15 interviews (Beck & Watson, 2008; De Wet, 2010; Guest et al., 2006; Martins, 2008), the sample size for this study was determined to be 15 participants.

Purposive sampling. Purposive sampling is a sampling technique often used in qualitative research to identify and select individuals that are knowledgeable about and have experience in the phenomenon of interest (Anderson, 2010; Creswell & Plano Clark, 2011; Palinkas, Horwitz, Green, Wisdom, Duan, & Hoagwood, 2015; Patton, 1990; Patton, 2002; Sandelowski, 1995). In addition to having knowledge and experience, it is important for the subjects to be available, willing to participate, and able to communicate in an articulate manner (Bernard, 2002). Purposive sampling in qualitative research generates depth of understanding whereas quantitative research focuses more on breadth of understanding (Palinkas et al., 2015).

Participation selection: Sampling frame to create the master list. Purposive sampling was applied to this study to identify and select the individuals utilizing the following procedures. Sampling frame is the master list of people who form the population from which the sample is taken (Coyne, 1997). For this qualitative research study, a systematic procedure was developed to create a master list of possible participants as explained below:

1. The XYZ Unified School District website was visited at https://www.xxxxx.org (name redacted to ensure confidentiality).
2. Under the “Schools” tab, “Elementary A-L” was selected. There were 12 elementary schools.
3. The “Elementary M-Z” page was selected. There were 11 elementary schools.

4. The “View Website” button under each elementary school name was clicked. This displayed each elementary school website.
5. On the individual school menu bar, “Programs” was expanded and “Teachers and Websites” was selected.
6. Grade levels kindergarten through sixth grade were displayed. Grades first through sixth were expanded and teacher names and emails were displayed.
7. This search generated 430 first through sixth grade teachers that made up the master list. The master list included name, email, grade, and school, so inclusion and exclusion criteria and maximum variation could be executed.
8. A master list of the population of first through sixth grade elementary teachers in the XYZ Unified School District was created.
9. Inclusion and exclusion criteria such as education level, years of experience, and availability for interviews eliminates a percentage of the potentially eligible population (Preskorn, Macaluso, & Trivedi, 2015). The master list of eligible participants was reduced by applying the inclusion and exclusion criteria as explained subsequently.
10. Applying criteria for maximum variation. Maximum variation is an approach that determines certain criteria in advance to differentiate the participants (Coyne, 1997; Creswell, 2013;). Participants are then selected that differ on the criteria. Examples of maximum variation are age, gender, ethnicity, and grade level of classroom. An advantage of maximum variation is that it increases the probability that the research findings will represent different perspectives, which is “an ideal in qualitative research” (Creswell, 2013, p. 157).

Criteria of inclusion. Criteria for inclusion were applied to the master list to further create the sample. Each teacher's name was entered on the CA Commission on Teacher Credentialing website https://www.ctc.ca.gov on the "Public Search for an Educator" page. For inclusion into the subpopulation of the study, the teacher needed to:

- Possess a Multiple Subject Teaching Credential
- Possess a Cross-cultural, Language, and Academic Development Certificate.
- Have had their teaching credential for five or more years
- Have three years of teaching experience

Criteria of exclusion. The following were criteria for exclusion:

- Any participants not available in January through March of 2018 for interviews will be excluded.
- Any participant not willing to be audio recorded will be excluded.

Purposive sampling maximum variation. Maximum variation is a strategy that captures and describes central themes that branch across participant variation (Hoepfl, 1997). It ensures a variety of participants are selected and allows for patterns to emerge across the variation. If the study's sample list was larger than 20 individuals, then maximum variation was applied. Gender, grade level, and location of school were used to ensure the list had variety. Finally, the master list of potential teachers was contacted and invited to participate. Through the processes of inclusion, exclusion, and maximum variation, a final list of 15 eligible participants was generated.

Protection of Human Subjects

In accordance with Pepperdine University's Internal Review Board (IRB) when conducting research with human participants, consent must be obtained. For this study, the researcher submitted an exempt application to IRB for review and approval prior to recruiting participants (see Appendix A). In addition, the researcher completed the CITI program required for persons conducting research (see Appendix B). The goal of the IRB process is two-fold: (a) protect the welfare and dignity of human subjects, and (b) assist investigators in conducting ethical research that complies with applicable regulations. As stated by Pepperdine University's IRB (2017),

> It is the policy of Pepperdine University that all research involving human participants must be conducted in accordance with accepted ethical, federal, and professional standards for research and that all such research must be approved by one of the university's Institutional Review Boards (IRBs). In the review and conduct of research, Pepperdine University is guided by the ethical principles set forth in the Belmont Report. In addition, all human subjects research conducted by or under the auspices of Pepperdine University will be performed in accordance with the U.S. Code of Federal Regulations, CHHS (CFR), Title 45 Part 46 (45 CFR 46), entitled Protection of Human Research Subjects, and Parts 160 and 164, entitled Standards for Privacy of Individually Identifiable Health Information and the California Protection of Human Subjects in Medical Experimentation Act. (para. 2)

Prior to beginning the study, each participant signed an informed consent form that acknowledged the protection of their human rights (see Appendix C). Informed consent forms included the following (Sarantakos, 2005):

- Identification of the researcher
- Identification of the sponsoring institution

- Identification of the purpose of the study
- Identification of the benefits for participating
- Identification of the level and type of participant involvement
- Notation of risks to the participant
- Guarantee of confidentiality to the participant
- Assurance that the participant can withdraw at any time
- Provision of names of persons to contact if questions arise (p. 96).

Study participants originally received an e-mail to participate (see Appendix D). Participation was voluntary and if a subject agreed to participate, the consent form (see Appendix C) was secured. Confidentiality and anonymity was emphasized both verbally and in writing. Participants were reminded that no negative ramifications would result from their participation. Participants were identified as P1 through P15, so no records, including the researcher's notebook, had personally identifiable information. The researcher's laptop was password protected and all of the data were secured. As soon as the interviews were transcribed, the recordings were destroyed. Upon completion of the study, all data with personally identifiable information were destroyed. The transcriptions and non-identifiable data will be kept securely at the researcher's residence and destroyed after five years. Participants received no remuneration other than a written thank you note and a copy of the completed research.

Data Collection

Subjects were contacted via e-mail using the IRB approved recruitment script (see Appendix D). If no response was received within three days, then another e-mail was sent. Once the subject agreed to participate in the study, the informed consent form (see Appendix C) and interview questions (see Table 6) were e-mailed. E-mail correspondence was used to schedule one-hour, in-person interviews at a convenient location for the participant. At the beginning of each interview, the signed consent form was collected. A hard copy of the consent form was brought to the interview in the event that the participant did not bring his signed copy. Each interview was recorded using two recording devices and the researcher had a notebook for key thoughts or questions for later reflection.

Interview Techniques

A semi-structured interview technique was used for the data collection in this phenomenological research study. Before explaining the reasoning behind selecting the semi-structured interview, the three types of interviews in qualitative research will be explained in detail. The first type, the structured interview, follows a set of stringent questions that do not allow the interviewer to divert (DiCicco-Bloom & Crabtree, 2006; Gray, 2009). A strength of the structured interview is that it is believed to reduce interviewer bias (Bragger, Kutcher, Morgan, & Firth, 2002), and a weakness is that it does not provide any flexibility if the interviewer would like to ask follow-up questions or probe deeper based on the participant's responses. The second type is the semi-structured interview, which is an in-depth interview where the interviewer asks predesigned open-ended questions (Jamshed, 2014). It is generally conducted one time, with an individual or group, and lasts 30 minutes to one hour (Corbin & Strauss, 2008; DiCicco-Bloom & Crabtree, 2006). Collecting descriptive responses during a semi-structured interview helps to achieve the goal of making meaning out of a particular phenomenon (Englander, 2012). Weaknesses of the semi-structured interview include limited flexibility in questions and responses, duration of time, and a lack of detailed responses if the interviewer is not skilled and the interviewee is not articulate (Fontana & Frey, 2000). The third type, the unstructured interview, resembles a conversation without a pre-planned set of questions and it is often used in long-term field work (Jamshed, 2014). It is more difficult to control for interviewer bias during the unstructured interview; however, it offers more of an in-depth understanding of the phenomenon and human behavior (Fontana & Frey, 2000).

For this study, the semi-structured interview was selected because it allowed the interviewer to be prepared with questions and possible follow-up questions, and it allotted time for the interviewee to ruminate on the questions in advance. In addition, the semi-structured interview had strong validity due to the lack of interference from the interviewer (Cal, 2017), and it allowed the interviewee to speak in detail about the phenomenon of math anxiety (Englander, 2012). According to Seidman (2013), the purpose of the interview was not to obtain answers to questions, but to understand the lived experiences of the participants. The interview allowed for the participants to explain their experiences and for the interviewer to listen carefully and follow-up accordingly (Castillo-Montoya, 2016).

One week prior to the scheduled interviews, a reminder e-mail was sent to each participant. In addition, the informed consent form and interview questions were re-sent. Receiving the interview questions in advance allowed the participants time to consider their responses. The evening before the interviews, a final reminder e-mail was sent detailing the date, time, and location of the interview appointment.

For each interview, the researcher arrived 15 minutes early to the location with two recording devices, pens, and a notebook. She introduced herself to the participant with eye contact and a firm handshake and expressed gratitude for the subject's willingness to participate. The goal was to build rapport with the interviewee (Rubin & Rubin, 2012). She reviewed and collected the signed copy of the informed consent form and asked if there were any clarifying questions before they began. The researcher reminded the participant that the interview would be recorded and confirmed confidentiality. To open the interview, the researcher asked two ice-breaker questions about the participant's professional background and thoughts on math anxiety (Castillo-Montoya, 2016). The interviewer then proceeded to ask all eight questions (see Table 6) and any follow-up questions as deemed appropriate. The researcher was prepared and engaged, so she was able to respond thoughtfully to the responses and further probe themes (Louw, Todd, & Jimakorn, n.d.). Throughout the interview, the researcher practiced active listening, which is listening with a purpose (Pearson, Nelson, Titsworth, & Harter, 2006). The researcher asked follow-up questions and statements, such as (Wilson, 2016):

- "How do you typically…?"
- "Why do you think…?
- "Can you clarify…?"
- "Tell me more…"

To close the interview, the researcher asked if the participant had any final thoughts and reiterated confidentiality. The researcher explained the written transcription would be provided, expressed gratitude for the participant's time and willingness to share, and explained a copy of the research findings would be provided once complete. The researcher sent a handwritten thank you note to each participant within a week of the interview.

Interview Protocol

The study was guided by the following interview questions:

IQ 1: How do you detect math anxiety in a student?

IQ 2: What strategies do you use to reduce math anxiety in your students?

IQ 3: In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety?

IQ 4: What other challenges have you faced regarding math anxiety?

IQ 5: Share some of your success stories in helping students who have math anxiety.

IQ 6: What is your system for measuring and tracking success?

IQ 7: How do you keep track of your success with students who have math anxiety?

IQ 8: What advice do you have for new teachers who have students with math anxiety?

Relationship between research and interview questions. The development of the eight interview questions was designed to address each research question. The interview questions resulted from literature reviewed in Chapter 2, personal knowledge, and a three-step process to establish validity that included prima facie, peer review, and expert review. The process will be explained in detail below.

Validity of the study. Validity in qualitative research is how accurately the data truly represent the phenomenon being studied and the extent an instrument measures what it is intended to measure (Biddix, n.d.; Creswell, 2000; Creswell & Miller, 2000). Moreover, validity relates to the terms "trustworthiness, authenticity, and credibility" (Creswell, 2013, p. 205). To ensure that the interview questions addressed the research questions and, ultimately, provided accuracy in the research findings, the research instrument was validated using the three-step process of prima facie, peer review, and expert review.

Prima facie and content validity. Prima facie is a Latin term used in the early works of Roman and Medieval scholars of philosophy and law (Herlitz, 1994). Translated, prima facie means "on/at first appearance" (Herlitz, 1994, p. 392). Content validity is the "appropriateness of the content of the instrument" (Biddix, n.d., p. 2). The first step in establishing instrument validity was prima facie and content validity: Does the instrument accurately assess the phenomenon? Four research questions were developed and then approved by the dissertation committee. After completing a review of the extensive literature on math anxiety, nine interview questions were developed corresponding to the research questions. The instrument has face validity since the interview questions directly relate to each research question (see Table 3).

Table 3

Research Questions and Corresponding Interview Questions

Research Questions	Corresponding Interview Questions
RQ 1: What strategies and practices do teachers employ to reduce math anxiety?	IQ 1: How prevalent is math anxiety in your classroom? IQ 2: What strategies do you use to reduce math anxiety in your students?
RQ 2: What challenges do teachers face in reducing math anxiety?	IQ 3: How do you detect math anxiety in a student? IQ 4: In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety? IQ 5: Are there other challenges that you have faced?
RQ 3: How do teachers measure the success of their practices in reducing math anxiety?	IQ 6: Share some of your success stories in helping students who have math anxiety. IQ 7: What is your system for measuring and tracking success?
RQ 4: What recommendations would teachers make for future implementation of strategies in reducing math anxiety?	IQ 8: How do you keep track of your success with students who have math anxiety? IQ 9: What advice do you have for new teachers who have students with math anxiety?

Peer-review validity. The second step in establishing instrument validity was peer review. Two Pepperdine University doctoral students served as peer reviewers. The peer reviewers were provided a document via email of the research questions and corresponding interview questions (see Appendix E). For each interview question, the peer reviewers had three options:

1. Keep the question as stated because it directly relates to the research question.
2. Delete the question because it is irrelevant to the research question.
3. Modify the question.

The peer reviewers provided written feedback on the document and returned to the researcher via email within one week. Based on the doctoral students' feedback, interview question five (IQ 5) was revised to obtain explicitness (see Table 4).

Table 4

Research Questions and Corresponding Interview Questions (Revised)

Research Questions	Corresponding Interview Questions (Revised)
RQ 1: What strategies and practices do teachers employ to reduce math anxiety?	IQ 1: How prevalent is math anxiety in your classroom? IQ 2: What strategies do you use to reduce math anxiety in your students?
RQ 2: What challenges do teachers face in reducing math anxiety?	IQ 3: How do you detect math anxiety in a student? IQ 4: In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety? IQ 5: What other challenges have you faced regarding math anxiety?
RQ 3: How do teachers measure the success of their practices in reducing math anxiety?	IQ 6: Share some of your success stories in helping students who have math anxiety. IQ 7: What is your system for measuring and tracking success?
RQ 4: What recommendations would teachers make for future implementation of strategies in reducing math anxiety?	IQ 8: If there was a student you could go back and help in math, what would you do differently? IQ 9: What advice do you have for new teachers who have students with math anxiety?

Reliability of the study and pilot interview. Reliability is the degree to which the instrument consistently measures what it is supposed to measure (Biddix, n.d.). Specifically, reliability is repeatability and consistency. Richard and Morse (2013) explained that a study has reliability if it yields the same results when repeated. In order to establish the reliability of the instrument, the researcher conducted two pilot interviews with current teachers who met the criteria for participation. At the end of each interview, the researcher sought input from the interviewees regarding clarity, flow, and understandability of the interview questions. Their recommendations were incorporated into the interview questions (see Table 5).

Table 5

Research Questions and Corresponding Interview Questions (Pilot)

Research Questions	Corresponding Interview Questions (Pilot)
RQ 1: What strategies and practices do teachers employ to reduce math anxiety?	IQ 1: How prevalent is math anxiety in your classroom? IQ 2: What strategies do you use to reduce math anxiety in your students?
RQ 2: What challenges do teachers face in reducing math anxiety?	IQ 3: How do you detect math anxiety in a student? IQ 4: In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety? IQ 5: What other challenges have you faced regarding math anxiety?
RQ 3: How do teachers measure the success of their practices in reducing math anxiety?	IQ 6: Share some of your success stories in helping students who have math anxiety. IQ 7: What is your system for measuring and tracking success?
RQ 4: What recommendations would teachers make for future implementation of strategies in reducing math anxiety?	IQ 8: If there was a student you could go back and help in math, what would you do differently? IQ 9: What advice do you have for new teachers who have students with math anxiety?

Expert review validity. The third step in establishing instrument validity was expert review. The dissertation committee reviewed the interview questions and provided feedback. Any suggested modifications were used to revise the interview questions. The final interview questions are reflected in Table 6.

Table 6

Research Questions and Corresponding Interview Questions (Final)

Research Questions	Corresponding Interview Questions (Final)
RQ 1: What strategies and practices do teachers employ to reduce math anxiety?	IQ 1: How do you detect math anxiety in a student? IQ 2: What strategies do you use to reduce math anxiety in your students?
RQ 2: What challenges do teachers face in reducing math anxiety?	IQ 3: In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety? IQ 4: What other challenges have you faced regarding math anxiety?
RQ 3: How do teachers measure the success of their practices in reducing math anxiety?	IQ 5: Share some of your success stories in helping students who have math anxiety. IQ 6: What is your system for measuring and tracking success?
RQ 4: What recommendations would teachers make for future implementation of strategies in reducing math anxiety?	IQ 7: How do you keep track of your success with students who have math anxiety? IQ 8: What advice do you have for new teachers who have students with math anxiety?

Statement of Personal Bias

It is important to “clarify the bias the researcher brings to the study” (Creswell, 2014, p. 202) because it can affect the interpretation of the findings. Rajendran (2001) explains that even though specific procedures are followed in conducting the study, researchers still need to guard against their own bias. The researcher’s professional experience in math instruction, teaching, and educational administration have shaped the researcher’s perspective on best teaching practices in mathematics. The researcher’s bias likely had an effect on the research design.

Bracketing and epoche. Epoche is a Greek word meaning to “refrain from judgment” (Moerer-Urdahl & Creswell, 2004, p. 19), and specifically, relates to the researcher “setting aside prejudgments as much as possible and using systematic procedures for analyzing the data” (Moerer-Urdahl & Creswell, 2004, p. 19). Epoche essentially is bracketing because the researcher is bracketing, or suspending judgment, and setting aside her experiences to have a fresh perspective regarding the phenomenon under study (Aagaard, 2017; Creswell, 2013; Moerer-Urdahl & Creswell, 2004; Moustakas, 1994). For this study, the researcher listed all preconceived thoughts on math anxiety and mindset toward math prior to beginning the interviews. In addition, the researcher kept a reflective journal of observations and assumptions during the data collection process. This journal allowed for a clearing of thoughts where preconceptions and prejudgments leave the mind, so the researcher could focus on the participants' answers during the interviews (Moerer-Urdahl & Creswell, 2004). These two exercises served as a means of bracketing (Creswell, 2013) and helped to reduce personal biases.

Data Analysis

After the data were collected and transcribed, the data analysis began. The researcher read all of the transcriptions while writing down brief notes in the margins. Coding followed. According to Moustakas (1994), analyzing the data consist of the researcher identifying significant words and phrases from participants, clustering these phrases into themes, synthesizing the themes into descriptions of the interviewees' experiences, and making meaning about the essence of the phenomenon. Creswell (2014) used Moustakas' approach to develop six specific steps in qualitative data analysis: (a) prepare the data for analysis, including transcription, (b) read all of the data and write brief notes regarding initial impressions, (c) code the data, (d) use the coding to generate descriptions and themes, (e) explain the findings through narration, tables, graphs, and (f) interpret the findings and results.

Coding. Coding is a word or short phrase that assigns an "essence-capturing attribute" (Saldana, 2013, p. 2) for a portion of the data. The three main types of coding are structured, semi-structured, and unstructured. Structured coding uses a “conceptual phrase representing a topic of inquiry to a segment of data that relates to a specific research question used to frame the interview” (MacQueen, McLellan-Lemal, Bartholow, & Milstein, 2008, p. 124). It is a questions-based code and is appropriate for all qualitative studies, particularly hypothesis testing and structured or semi-structured interviews (Saldana, 2013). Unstructured coding does not have a predetermined notion of the codes to use during the coding process. It is also effective for all qualitative studies. Semi-structured coding is a combination of the two. This study used unstructured coding to allow themes to develop from the interpretation of data.

The transcribed data were analyzed and coded. The codes were one-word descriptive codes, which summarize the main topic of the excerpt. Other codes were phrases that captured the essence of the excerpt. Creswell (2014) explains that 25 to 30 codes is the ideal range to develop five to six themes. A table was created for each interview question and each column represented one of the 15 participants. The codes were added to the table and were used to arrive at themes.

Inter-rater reliability and validity. External validity is “the extent to which the results of a study can be generalized from a sample to a population” (Biddix, n.d., p. 2). One procedure to reduce the threat to external validity is to incorporate inter-rater reliability (Creswell, 2014). Inter-rater reliability is a measure of reliability used to assess the degree to which different raters or observers agree on the same phenomenon (Phelan & Wren, 2005). A three-step process was used to establish inter-rater reliability.

> **Step 1**: The researcher individually coded the first three interviews according to the coding process explained previously.

Step 2: The researcher shared the transcripts and coding results from the three interviews with two peer reviewers. The reviewers were doctoral students in the Organizational Leadership program at Pepperdine University. They were experienced in qualitative research and were both completing dissertation work with a similar coding process. The reviewers reviewed the transcripts and coding results and supported the initial results or recommended modifications. The researcher and reviewers discussed until consensus was reached. If the panel was unable to arrive at a consensus, the dissertation committee reviewed.

Step 3: The researcher proceeded to code the remaining 12 interviews. The researcher once again shared the transcripts and coding results with the two peer reviewers. Upon review, the researcher and reviewers discussed to gain consensus. If consensus was not reached, the dissertation committee worked to resolve the differences and made the final decision.

Summary

Chapter 3 discussed the nature of qualitative research and presented the strengths and weaknesses of qualitative studies. The research questions were re-stated and the specific methodology for this phenomenological study was explained in detail. Data were collected through semi-structured interviews, and the interview questions were developed through a three-step process including prima facie, peer review, and expert review. Techniques for conducting valid and reliable qualitative research were described. The chapter concluded with a discussion on data analysis. The research findings are presented in Chapter 4.

Chapter 4: Findings

Introduction

Competence in mathematics is necessary to achieve success in STEM fields (National Mathematics Advisory Panel, 2008). One area that significantly impacts math proficiency is math anxiety (Ashcraft, 2002), and math anxiety can cause students to develop negative attitudes toward math, avoid future math courses, and refrain from careers involving math (Ferguson et al., 2015). Even if a student is not going to pursue a career in STEM fields, it is essential to reduce math anxiety and increase mathematical competence for daily math literacy (Schoenfeld, 1995). The intention of this qualitative study was to investigate best practices in reducing math anxiety.

Specifically, the purpose of the study was to (a) determine the strategies and practices teachers employ to reduce math anxiety, (b) determine the challenges teachers face in reducing math anxiety, (c) determine how teachers measure the success of their practices in reducing math anxiety, and (d) determine the recommendations teachers would make for future implementation of strategies in reducing math anxiety. To accomplish this task, this study sought to answer the following four research questions:

> Research Question 1: What strategies and practices do teachers employ to reduce math anxiety?
>
> Research Question 2: What challenges do teachers face in reducing math anxiety?
>
> Research Question 3: How do teachers measure the success of their practices in reducing math anxiety?
>
> Research Question 4: What recommendations would teachers make for future implementation of strategies in reducing math anxiety?

To answer these four research questions, eight open-ended interview questions were developed that directly inform a specific research question. The interview questions were confirmed through a three-step validity process that included prima facie, peer review, and expert review. Reliability was established by conducting pilot interviews with two current teachers who meet the criteria for participation. The following eight interview questions were included in the interview protocol and were used to interview the participants in the study:

IQ 1: How do you detect math anxiety in a student?

IQ 2: What strategies do you use to reduce math anxiety in your students?

IQ 3: In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety?

IQ 4: What other challenges have you faced regarding math anxiety?

IQ 5: Share some of your success stories in helping students who have math anxiety.

IQ 6: What is your system for measuring and tracking success?

IQ 7: How do you keep track of your success with students who have math anxiety?

IQ 8: What advice do you have for new teachers who have students with math anxiety?

Interview participants were asked to provide responses to the eight interview questions in as much detail as possible. The interviewer asked further probing and follow-up questions as deemed appropriate. This chapter provides a description of the participants in this study, a discussion of the data collection and data analysis process, and a description of the inter-rater review process. Finally, the chapter details the findings from the data collected from the eight interview questions.

Participants

A total of 15 participants were interviewed for this study. As stated in the criteria of inclusion, all 15 possess a Multiple Subject Teaching Credential, have a Crosscultural, Language and Academic Development Certificate, have had their teaching credential for five or more years, and have at least three years of teaching experience. Of the 15 participants, 13 are female and two are male. Eight of the participants have a master's degree and seven have a bachelor's degree. They come from seven different elementary schools in the XYZ Unified School District and represent all grades from first through sixth grade. Their years of teaching experience range from three years to forty-two years (see Table 7).

Table 7

Interview Participant Details

Participant	**Gender**	**Degree Earned**	**Grade**	**Years of Experience**	**Date Interviewed**
P1	F	Masters	1st	22	February 26, 2018
P2	F	Masters	1st	32	March 1, 2018
P3	M	Masters	6th	42	March 3, 2018
P4	F	Masters	6th	16	March 5, 2018
P5	F	Bachelors	2nd	32	March 5, 2018
P6	F	Masters	6th	21	March 6, 2018
P7	F	Bachelors	1st/2nd combo	20	March 6, 2018
P8	F	Bachelors	6th	6	March 6, 2018
P9	F	Masters	1st	33	March 8, 2018
P10	F	Bachelors	4th	22	March 8, 2018
P11	F	Bachelors	3rd	3	March 8, 2018
P12	F	Masters	5th	22	March 10, 2018
P13	F	Masters	6th	10	March 11, 2018
P14	M	Bachelors	4th/5th combo	23	March 14, 2018
P15	F	Bachelors	5th	10	March 18, 2018

Data Collection

Data collection began in mid-February of 2018 after receiving full IRB approval from Pepperdine University on February 16, 2018. Data collection was conducted over the last two weeks of February and through the first three weeks of March using the IRB approved recruitment script (see Appendix D). First, the master list was created using the XYZ Unified School District website http://www.xxxxx.org (name redacted to ensure confidentiality), and the four criteria of inclusion were applied to ensure that the participants possessed a Multiple Subject Teaching Credential, possessed a Crosscultural, Language and Academic Development Certificate, had their teaching credential for five or more years, and had three years of teaching experience. Criteria for inclusion was verified by visiting the CA Commission on Teacher Credentialing website https://www.ctc.ca.gov and each teacher's website. Maximum variation was applied to guarantee a variety of participants were included. On February 18, 2018, 15 recruitment e-mails were sent. The first batch of recruitment e-mails yielded three interviews, one response of no interest, and 11 non-responses. On February 21, 2018, a second e-mail was sent to the 11 non-responders, which yielded six interviews. The master list was revisited and on February 25, 2018, 20 new recruitment e-mails were sent, which yielded six interviews. The interviewer applied the exclusion criteria by ensuring that the participants were available during the last half of February and first half of March for interviews and that they were willing to be audio-recorded. A total of 46 interview requests were sent during a two-week time period yielding a total of 15 interviews.

Once a participant agreed to an interview, the informed consent form (see Appendix C) and interview questions (see Table 6) were e-mailed. All interview participants were provided with the opportunity to ask questions prior to signing the consent form. A total of one hour was requested to conduct the interview; however, none of the interviews lasted the full hour. The interviews ranged in duration from 18 minutes to 54 minutes. Fourteen interviews were conducted in-person and one interview was conducted via telephone. Saturation was reached in data collection at interviews 11 and 12. All interviews were audio-recorded after obtaining the consent form from the participants. The participants were ensured confidentiality.

Data Analysis

Data analysis began by the researcher listening to each audio recording and transcribing the recordings into Word documents. As the transcriptions were complete, the researcher read through the transcripts twice making notes in the margins and highlighting key words, phrases, viewpoints. The researcher developed a spreadsheet organized by question number for all responses. The responses for each question were coded and added to the spreadsheet by question and participant number. The codes were then analyzed to derive common themes. Theme names were developed by utilizing verbiage included in the transcripts. The next step in the data analysis process was utilizing the inter-rater review process to ensure reliability and external validity.

Inter-Rater Review Process

Once the researcher coded the first three interviews, she shared the transcripts and spreadsheet of coding results with two peer reviewers. The peer reviewers were fellow doctoral students in the Organizational Leadership program at Pepperdine University and have training in qualitative research methods and data analysis. The reviewers reviewed the transcripts and supported the initial results of interview questions one and three. They recommended modifications of combining themes for question two. The panel was in consensus for the recommended modifications. The specific edits can be seen in Table 8. After the remaining 12 interviews were transcribed and coded, the researcher shared the coding spreadsheet with the peer reviewers. After a general discussion, the reviewers recommended combining some of the themes for interview questions six, seven, and eight. The researcher made the changes and combined several of the themes into broader, overarching themes (see Table 8).

Table 8

Inter-Rater Coding Edit Recommendations

Question	**Theme – before edit**	**Action**	**Theme – after edit**
IQ 2	Small groups	Combine	Small instructional groupings
IQ 2	Partner work/peer tutors	Combine	Small instructional groupings
IQ 2	One-on-one	Combine	Small instructional groupings
IQ 2	Pre-teach	Move to	Modifications
IQ 2	Reteach	Move to	Modifications
IQ 2	Teach for conceptual understanding	Combine	Teaching techniques
IQ 2	Step-by-step instruction	Combine	Teaching techniques
IQ 2	Ask questions	Combine	Teaching techniques
IQ 2	Manipulatives	Combine	Teaching techniques
IQ 2	Math Journals	Combine	Teaching techniques
IQ 2	Number talks	Move to	Engagement strategies
IQ 2	Math games	Combine	Math games/technology
IQ 2	Technology	Combine	Math games/technology
IQ 6	Tests (summative)	Combine	Assessments
IQ 6	Quizzes (formative)	Combine	Assessments
IQ 6	White boards	Combine	Assessments
IQ 6	Exit tickets	Combine	Assessments
IQ 6	Benchmarks	Combine	Assessments
IQ 6	Anecdotal records	Combine	Assessments
IQ 6	Performance tasks	Combine	Assessments
IQ 7	Anecdotal records	Combine	Assessments
IQ 7	Weekly timed tests/reflection	Combine	Assessments
IQ 7	Small groups	Combine	Small instructional groupings
IQ 7	One-on-one	Combine	Small instructional groupings
IQ 8	Work with parents on mindset	Move to	Model and instill growth mindset
IQ 8	Be positive about teaching and math	Move to	Model and instill growth mindset

Note. This table demonstrates the modifications made after the inter-rater reviewers reviewed the coding table provided by the researcher.

Data Display

Data are presented and organized in this chapter by research question and corresponding interview questions. Key words, phrases, viewpoints, and responses were coded and sorted into common themes for each interview question. A description of each theme is provided and corroborated with a participant quote from at least one participant in the transcribed data. To preserve the integrity of the data, phrases and responses are reported verbatim and may include incomplete sentences. Every attempt was made to ensure that the participants' intent is clearly communicated and interpreted. Participant quotes are reported using labels corresponding to their interview order. For example, the first interviewee is Participant 1 and is labeled P1, the second interviewee is Participant 2 and is labeled P2, and so on through Participant 15.

Research Question One

Research question one asked, "What strategies and practices do teachers employ to reduce math anxiety?" A total of two interview questions were asked to the participants to provide an answer to research question number one. The two interview questions relating to research question one are as follows:

IQ 1. How do you detect math anxiety in a student?

IQ 2. What strategies do you use to reduce math anxiety in your students?

The responses from all participants were coded and analyzed for common themes that informed the overall response to research question one.

Interview question one. "How do you detect math anxiety in a student?" Through the analysis of all responses to interview question one, a total of 45 key words, phrases, or viewpoints were identified as ways to detect math anxiety in a student. The eight common themes that emerged are as follows: (a) shuts down, (b) avoidance, (c) facial expressions, (d) student communicates, (e) body language, (f) frustration, (g) parents reports, and (h) preoccupation with grades (see Figure 11).

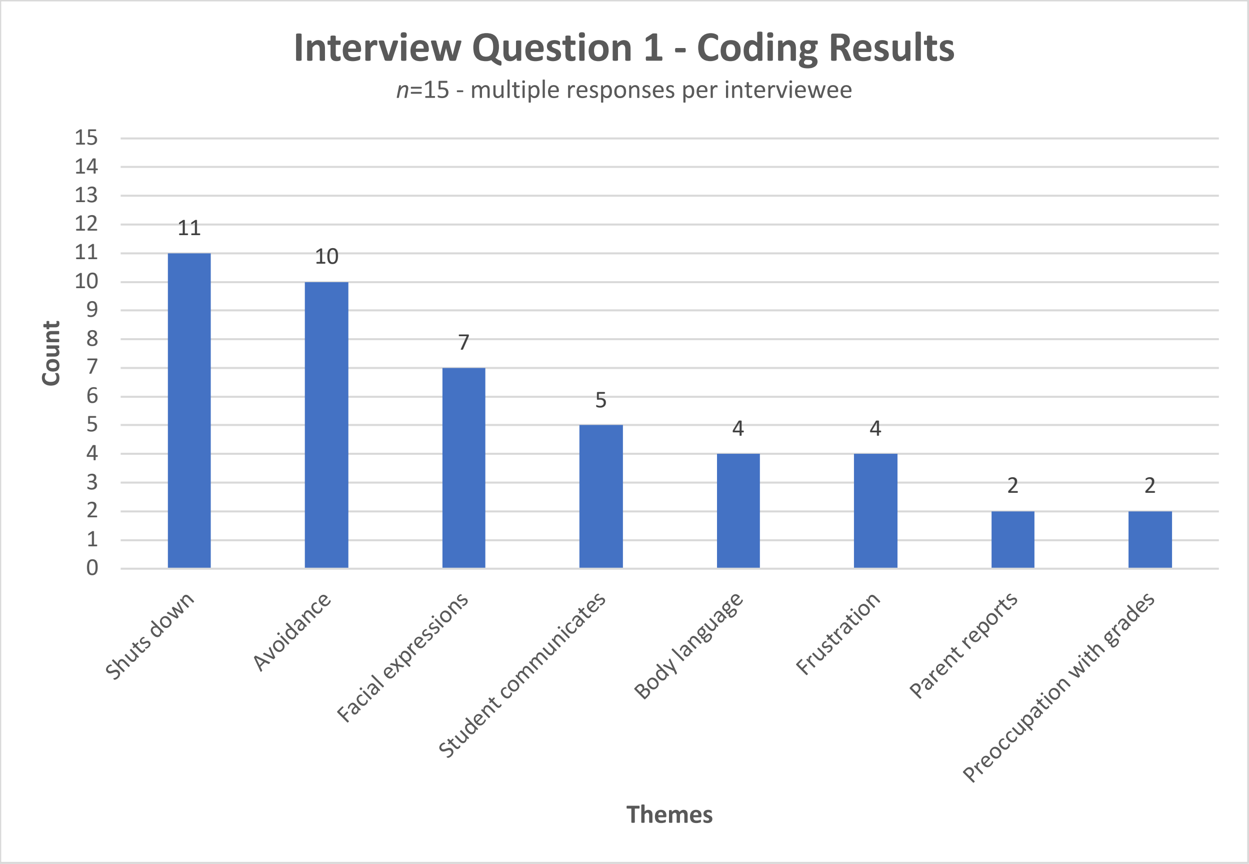


Figure 11. Ways to detect math anxiety in a student. The figure demonstrates the eight themes that emerged from responses to interview question one. Data is presented in decreasing order of frequency. The numbers in each theme indicate the number of times a direct or indirect statement was made by an interview participant that fell into the respective theme category.

Shuts down. A student shutting down ranked highest in frequency for ways to detect math anxiety in a student. Of the 45 key words, phrases, viewpoints, or responses to interview question one, 11 (24%) of the responses were directly or indirectly related to a student shutting down. The theme of shuts down includes shutting down, believing he or she cannot from previous experience, being negative, not wanting to put themselves out there to try it, sitting there doing nothing, tuning out, making up mind they are not going to get it, being very hesitant, lacking confidence, giving up, pulling back, and not participating. For example, P4 noted, "Well, I teach sixth graders, so a lot of times, they shut down and nothing happens, so I feel like that's when I, you know, there's an alert there" (P4).

Avoidance. Avoidance ranked second highest in frequency for ways to detect math anxiety in a student. Of the 45 key words, phrases, viewpoints, or responses to interview question one, ten (22%) of the responses were directly or indirectly related to avoidance. The theme of avoidance includes a student vegging out, avoiding the task, having a hard time getting started, looking at a neighbor, asking to use the restroom, asking to go to the health office, taking the trash out, asking for a drink, wanting to return a library book, missing math book, looking down to avoid eye contact, and being off task. For example, P12 explained,

> Well, the way I detect it in my students, the first sign is always just avoidance. I need to go the bathroom. Can I get a drink? I can't find my math book. My stomach hurts. Oh, I need to return the library book. Um, they'll be sitting there and be completely off task. It's just usually complete avoidance, but also, sometimes I've seen as much but the kid will just sit there, or the kid will put anything on their paper because they just don't - they don't want to deal with it at all. (P12)

Facial expressions. Facial expressions ranked third highest in frequency for ways to detect math anxiety in a student. Of the 45 key words, phrases, viewpoints, or responses to interview question one, seven (16%) of the responses were directly or indirectly related to facial expressions. The theme of facial expressions includes a puzzled look on face, startled look, halted expression, pained or strained look, confused look, and blank stares. For example, P10 commented, "Sometimes they might have kind of like a deer in headlights look on their face or kind of a strained or pained look on their face like I can't do this" (P10).

Student communicates. Student communicates ranked fourth highest in frequency for ways to detect math anxiety in a student. Of the 45 key words, phrases, viewpoints, or responses to interview question one, five (11%) of the responses were directly or indirectly related to student communicates. The theme of student communicates includes a student sighing, telling the teacher, verbalizing they are nervous, saying "I don't get this," and saying, "I can't do this." For example, P7 expressed, "But I had a little girl who just a couple of years ago, just bursting out and she would, you know, be a little verbal and actually know that this is making me nervous, you know" (P7).

Body language. Body language ranked fifth highest in frequency for ways to detect math anxiety in a student. Of the 45 key words, phrases, viewpoints, or responses to interview question one, four (9%) of the responses were directly or indirectly related to body language. The theme of body language includes shaking, rubbing temples, holding head in hands, and tapping legs. For example, P11 described, "I think if one of my particular students who is tapping her legs or like shaking - like her shoulders are moving so that's one indicator" (P11).

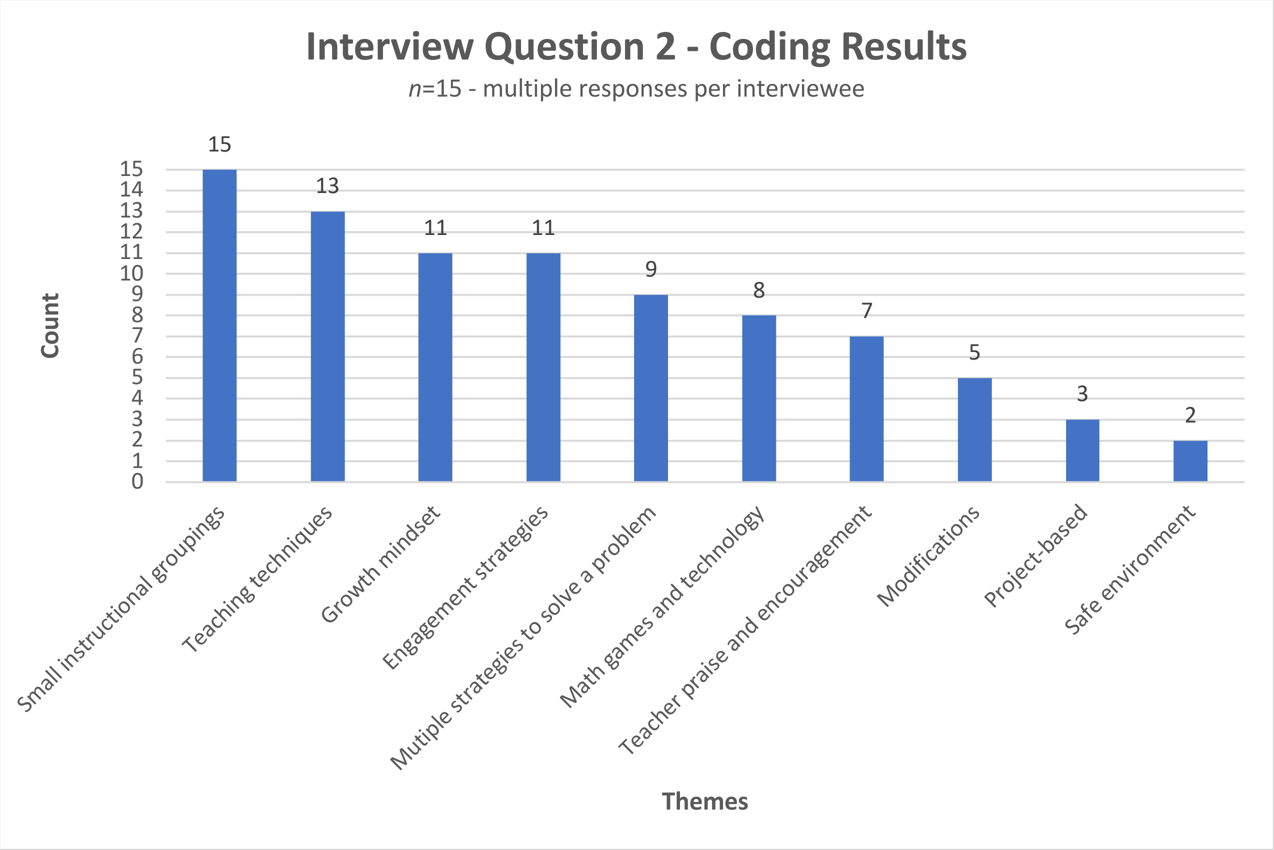
Frustration. Frustration also ranked fifth highest in frequency for ways to detect math anxiety in a student. Of the 45 key words, phrases, viewpoints, or responses to interview question one, four (9%) of the responses were directly or indirectly related to frustration. The theme of frustration includes frustration and crying. For example, P7 shared, "I do think it's, you know, the frustration or just the...I mean I do have a tear sometimes in second grade and first grade just with new concepts or not understanding something" (P7).

Parent reports. Parent reports ranked lowest in frequency for ways to detect math anxiety in a student. Of the 45 key words, phrases, viewpoints, or responses to interview question one, two (4%) of the responses were directly or indirectly related to parent reports. The theme of parent reports includes parents sharing about a meltdown or frustration at home and parents reinforcing that math is not the student's strength. For example, P4 described,

> I hear about it from their parents. Like, they will have meltdowns at home about the math; I can't do this, or they shut down or they walk away, or they just don't want to do it with their parents. For instance, I have a student this year, she is very low in math. She doesn't know her math facts. You know, even though we work on it in class. Anyway, [dad] told me that at night, it's like pulling teeth to get her to complete the assignments and even though he's there to help her. (P4)

Preoccupation with grades. Preoccupation with grades also ranked lowest in frequency for ways to detect math anxiety in a student. Of the 45 key words, phrases, viewpoints, or responses to interview question one, two (4%) of the responses were directly or indirectly related to preoccupation with grades. The theme of preoccupation with grades includes an intense focus on math grades and comparing grades to other students. For example, P11 shared, "So, I think that intense focus on grades, I think, is a demonstration of anxiety about math because they are so anxious that they need to perform at a certain level" (P11).

Interview question two. "What strategies do you use to reduce math anxiety in your students?" Through the analysis of all responses to interview question two, a total of 84 key words, phrases, or viewpoints were identified as strategies to reduce math anxiety in students. The ten common themes that emerged are as follows: (a) small instructional groupings, (b) teaching techniques, (c) growth mindset, (d) engagement strategies, (e) multiple strategies to solve a problem, (f) math games and technology, (g) teacher praise and encouragement, (h) modifications, (i) project-based, and (j) safe environment (see Figure 12).



Small instructional groupings	15
Teaching techniques	13
Growth mindset	11
Engagement strategies	11
Mutiple strategies to solve a problem	9
Math games and technology	8
Teacher praise and encouragement	7
Modifications	5
Project-based	3
Safe environment	2

Figure 12. Strategies to reduce math anxiety in a student. The figure demonstrates the ten themes that emerged from responses to interview question two. Data is presented in decreasing order of frequency. The numbers in each theme indicate the number of times a direct or indirect statement was made by an interview participant that fell into the respective theme category.

Small instructional groupings. Small instructional groupings ranked highest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, 15 (18%) of the responses were directly or indirectly related to small instructional groupings. The theme of small instructional groupings includes peer tutors, partners, small groups, before or after school help, one-on-one, Little Buddies, math rotations, collaboration, and special configuration of table groups. For example, P8 explained,

> I organize them in their table groups and they have partners, but whenever we do math, we would do half tables because I always...when I configured the tables, I

> look at the math students, the type of math students, when I configure the table groups. So, I usually have a high, a high medium, and a medium and a low so they're always able to help one another. I talked to the kids about, you know what? I put you in these groups because some of you have strengths and weaknesses and we bounce ideas off of each other and that's how we learn. (P8)

Teaching techniques. Teaching techniques ranked second highest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, 13 (15%) of the responses were directly or indirectly related to teaching techniques. The theme of teaching techniques includes multiple explanations, manipulatives, step-by-step instruction, challenge questions, math journals, interactive notebooks, conceptual understanding, metacognition, and real-life problem solving. For example, P2 said, "So, one of the things, I just think explaining things as many different ways as you can. We use a lot of manipulatives in first grade and our program has a lot of manipulatives that came with it" (P2).

Growth mindset. Growth mindset ranked third highest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, 11 (13%) of the responses were directly or indirectly related to growth mindset. The theme of growth mindset includes the message to keep trying, make mistakes, focus on Carol Dweck and Jo Boaler's growth mindset, ask for help, have a growth mindset bulletin board, memorize a growth mindset quote of the week, see teachers make mistakes, grow your brain with mistakes, persevere, reward effort, and understand brain blocks. For example, P1 shared,

> My main thing is for them to be able to say that they are struggling and to maybe not do things exactly perfect or correct so that they'll still try, that they'll still keep trying. And my mantra right now this year is, 'What's first grade for? First grade's for making mistakes!' (P1)

Engagement strategies. Engagement strategies also ranked third highest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, 11 (13%) of the responses were directly or indirectly related to engagement strategies. The theme of engagement strategies includes number tricks, whiteboards, number talks, Factwise, dot cards, foldables, thumbs up/thumbs down, finger raising, and brain breaks. For example, P14 explained,

> You know a big thing with math is engagement - you know, engagement strategies. That's kind of the, actually with all of the subjects now, all of the kids are engaged. It's not so much standing up and asking a question and kids are raising their hands, but you know we're doing a lot with whiteboards and things, so, you know, everybody is holding up their whiteboard. (P14)

Multiple strategies to solve a problem. Multiple strategies to solve a problem ranked fourth highest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, nine (11%) of the responses were directly or indirectly related to multiple strategies to solve a problem. The theme of multiple strategies to solve a problem includes multiple problem-solving strategies, drawing pictures to illustrate problems, cognitively-guided instruction, math task cards, open-ended problems, highlighting key words in problems, mental math strategies, number pictures, and incorporating math in spare daily moments. For example, P3 explained, "Teach numerous strategies to solve problems. You can show your students how to use the distributive property to break up numbers and help with mental math" (P3).

Math games and technology. Math games and technology ranked fifth highest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, eight (10%) of the responses were directly or indirectly related to math games and technology. The theme of math games and technology includes videos, Khan Academy, Aleks, technology, online tools, math games, make math fun, and math homework games. For example, P9 stated, "I've read research that says that the games for math are actually highly effective and far more so than just paper/pencil" (P9).

Teacher praise and encouragement. Teacher praise and encouragement ranked sixth highest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, seven (8%) of the responses were directly or indirectly related to teacher praise and encouragement. The theme of teacher praise and encouragement includes reassure students, help students experience success, play a little bit, be excited, be patient, praise effort, give pep talks, know our students, and focus on the teacher/student relationship. For example, P14 said, "I give a lot of pep talks, you know" (P14).

Modifications. Modifications ranked seventh highest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, five (6%) of the responses were directly or indirectly related to modifications. The theme of modifications includes backing up students to a previous familiar concept, providing additional time, modifying assignments, introducing concepts early, having students practice basic skills every day, flipping the classroom, and front loading of information. For example, P13 explained,

> I try to go back to the beginning and where did this start and I truly believe your basic skills, your adding, subtracting, multiplying, dividing is a key defining moment, that if they're struggling with that, no wonder they're struggling with number sense, no wonder they're struggling with ratios because they don't really understand the numbers. So, I force my kids to do basic skills they're supposed to do every day and they have a computerized program. (P13)

Project-based. Project-based ranked eighth highest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, three (4%) of the responses were directly or indirectly related to project-based. The theme of project-based includes project-based assignments, investigations, real life math experiences, hands-on activities, and cooking. For example, P6 shared,

> I feel project-based, embedding the math into something that they can relate to. So, one year for Willy Wonka, using scale and drawings and math, you know, measurements, we came up with scenery for our play so it's like being able to embed the math into their everyday experiences and what they can use. (P6)

Safe environment. Safe environment ranked lowest in frequency for strategies used to reduce math anxiety in students. Of the 84 key words, phrases, viewpoints, or responses to interview question two, two (2%) of the responses were directly or indirectly related to safe environment. The theme of safe environment includes safe environment and privacy folders. For example, P1 said, "My main thing is trying to make it a safe environment for them" (P1).

Summary of research question one. Research question one sought to identify the strategies and practices teachers employ to reduce math anxiety. A total of 18 themes were identified by analyzing key words, phrases, viewpoints, or responses to the two interview questions. Eight of the themes informed how teachers detect math anxiety: shuts down, avoidance, facial expressions, body language, student communicates, frustration, parent reports, and preoccupation with grades. Ten of the themes identified strategies that teacher employ: small instructional groupings, growth mindset, teaching techniques, multiple strategies to solve a problem, engagement strategies, teacher praise and encouragement, math games and technology, modifications, project-based, and safe environment.

Research Question Two

Research question two asked, “What challenges do teachers face in reducing math anxiety?” A total of two interview questions were asked to the participants to provide an answer to research question number two. The two interview questions relating to research question two are as follows:

IQ 3. In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety?

IQ 4. What other challenges have you faced regarding math anxiety?

The responses from all participants were coded and analyzed for common themes that informed the overall response to research question two.

Interview question three. “In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety?” Through the analysis of all responses to interview question three, a total of 23 key words, phrases, or viewpoints were identified as challenges faced in teaching students with math anxiety. The eight common themes that emerged are as follows: (a) student mindset, (b) differentiation, (c) time, (d) exhausted options, (e) parents, (f) bound to curriculum, (g) student behavior, and (h) administration (see Figure 13).

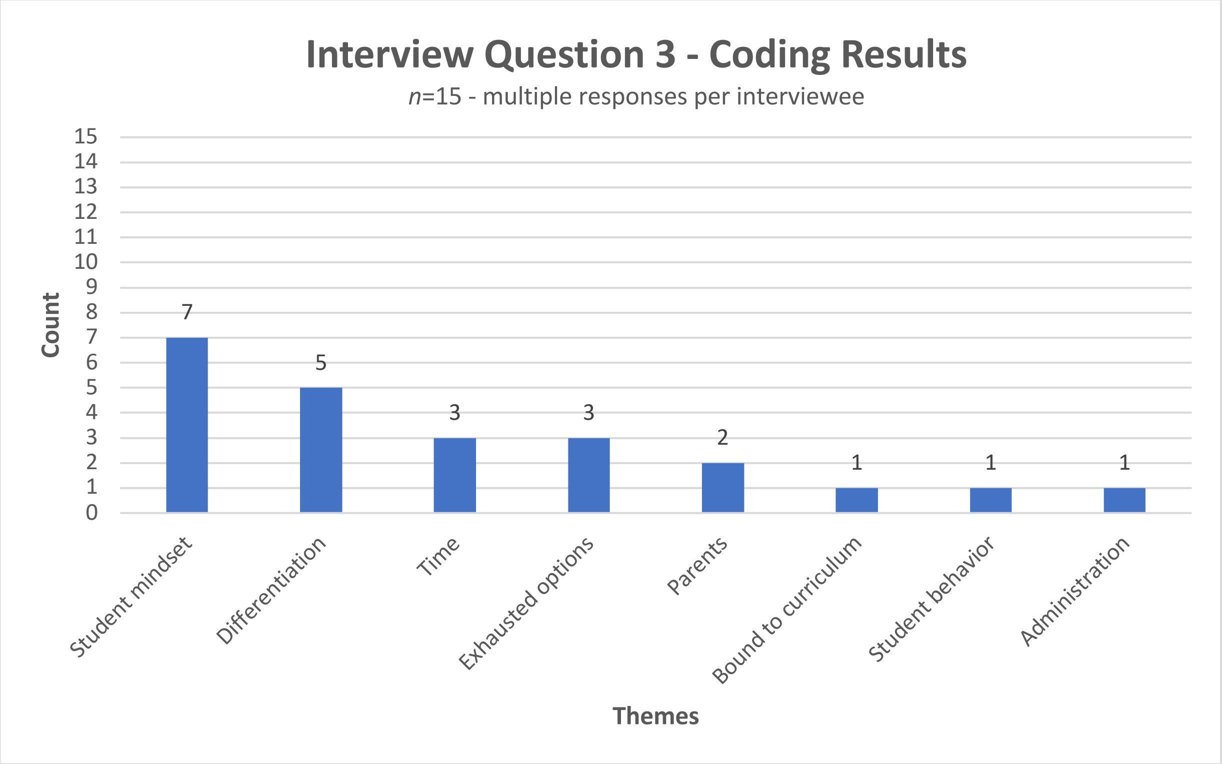


Figure 13. Challenges faced in teaching students with math anxiety. The figure demonstrates the eight themes that emerged from responses to interview question three. Data is presented in decreasing order of frequency. The numbers in each theme indicate the number of times a direct or indirect statement was made by an interview participant that fell into the respective theme category.

Student mindset. Student mindset ranked highest in frequency for challenges faced in teaching students with math anxiety. Of the 23 key words, phrases, viewpoints, or responses to interview question three, seven (30%) of the responses were directly or indirectly related to student mindset. The theme of student mindset includes students who are afraid to make mistakes and take risks, are paralyzed by fear, do not participate, sit back, have a defeatist attitude, do not try, do not take chances, are afraid or embarrassed to ask for help, shut down, lack confidence, and are emotional. For example, P13 shared,

> One of them is the whole mindset. I'm just not good in math. My family is not good in math. Um, the whole mentality of, again if I say I'm - if I'm gonna fail so I'm not gonna bother to try because it's gonna' hurt worse if I'm trying and I fail than if I just say I give up. So, one of the biggest problems is the kids that refuse, and they just won't even try. (P13)

Differentiation. Differentiation ranked second highest in frequency for challenges faced in teaching students with math anxiety. Of the 23 key words, phrases, viewpoints, or responses to interview question three, five (22%) of the responses were directly or indirectly related to differentiation. The theme of differentiation includes different abilities and levels, little knowledge of math facts, differentiating instruction. For example, P12 expressed,

> I think the biggest challenge is, um, especially with any of those strategies is the differentiation within your classroom. You've got kids at different levels and when you're trying to use those strategies and meet kids where they are so that they can always be successful. (P12)

Time. Time ranked third highest in frequency for challenges faced in teaching students with math anxiety. Of the 23 key words, phrases, viewpoints, or responses to interview question three, three (13%) of the responses were directly or indirectly related to time. The theme of time includes not enough time, hard to fit everything in, and finding time for one-on-one help. For example, P9 explained,

> Time. Not enough. I mean really, that's it. I've been feeling guilty because I feel like I should, you know, bring some kids in and tutor them in the mornings, you know, before school. But, you know, it is, it's the time. (P9)

Exhausted options. Exhausted options also ranked third highest in frequency for challenges faced in teaching students with math anxiety. Of the 23 key words, phrases, viewpoints, or responses to interview question three, three (13%) of the responses were directly or indirectly related to exhausted options. The theme of exhausted options includes still not getting it even with small groups, when you've explained it every way possible, and unable to motivate student. For example, P10 said, "And you explain it all the ways that you think you can explain it and they're still not getting it" (P10).

Parents. Parents ranked fourth highest in frequency for challenges faced in teaching students with math anxiety. Of the 23 key words, phrases, viewpoints, or responses to interview question three, two (9%) of the responses were directly or indirectly related to parents. The theme of parents includes parents hyper-focused on test score, parents with a fixed mindset, and parents not supporting children with homework or staying after school. For example, P11 indicated, "So I think that if the parents of my students don't understand growth mindset, it's really hard for me to communicate that to them" (P11).

Bound to curriculum. Bound to curriculum ranked lowest in frequency for challenges faced in teaching students with math anxiety. Of the 23 key words, phrases, viewpoints, or responses to interview question three, one (4%) of the responses was directly or indirectly related to bound to curriculum. The theme of bound to curriculum includes curriculum, district fluency tests, and not much freedom. For example, P7 noted, "I think that sometimes because we are kind of bound to the curriculum and so we do have to teach it, you know they - they basically have to learn it all and they have to perform and there are benchmarks" (P7).

Student behavior. Student behavior also ranked lowest in frequency for challenges faced in teaching students with math anxiety. Of the 23 key words, phrases, viewpoints, or responses to interview question three, one (4%) of the responses was directly or indirectly related to student behavior. The theme of student behavior includes establishing procedures, expectations, and boundaries. For example, P6 noted, "You know, moving around the classroom, you encounter challenges with certain students. So, you know it's just more the management and showing them" (P6).

Administration. Administration also ranked lowest in frequency for challenges faced in teaching students with math anxiety. Of the 23 key words, phrases, viewpoints, or responses to interview question three, one (4%) of the responses was directly or indirectly related to administration. The theme of administration includes arrangement of classes. For example, P13 stated,

> And then another one, I think, is follow through as far as, you know, I hate to say it, but administration within the school, trying to provide the time and trying to put the kids in some sort of assisted class. (P13)

Interview question four. "What other challenges have you faced regarding math anxiety?" Through the analysis of all responses to interview question four, a total of 16 key words, phrases, or viewpoints were identified as other challenges teachers face regarding math anxiety. The eight common themes that emerged are as follows: (a) differentiation, (b) unrealistic standards, (c) student mindset, (d) parents, (e) student behavior, (f) teachers being open-minded, (g) alternative assessments, and (h) time. Five of the themes also emerged in interview question three: differentiation, student mindset, student behavior, parents, and time (see Figure 14).

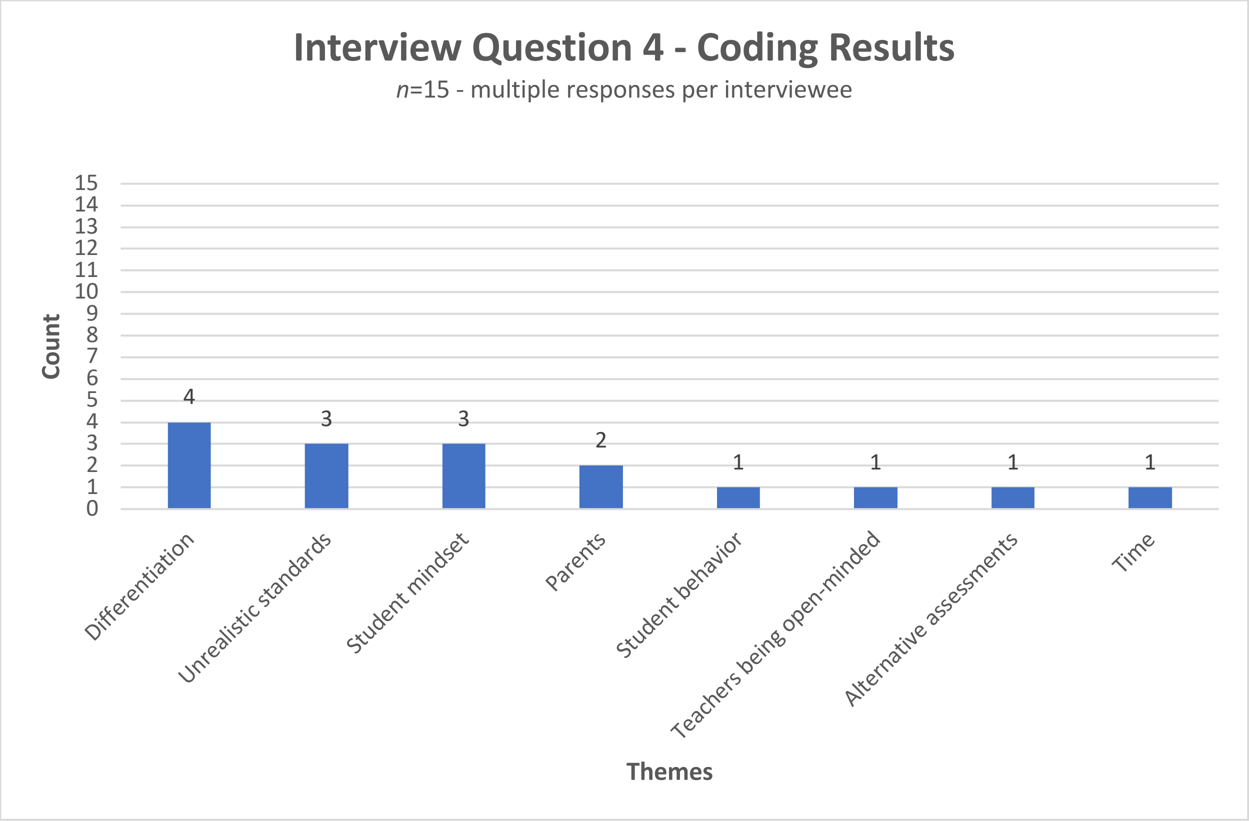


Figure 14. Additional challenges faced in teaching students with math anxiety. The figure demonstrates the eight themes that emerged from responses to interview question four. Data is presented in decreasing order of frequency. The numbers in each theme indicate the number of times a direct or indirect statement was made by an interview participant that fell into the respective theme category.

Differentiation. Differentiation ranked highest in frequency for additional challenges faced in teaching students with math anxiety. Of the 16 key words, phrases, viewpoints, or responses to interview question four, four (25%) of the responses were directly or indirectly related to differentiation. The theme of differentiation includes incorporating additional resources to meet all students' needs and providing different levels of instruction. For example, P3 noted, "You need to incorporate additional resources to meet all students' needs" (P3).

Unrealistic standards. Unrealistic standards ranked second highest in frequency for additional challenges faced in teaching students with math anxiety. Of the 16 key words, phrases, viewpoints, or responses to interview question four, three (19%) of the responses were directly or indirectly related to unrealistic standards. The theme of unrealistic standards includes standards moving to earlier grades and expectations to teach certain standards by grade level. For example, P9 shared,

> I remember probably about 15 years ago Marilyn Burns came out with an assessment, and she said that it was appropriate for fourth grade and above, where she said to write the number 18 and then have 18 objects. Ask the child to count the 18 objects and point out the ones place and say, 'What does this number represent?' So, of course they, you know, count the eight and put them forward. And then you point to the tens and say, 'Show me what this number represents,' and, you know, children that understand value will say, 'The remaining.' The remaining objects are ten. But most, you know, kids that don't understand would just pull the one. She said that was appropriate developmentally when they were about nine. And now, first graders are being expected to understand place value and demonstrate their understanding, not just memorize. (P9)

Student mindset. Student mindset also ranked second highest in frequency for additional challenges faced in teaching students with math anxiety. Of the 16 key words, phrases, viewpoints, or responses to interview question four, three (19%) of the responses were directly or indirectly related to student mindset. The theme of student mindset includes not asking for help, shutting down, and lacking confidence. For example, P5 noted, "I think just having them sort of shut down or be frustrated or just be unwilling to try" (P5).

Parents. Parents ranked third highest in frequency for additional challenges faced in teaching students with math anxiety. Of the 16 key words, phrases, viewpoints, or responses to interview question four, two (13%) of the responses were directly or indirectly related to parents. The theme of parents includes math anxiety continuing at home if parents have math anxiety and parents saying they are not good at math. For example, P8 explained, “Some of that math anxiety comes from when they go home, the parents have that math anxiety” (P8).

Student behavior. Student behavior ranked lowest in frequency for additional challenges faced in teaching students with math anxiety. Of the 16 key words, phrases, viewpoints, or responses to interview question four, one (6%) of the responses was directly or indirectly related to student behavior. The theme of student behavior includes behavior disruptions and challenging behavior. For example, P2 stated, “That was one of the hardest years of my life teaching. You can have one child like that and those behavior disruptions really can impact. We all feel like behavior is really changing. It makes it more challenging” (P2).

Teachers being open-minded. Teachers being open-minded also ranked lowest in frequency for additional challenges faced in teaching students with math anxiety. Of the 16 key words, phrases, viewpoints, or responses to interview question four, one (6%) of the responses was directly or indirectly related to teachers being open-minded. The theme of teachers being open-minded includes teacher attitude and instructional strategies used. For example, P12 shared,

> Some teachers still think, well the kids just gotta do it, they gotta know it. This is what they gotta do. It’s hard to get teachers to understand, no this is something that you’ve gotta work with. This is a real issue and we need to get on top of this. This is what’s keeping them from learning. (P12)

Alternative assessments. Alternative assessments also ranked lowest in frequency for additional challenges faced in teaching students with math anxiety. Of the 16 key words, phrases, viewpoints, or responses to interview question four, one (6%) of the responses was directly or indirectly related to alternative assessments. The theme of alternative assessments includes creating alternative assessments and educating colleagues and parents on the value of alternative assessments. For example, P11 indicated,

> I feel like I am tirelessly like creating exit and entrance tickets and all different things and like the last thing I wanna do is create an alternative form of assessment, which then I have to prove to my team is the same as the book's test. So, I think that is a challenge. (P11)

Time. Time also ranked lowest in frequency for additional challenges faced in teaching students with math anxiety. Of the 16 key words, phrases, viewpoints, or responses to interview question four, one (6%) of the responses was directly or indirectly related to time. The theme of time includes making time to have math rotations with small groups. For example, P7 explained, "You know, it's hard pulling small groups and, you know, working with math rotations like we do in language arts" (P7).

Summary of research question two. Research question two sought to identify the challenges teachers face in reducing math anxiety. A total of 16 themes were identified by analyzing key words, phrases, viewpoints, or responses to the two interview questions. The 16 themes are as follows: student mindset (appearing once in each question), differentiation (appearing once in each question), time (appearing once in each question), parents (appearing once in each question), bound to curriculum, exhausted options, student behavior (appearing once in each question), administration, unrealistic standards, teachers being open-minded, and alternative assessments.

Research Question Three

Research question three asked, "How do teachers measure the success of their practices in reducing math anxiety?" A total of two interview questions were asked to the participants to provide an answer to research question number three. The two interview questions relating to research question three are as follows:

IQ 5. Share some of your success stories in helping students who have math anxiety.

IQ 6. What is your system for measuring and tracking success?

The responses from all participants were coded and analyzed for common themes that informed the overall response to research question three.

Interview question five. "Share some of your success stories in helping students who have math anxiety." Through the analysis of all responses to interview question five, a total of 18 key words, phrases, or viewpoints were identified as success stories in helping students who have math anxiety. The three common themes that emerged are as follows: (a) confidence increases, (b) consistent effort and perseverance, and (c) alternate strategies (see Figure 15).

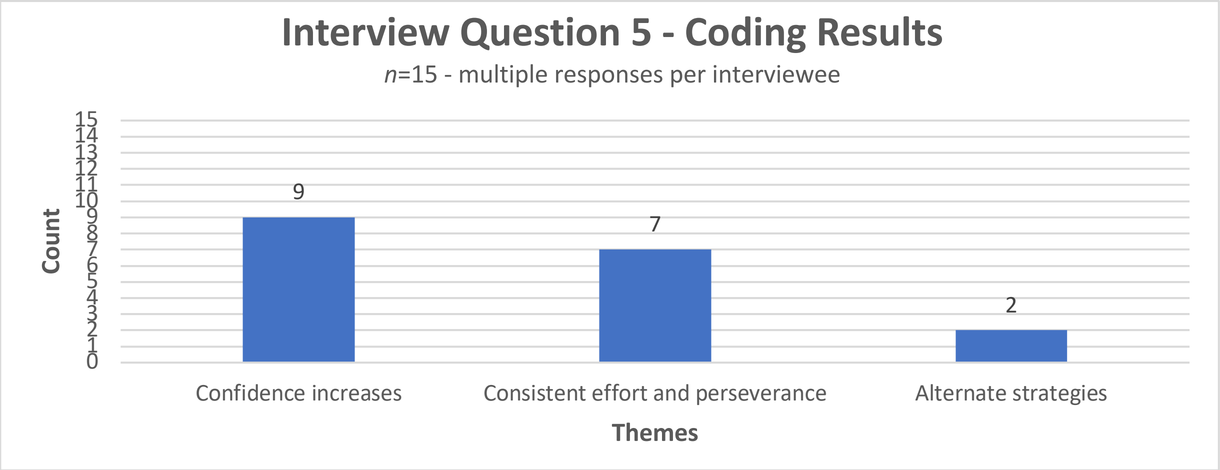


Figure 15. Success stories in helping students who have math anxiety. The figure demonstrates the three themes that emerged from responses to interview question five. Data is presented in decreasing order of frequency. The numbers in each theme indicate the number of times a direct or indirect statement was made by an interview participant that fell into the respective theme category.

Confidence increases. Confidence increases ranked highest in frequency for success stories in helping students who have math anxiety. Of the 18 key words, phrases, viewpoints, or responses to interview question five, nine (50%) of the responses were directly or indirectly related to confidence increases. The theme of confidence increases includes students leading their group, modeling a problem in front of the class, sharing their group's solution with the class, asking questions, having the light bulb go off, and participating. For example, P1, enthusiastically shared,

> This was great last year. I had three students at the beginning of the year who just weren't getting it and half the time they were crying in math. I worked with them in a small group and tried to eliminate the anxiety by pretending that I didn't know what I was doing. 'What do we do? How do we do this together?' Over time, they were starting to lead the group. I was like, and I was like so surprised and blown away because I was depending on this other student to lead the group and this other student asked them, 'Well, do you want to take over today and we can discuss this together. And you can be the one who describes to the class what we're doing.' They were able to do it. I was like, 'Oh, my goodness!' That part was all working out. They were able to not feel stressed, stand up in front of the class and describe what their group came up with as far as what the lesson was going to be about. And I thought, 'Oh man, they got it. It connected! It really connected!' I think I had three students that struggled that did that. (P1)

Consistent effort and perseverance. Consistent effort and perseverance ranked second highest in frequency for success stories in helping students who have math anxiety. Of the 18 key words, phrases, viewpoints, or responses to interview question five, seven (39%) of the responses were directly or indirectly related to consistent effort and perseverance. The theme of consistent effort and perseverance includes students now at grade level as a result of consistency through games, manipulatives, partners, effort, interventions, and after school help. For example, P9 shared,

> I have this one little girls who's in, she's in fourth grade now and her parents are really bright, bright, bright professionals. And, um, you know when they came to the first conference and I said - and they're doctors. So, I said, 'Well I hate to tell you, but your child's really struggling in math.' She had no concept of numbers. I just did all of the strategies and by the end of the year, I mean, she was smiling. She loved math. She wanted to do it, but it was just all of those, you know, manipulatives and never just giving her the numeric representation. (P9)

Alternate strategies. Alternate strategies ranked lowest in frequency for success stories in helping students who have math anxiety. Of the 18 key words, phrases, viewpoints, or responses to interview question five, two (11%) of the responses were directly or indirectly related to alternate strategies. The theme of alternate strategies includes showing knowledge of fractions during a cooking activity and a student with dyscalculia using various strategies to experience success. For example, P12 explained,

> Well, one in particular I can think of, I had a little girl who's probably in college now and actually had math anxiety severe because she had dyscalculia. And she, so any time she knew numbers were coming, she would have anxiety. So, we ended up being able to get her the help she wanted, and we were able to work with her and we found that if we could read the problems to her, she could actually do the mental math better than she could with paper if we could break it

down. And she finally got to the point where she was actually having some pretty good success in math. (P12)

Interview question six. "What is your system for measuring and tracking success?" Through the analysis of all responses to interview question six, a total of 37 key words, phrases, or viewpoints were identified as parts of a system for measuring and tracking success. The five common themes that emerged are as follows: (a) assessments, (b) teacher observation, (c) gradebook, (d) homework, and (e) tracking system (see Figure 16).

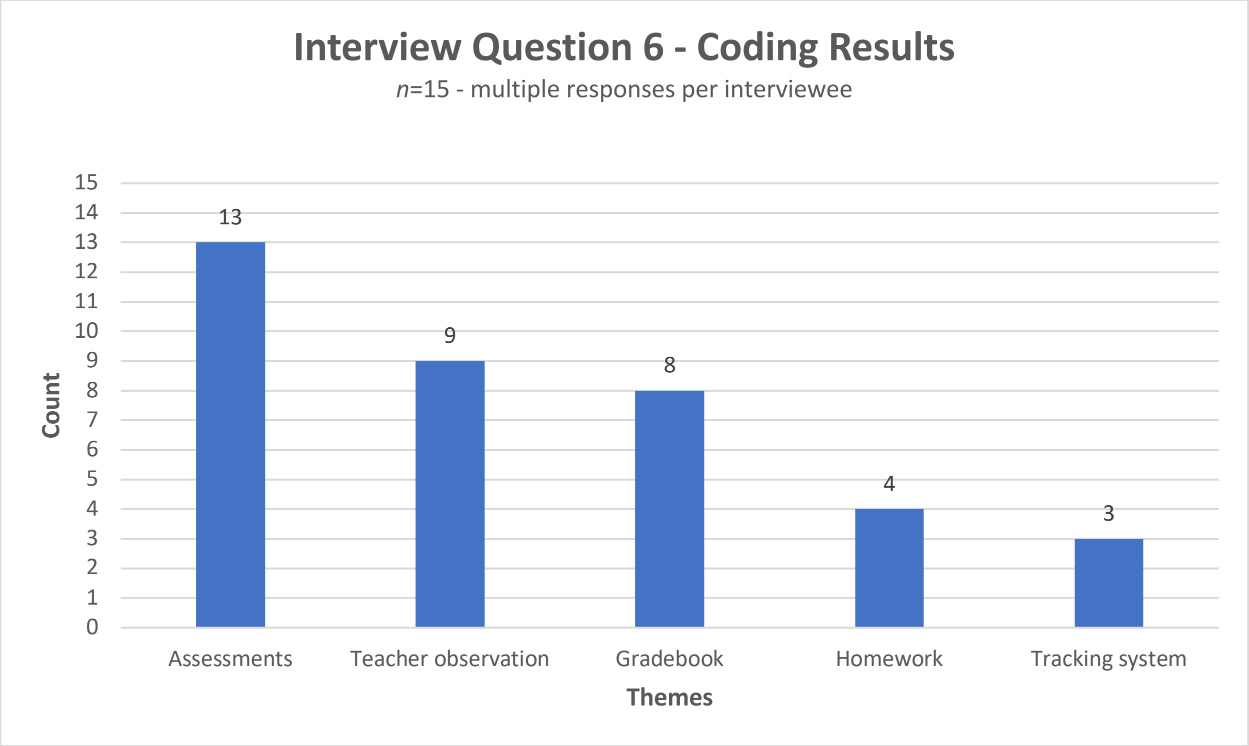


Figure 16. System for measuring and tracking success. The figure demonstrates the five themes that emerged from responses to interview question six. Data is presented in decreasing order of frequency. The numbers in each theme indicate the number of times a direct or indirect statement was made by an interview participant that fell into the respective theme category.

Assessments. Assessments ranked highest in frequency for your system for measuring and tracking success. Of the 37 key words, phrases, viewpoints, or responses to interview question six, 13 (35%) of the responses were directly or indirectly related to assessments. The theme of assessments includes formative, summative, quizzes, tests, whiteboards, exit tickets, benchmarks, anecdotal records, performance tasks, engagement strategies, fluency assessments, and inventories. For example, P15 noted, “So informally would be the whiteboards. I can see boom, boom, look if she doesn't get it. I mean I can just tell and it is from the whiteboards” (P15).

Teacher observation. Teacher observation ranked second highest in frequency for your system for measuring and tracking success. Of the 37 key words, phrases, viewpoints, or responses to interview question six, nine (24%) of the responses were directly or indirectly related to teacher observation. The theme of teacher observation includes observation, checking on students, walking around classroom, and monitoring students. For example, P5 said, “Even in second grade, just observing every single day and seeing where they are and just really being in the mix. Being up and around, seeing what they’re doing” (P5).

Gradebook. Gradebook ranked third highest in frequency for your system for measuring and tracking success. Of the 37 key words, phrases, viewpoints, or responses to interview question six, eight (22%) of the responses were directly or indirectly related to gradebook. The theme of gradebook includes grades and gradebook. For example, P13 indicated, “I keep my gradebook up daily” (P13).

Homework. Homework ranked fourth highest in frequency for your system for measuring and tracking success. Of the 37 key words, phrases, viewpoints, or responses to interview question six, four (11%) of the responses were directly or indirectly related to homework. The theme of homework includes nightly homework, correcting daily work, and importance of effort on daily work. For example, P14 shared,

> Now it’s safe. Kids are allowed to mess up in here. The daily assignments that they’re doing in here, it’s not a grade to me. You know, that’s practice. Even I grade effort. I don’t really let them know this - that it’s really credit/no credit. (P14)

Tracking system. Tracking system ranked lowest in frequency for your system for measuring and tracking success. Of the 37 key words, phrases, viewpoints, or responses to interview question six, three (8%) of the responses were directly or indirectly related to tracking system. The theme of tracking system includes spreadsheets to track each student, students track exit tickets based on standards, and bulletin board keeping track of progress. For example, P6 noted, “I use different measurement tools that you know track what they’re doing and then I do a lot of spreadsheets so that I can see” (P6).

Summary of research question three. Research question three sought to identify how teachers measure the success of their practices in reducing math anxiety. A total of two interview questions were used to inform research question three. A total of eight themes were identified by analyzing key words, phrases, viewpoints, or responses to the two interview questions. The eight themes are as follows: confidence increases, consistent effort and perseverance, alternate strategies, assessments, teacher observation, gradebook, tracking system, and homework.

Research Question Four

Research question four asked, “What recommendations would teachers make for future implementation of strategies in reducing math anxiety?” A total of two interview questions were asked to the participants to provide an answer to research question number four. The two interview questions relating to research question four are as follows:

IQ 7. How do you keep track of your success with students who have math anxiety?

IQ 8. What advice do you have for new teachers who have students with math anxiety? The responses from all participants were coded and analyzed for common themes that informed the overall response to research question four.

Interview question seven. "How do you keep track of your success with students who have math anxiety?" Through the analysis of all responses to interview question seven, a total of 31 key words, phrases, or viewpoints were identified as ways to track success with students who have math anxiety. The seven common themes that emerged are as follows: (a) assessments, (b) observation, (c) small instructional groupings, (d) analysis, (e) closely monitor and check-in, (f) communicate with parents, and (g) preview tests and performance tasks (see Figure 17).

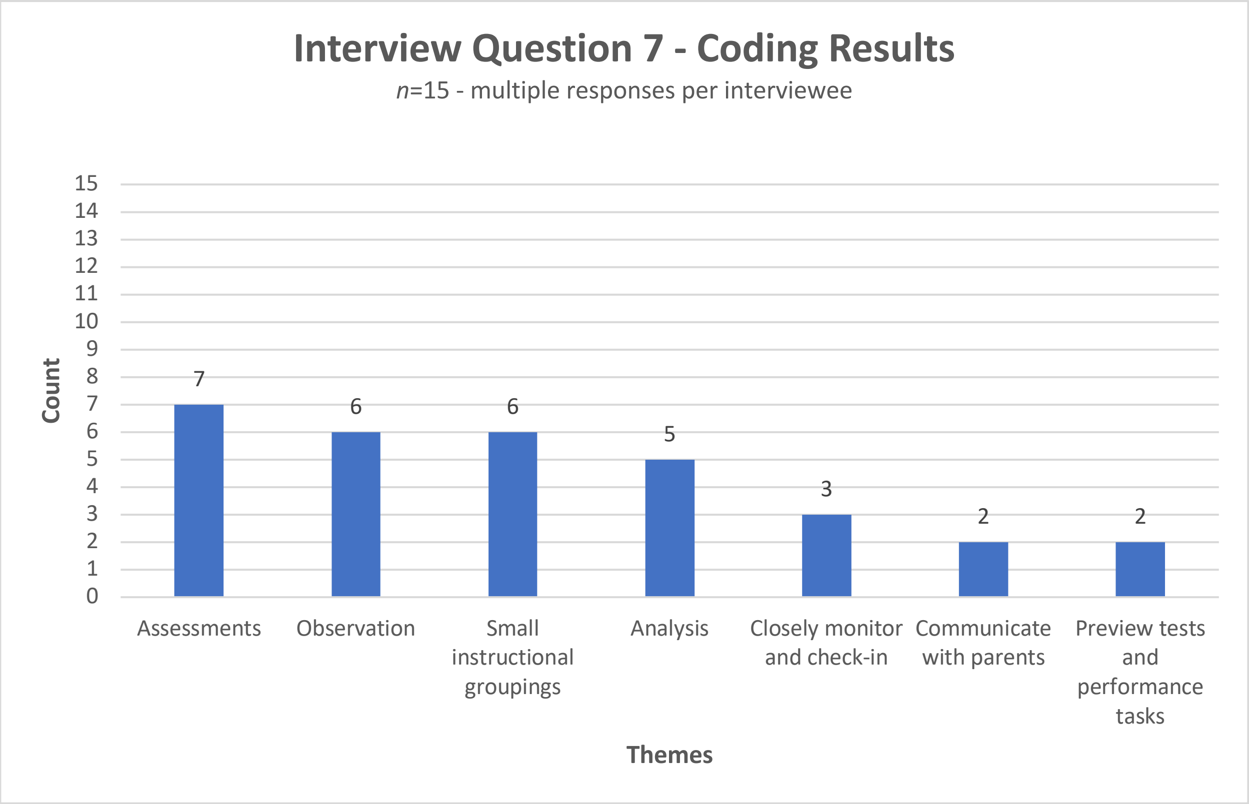


Figure 17. Keeping track of success with students who have math anxiety. The figure demonstrates the seven themes that emerged from responses to interview question seven. Data is presented in decreasing order of frequency. The numbers in each theme indicate the number of times a direct or indirect statement was made by an interview participant that fell into the respective theme category.

Assessments. Assessments ranked highest in frequency for keeping track of success with students who have math anxiety. Of the 31 key words, phrases, viewpoints, or responses to interview question seven, seven (23%) of the responses were directly or indirectly related to assessments. The theme of assessments includes writing notes, keeping anecdotal records, checking for understanding using whiteboards, reading math journals, and ongoing timed tests. For example, P13 explained,

> I think it's more just like anecdotal or just kind of thinking about it. Yeah, I have a page for each kid in my planning book and I just stick Post-it notes on there so when the time comes that I have to give information on them, I have all of this information to give. (P13)

Observation. Observation ranked second highest in frequency for keeping track of success with students who have math anxiety. Of the 31 key words, phrases, viewpoints, or responses to interview question seven, six (19%) of the responses were directly or indirectly related to observation. The theme of observation includes observation and mental notes. For example, P3 explained, "Observing in first grade is key. Being out there when they're working, you can automatically check on your students who have math anxiety and see who's struggling and who's stuck and who needs that support" (P2).

Small instructional groupings. Small instructional groupings also ranked second highest in frequency for keeping track of success with students who have math anxiety. Of the 31 key words, phrases, viewpoints, or responses to interview question seven, six (19%) of the responses were directly or indirectly related to small instructional groupings. The theme of small instructional groupings includes one-on-one, small groups, and after school practice. For example, P4 shared,

> So, during that math computer game time on Fridays, I can then pull kids that I've noticed that have struggled. And again, tracking. It's basically what I've done through the week and maybe I have those papers here and I've pulled kids aside. So that's my system as far as meeting those needs of those kids that are struggling with math anxiety. (P4)

Analysis. Analysis ranked third highest in frequency for keeping track of success with students who have math anxiety. Of the 31 key words, phrases, viewpoints, or responses to interview question seven, five (16%) of the responses were directly or indirectly related to analysis. The theme of analysis includes analyzing data, documenting when pull kids, keeping track of different strategies, and looking at data from tests. For example, P7 explained, "You're inputting data constantly. You're constantly looking a pie charts and you're looking at, you know, individual students in sub groups and so you know. I mean, you're evaluating yourself constantly" (P7).

Closely monitor and check-in. Closely monitor and check-in ranked fourth highest in frequency for keeping track of success with students who have math anxiety. Of the 31 key words, phrases, viewpoints, or responses to interview question seven, three (10%) of the responses were directly or indirectly related to closely monitor and check-in. The theme of closely monitor and check-in includes paying attention to what kids need and checking in daily with students. For example, P8 noted, "Just checking in. I mean, you, you'll know who the kids are" (P8).

Communicate with parents. Communicate with parents ranked lowest in frequency for keeping track of success with students who have math anxiety. Of the 31 key words, phrases, viewpoints, or responses to interview question seven, two (6%) of the responses were directly or indirectly related to communication with parents. The theme of communicate with parents includes meeting with parents and communicating with them. For example, P10 shared, “You know, like meeting with parents and talking to them about if whether or not they can help at home and documenting” (P10).

Preview tests and performance tasks. Preview tests and performance tasks also ranked lowest in frequency for keeping track of success with students who have math anxiety. Of the 31 key words, phrases, viewpoints, or responses to interview question seven, two (6%) of the responses were directly or indirectly related to preview tests and performance tasks. The theme of preview tests and performance tasks includes giving practice tests and previewing problem-solving tasks. For example, P12 shared,

> And we’re definitely pushing in, and like, if we’re going to be doing a performance task or a problem-solving task, we might give them one that’s similar in the morning and walk them through it as a group so that when they have the real assessment, we can actually get a true measure of how well they’re gonna do because then they don’t feel - at least they’ve had some exposure. (P12)

Interview question eight. “What advice do you have for new teachers who have students with math anxiety?” Through the analysis of all responses to interview question eight, a total of 56 key words, phrases, or viewpoints were identified as advice for new teachers who have students with math anxiety. The 12 common themes that emerged are as follows: (a) incorporate multiple strategies, (b) know your students, (c) be your student’s biggest cheerleader, (d) be flexible with curriculum and pacing guide, (e) create safe environment, (f) observe while keeping anecdotal records, (g) model and instill growth mindset, (h) differentiate instruction, (i) work with students in smaller settings, (j) reflect on own teaching practices, (k) collaborate with other teachers, and (l) learn about the school culture. Two of the themes also emerged in interview question seven: observe and work with students in smaller settings (see Figure 18).

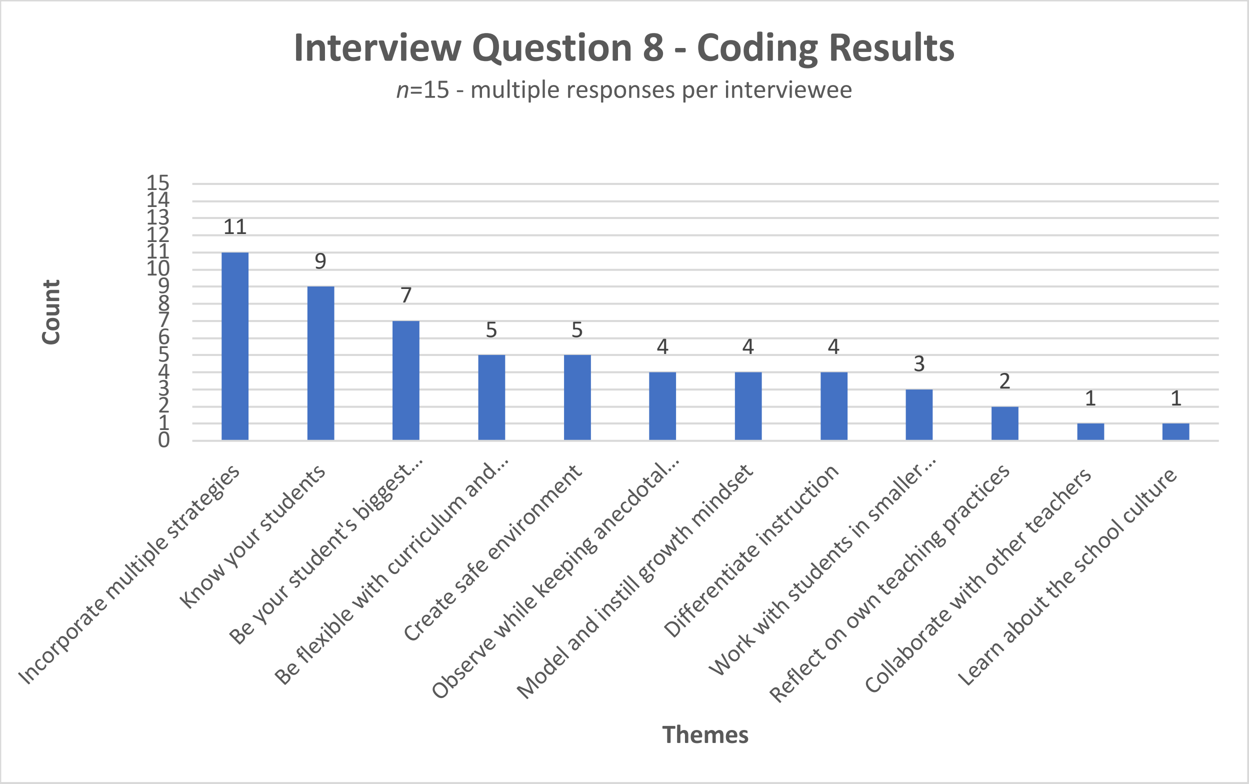


Figure 18. Advice for new teachers who have students with math anxiety. The figure demonstrates the 12 themes that emerged from responses to interview question eight. Data is presented in decreasing order of frequency. The numbers in each theme indicate the number of times a direct or indirect statement was made by an interview participant that fell into the respective theme category.

Incorporate multiple strategies. Incorporate multiple strategies ranked highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, 11 (20%) of the responses were directly or indirectly related to incorporate multiple strategies. The theme of incorporate multiple strategies includes games, manipulatives, math tricks, number patterns, different methods, seating strategies, whiteboards, engagement strategies, and different teaching techniques. For example, P9 stated, “Use the strategies that - that- that make math fun” (P9).

Know your students. Know your students ranked second highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, nine (16%) of the responses were directly or indirectly related to know your students. The theme of know your students includes collect information on students, relationship is key, find out their passion, know your kids, find out what motivates each child, don't label kids, and don't make assumptions. For example, P6 explained, "Bottom line is get to know your students. Get to know them really, really well. Find out what everyone brings to your classroom and find out what their passion is" (P6).

Be your student's biggest cheerleader. Be your student's biggest cheerleader ranked third highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, seven (13%) of the responses were directly or indirectly related to be your student's biggest cheerleader. The theme of be your student's biggest cheerleader includes reminding students of other successes they've experienced, letting students know how smart they are, having pep talks, being encouraging, catching them putting forth effort, and praising little successes and strengths. For example, P15, noted, "Let them know you're there for them. Let them know it's okay that they're anxious, and just find ways to help them learn" (P15).

Be flexible with curriculum and pacing guide. Be flexible with curriculum and packing guide ranked fourth highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, five (9%) of the responses were directly or indirectly related to be flexible with curriculum and pacing guide. The theme of be flexible with curriculum and pacing guide includes sometimes abandon the lesson plan, do not be so tied to curriculum calendar, be flexible, and do not be afraid to teach a student with material that is below grade level. For example, P9 said, "Don't move on just because the book says move to the next page tomorrow. You have to make sure that you have understanding and you're not gonna get it with every one of them" (P9).

Create safe environment. Create safe environment also ranked fourth highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, five (9%) of the responses were directly or indirectly related to create safe environment. The theme of create safe environment includes pray, safe to take risks, have patience, and allow students time. For example, P4 noted, "I think that relationship is so important with the kids and creating that environment where it's okay to take risks and you need to ask those questions because you are still learning" (P4).

Observe while keeping anecdotal records. Observe while keeping anecdotal records ranked fifth highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, four (7%) of the responses were directly or indirectly related to observe while keeping anecdotal records. The theme of observe while keeping anecdotal records includes observe, watch facial expressions, watch body language, focus on the why, stay in the trenches, stay away from your desk, keep anecdotals. For example, P1 explained, "The best thing is the observing, watching facial expressions, maybe body language, but mainly walking and standing by students" (P1).

Model and instill growth mindset. Model and instill growth mindset also ranked fifth highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, four (7%) of the responses were directly or indirectly related to model and instill growth mindset. The theme of model and instill growth mindset includes having a positive attitude toward every student and subject, getting parents to believe their kids can succeed, taking a positive approach to math, believing in students, constantly highlighting effort, encouraging mistakes, and using the word yet. For example, P14 shared,

> You know, just to encourage the effort and to be patient, you know, encourage them to be patient. I love the word yet, you know. You don't get it yet. You know, you'll get it. You know, and just let them know it's okay to struggle and that struggle becomes a good thing. (P14)

Differentiate instruction. Differentiate instruction also ranked fifth highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, four (7%) of the responses were directly or indirectly related to differentiate instruction. The theme of differentiate instruction includes varying groups, differentiate in chunks, and eventually differentiate each rotation. For example, P9 explained, "As a new teacher, don't overdo trying to differentiate your instruction completely. You have to take it in chunks" (P9).

Work with students in smaller settings. Work with students in smaller settings ranked sixth highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, three (5%) of the responses were directly or indirectly related to work with students in smaller settings. The theme of work with students in smaller settings includes working one-on-one, helping after school, and pulling kids individually. For example, P15 shared,

> Whether it's you sit with them and help them do white board if you can, I mean, helping after school I know is - a lot of teacher don't do that, but if you can, you know, go ahead and do that. (P15)

Reflect on own teaching practices. Reflect on own teaching practices ranked seventh highest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, two (4%) of the responses were directly or indirectly related to reflect on own teaching practices. The theme of reflect on own teaching practices includes analyze and reflect on your lessons. For example, P1 shared,

> Specifically to math, I would say, okay, watch the lesson, watch it go with the flow of the students, and then sometimes it bombs. You have to analyze what did I do to not get it through to the kids and what am I going to do better next time. I'm going to analyze and find a different way to do the lesson so that more students get it. How come it didn't work with this student and it did with this one. Things like that. (P1)

Collaborate with other teachers. Collaborate with other teachers ranked lowest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, one (2%) of the responses was directly or indirectly related to collaborate with other teachers. The theme of collaborate with other teachers includes talking to teachers for support and connecting with online teacher communities. For example, P2 advised,

> And then, talking to other teachers, definitely. Oh my gosh, if I didn't have these partners, I don't know what I would do. Um, you need a great support for all your

> academic areas and just like when you're frustrated or have a child who's really frustrated or anxious, talking to other people makes a huge difference because we were just talking about something in the lounge today, and everybody was talking about, and it was my thing and everybody was talking about it, and they all told me things I had not thought of. I was like, 'Wow! I had this whole other spin on this and you guys are alright.' Yeah, having that support is really important. (P2)

Learn about the school culture. Learn about the school culture also ranked lowest in frequency for advice for new teachers who have students with math anxiety. Of the 56 key words, phrases, viewpoints, or responses to interview question eight, one (2%) of the responses was directly or indirectly related to learn about the school culture. The theme of learn about the school culture includes learning about the parent population. For example, P11 noted,

> Yeah, I, um...especially for my school, it would have been nice to know a little bit more about the parent population because I felt like at the beginning of the year I was kind of like attacked. That this is not how math is taught; this is not the right way to do things. (P11)

Summary of research question four. Research question four sought to identify what recommendations teachers would make for future implementation of strategies in reducing math anxiety. A total of 19 themes were identified by analyzing key words, phrases, viewpoints, or responses to the two interview questions. The 19 themes are as follows: assessments, observation (appearing once in each question), small instructional groupings (appearing once in each question), analysis, closely monitor and check-in, communicate with parents, preview tests and performance tasks, incorporate multiple strategies, know your students, be your student's biggest cheerleader, model and instill growth mindset, be flexible with curriculum and pacing guide, differentiate instruction, create safe environment, collaborate with other teachers, reflect on own teaching practices, and learn about the school culture.

Summary

The purpose of this study was to determine the best practices and strategies teachers employ to reduce math anxiety, the challenges teachers face in reducing math anxiety, how teachers measure their success in reducing math anxiety, and recommendations teachers would make for future implementation of strategies in reducing math anxiety. To fulfill this purpose, 15 first through sixth grade teachers were recruited to participate in the research. All participants were asked eight semi-structured interview questions that were developed to inform the following four research questions:

1. What strategies and practices do teachers employ to reduce math anxiety?
2. What challenges do teachers face in reducing math anxiety?
3. How do teachers measure the success of their practices in reducing math anxiety?
4. What recommendations would teachers make for future implementation of strategies in reducing math anxiety?

Data were collected from 15 semi-structured interviews. The researcher coded the data and validated the results using two inter-rater Pepperdine doctoral candidates. Data analysis produced 61 themes. Table 9 displays all 61 themes and how they relate to each research question. Chapter 5 presents a summary of the study, an account of the findings, implications for the study, and recommendations for further research.

Table 9

Summary of Themes for Four Research Questions

RQ1 – Strategies and Practices	RQ2 – Challenges	RQ3 – Measurements of Success	RQ4 - Recommendations
Shuts down	Student mindset (x2)	Confidence increases	Assessments
Avoidance	Differentiation (x2)	Consistent effort and perseverance	Observe while keeping anecdotal records (x2)
Facial expressions	Time (x2)	Alternate strategies	Small instructional groupings (x2)
Body language	Parents (x2)	Assessments	Analysis
Student communicates	Bound to curriculum	Teacher observation	Closely monitor and check-in
Frustration	Exhausted options	Gradebook	Communicate with parents
Parent reports	Student behavior (x2)	Tracking system	Preview tests and performance tasks
Preoccupation with grades	Administration	Homework	Incorporate multiple strategies
Small instructional groupings	Unrealistic standards		Know your students
Growth mindset	Teachers being open-minded		Be your student's biggest cheerleader
Teaching techniques	Alternative assessments		Model and instill growth mindset
Multiple strategies to solve a problem			Be flexible with curriculum and pacing guide
Engagement strategies			Differentiate instruction
Teacher praise and encouragement			Create safe environment
Math games and technology			Collaborate with other teachers
Modifications			Reflect on own teaching practices
Project-based			Learn about the school culture
Safe environment			

Note: This table demonstrates a summary of all the themes derived through the data analysis process.

Chapter 5: Conclusions and Recommendations

Introduction

Proficiency in STEM education develops a STEM literate society, which is needed to compete in today's global economy (Bybee, 2013; U.S. Department of Education, 2017). Mathematical competence is certainly necessary to achieve success in STEM education fields; however, achieving competence is often hindered by math anxiety, which is shared by both adults and children (Blazer, 2011; Furner & Duffy, 2002). The purpose of this study was to determine the best practices teachers employ to reduce math anxiety and the challenges teachers face in reducing math anxiety. The teachers that participated in this study had various years of teaching experience and all shared that math anxiety is a real phenomenon shared by several of their students. Their willingness to share their knowledge and experience provided rich data that gives insight into reducing math anxiety in elementary students.

This study contributes to the existing literature on math anxiety by enhancing an understanding of strategies and best practices used to reduce math anxiety and the challenges that teachers face in reducing math anxiety. In addition, it provides key insights for teachers to implement strategies to reduce math anxiety in the future. This chapter outlines a summary of the study, discussion of the research findings, implications of the study, teacher and parent recommendations, and recommendations for future research.

Summary of the Study

This qualitative, phenomenological study investigated the best strategies and practices incorporated and challenges faced by teachers in reducing math anxiety. The following four research questions were addressed as part of this study.

Research Question 1: What strategies and practices do teachers employ to reduce math anxiety?

Research Question 2: What challenges do teachers face in reducing math anxiety?

Research Question 3: How do teachers measure the success of their practices in reducing math anxiety?

Research Question 4: What recommendations would teachers make for future implementation of strategies in reducing math anxiety?

Eight interview questions were developed that directly informed a specific research question. The interview questions were confirmed through a three-step validity process, and reliability was established by conducting two pilot interviews.

Participants for this study were identified through the XYZ Unified School District website and were first through sixth grade elementary teachers with a California teaching credential. The master list was tailored based on inclusion criteria of possessing a Multiple Subject Teaching Credential for five or more years, possessing a Cross-cultural, Language, and Academic Development Certificate, and having at least three years of teaching experience. The exclusion criteria applied were regarding availability to interview and audio recording. Maximum variation of gender, grade level, and school location was then applied. Ultimately, invitations were sent to 46 teachers and 15 agreed to participate. Of the 15 participants, 13 were female and two were male. The participants had a combined teaching experience of 312 years, ranging from three to 42 years with an average of 20.8 years.

Data were collected through semi-structured interviews, 14 of which were conducted in-person and one was conducted via telephone. The interviews were transcribed, and the principal researcher completed all of the coding and identified major themes (see Table 10). The data analysis was subsequently validated through an inter-rater review process with two fellow doctoral students from Pepperdine University.

Table 10

Summary of Themes for Four Research Questions with Related Theories

RQ1 – Strategies and Practices		RQ2 – Challenges		RQ3 – Measurements of Success		RQ4 – Recommendations	
Themes	*Theory/ Research*	*Themes*	*Theory/ Research*	*Themes*	*Theory/ Research*	*Themes*	*Theory/ Research*
Shuts down	Behavioral factors of math anxiety (Blazer, 2011; Jain & Dowson, 2009)	Student mindset	Growth Mindset (Dweck, 2008; Boaler, 2016) Self-Efficacy (Bandura, 1986)	Confidence increases	Efficacy to succeed in math (Ashcraft, 2002)	Assessments	Variety of assessments (Blazer, 2011; Woodard, 2004)
Avoidance	Debilitating Anxiety Model (Carey et al., 2016) Avoidance (Hembree, 1990)	Differentiation	Vary instruction (Blazer, 2011)	Consistent effort and perseverance	Brains grow with effort and when mistakes are made (Moser et al., 2011)	Observe while keeping anecdotal records	Observation (Woodard, 2004)
Facial expressions	Physiological symptoms of math anxiety (Kirkland, 2016)	Time		Alternate strategies	Vary instruction (Blazer, 2011)	Small instructional groupings	Cooperative learning groups (Blazer, 2011)
Body language	Physiological symptoms of math anxiety (Kirkland, 2016)	Parents	Parent's math anxiety affects children (Maloney et al., 2015; Soni & Kumari, 2017)	Assessments	Variety of assessments (Blazer, 2011; Woodard, 2004)	Analysis	Observation (Woodard, 2004)
Student communicates	Math anxiety (Ramirez et al., 2016)	Bound to curriculum		Teacher observation	Observation (Woodard, 2004)	Closely monitor and check-in	Observation (Woodard, 2004)
Frustration	Behavioral factors of math anxiety (Blazer, 2011; Jain & Dowson, 2009)	Exhausted options		Gradebook		Communicate with parents	Teachers and schools communicate (Maloney & Beilock, 2012)
Parent reports	Environmental/ social factors of math anxiety (Casad et al., 2015)	Student behavior	Behavior during math task (Ashcraft & Faust, 1994)	Tracking system		Preview tests and performance tasks	Performance tasks (Woodard, 2004)

(continued)

RQ1 – Strategies and Practices		RQ2 – Challenges		RQ3 – Measurements of Success		RQ4 – Recommendations	
Themes	*Theory/ Research*	*Themes*	*Theory/ Research*	*Themes*	*Theory/ Research*	*Themes*	*Theory/ Research*
Preoccupation with grades		Administration	Interventions (Soni & Kumari, 2017)	Homework		Incorporate multiple strategies	Vary instruction (Blazer, 2011)
Small instructional groupings	Cooperative learning groups (Blazer, 2011)	Unrealistic standards	Unrealistic expectations increase math anxiety (Blazer, 2011)			Know your students	Respect all learning styles (Geist, 2010)
Growth mindset	Growth Mindset (Dweck, 2008; Boaler, 2016) Self-Efficacy (Bandura, 1986)	Teachers being open-minded	Teacher's view contributes to students (Sparks, 2015)			Be your student's biggest cheerleader	Process praise (Dweck, 2008)
Teaching techniques	Active Learning (Blazer, 2011)	Alternative assessments	Variety of assessments (Blazer, 2011; Woodard, 2004)			Model and instill growth mindset	Growth Mindset (Dweck, 2008; Boaler, 2016) Self-Efficacy (Bandura, 1986)
Multiple strategies to solve a problem	Multiple teaching approaches (Gresham, 2007)					Be flexible with curriculum and pacing guide	
Engagement strategies	Multiple teaching approaches (Gresham, 2007)					Differentiate instruction	Vary instruction (Blazer, 2011)
Teacher praise and encouragement	Encouragement (Blazer, 2011)					Create safe environment	Safe, inviting classroom (Gresham, 2007)
Math games and technology	Vary instruction (Blazer, 2011)					Collaborate with other teachers	
Modifications	Vary instruction (Blazer, 2011)					Reflect on own teaching practices	Reflective notebooks (Salinas, 2004)
Project-based	Active Learning (Blazer, 2011)					Learn about the school culture	
Safe environment	Classroom be safe, inviting place (Gresham, 2007)						

Note: This table is a summary of all the themes derived through the data analysis process and how they relate to research.

Summary of Findings

The findings of this study are intended to identify the best practices teachers employ and challenges teachers face when reducing math anxiety. All 15 participants agreed that math anxiety exists in elementary-aged students, and they acknowledged that they have all taught students who experience math anxiety. As an icebreaker, the researcher asked the participants how they define math anxiety. Overall, the participants believed math anxiety is frustration, fear of math, and shutting down when confronted with a math problem. For all eight semi-structured interview questions, the participant responses provided rich, genuine data. The data analysis yielded 61 major themes, seven of which were duplicated in both interview questions for the corresponding research question. This section provides a summary of general findings and the subsequent section will present the key findings in detail by research question.

One overarching theme woven throughout most of the 61 themes is the importance of knowing your students. Teachers need to know how their students learn, what motivates them, how they communicate, what they like, what they dislike, and what their passion is. The teacher-student relationship is important and contributes to success. All 15 participants discussed the importance of knowing their students. By knowing their students, the teachers are able to successfully incorporate best practices such as partner and small groups, modifications, and teaching techniques. Knowing your students is also helpful in addressing and possibly overcoming challenges.

A second theme that resonated across all four of the research questions was mindset. Indeed, mindset was mentioned 62 times and is considered a best practice as well as a challenge. Multiple participants shared growth mindset as a best practice. The teacher participants mentioned having a growth mindset bulletin board in their classrooms, reading aloud growth mindset picture books, using growth mindset vocabulary, encouraging mistakes, making their own mistakes, sharing growth mindset with parents, and having a weekly growth mindset quote. Participants shared that their students who have a growth mindset perform better in class and persevere longer with challenging math problems. At the same time, participants shared that student and parent mindset is a challenge. When students have a fixed mindset, the participants see those students struggling in math. Some students are too afraid of making a mistake, and others believe they cannot perform well in math. One participant shared a story of a parent saying he did not have the math gene. The teacher felt like she promoted growth mindset in her classroom, but the student went home to a fixed mindset and to a parent with math anxiety (see Figure 19).

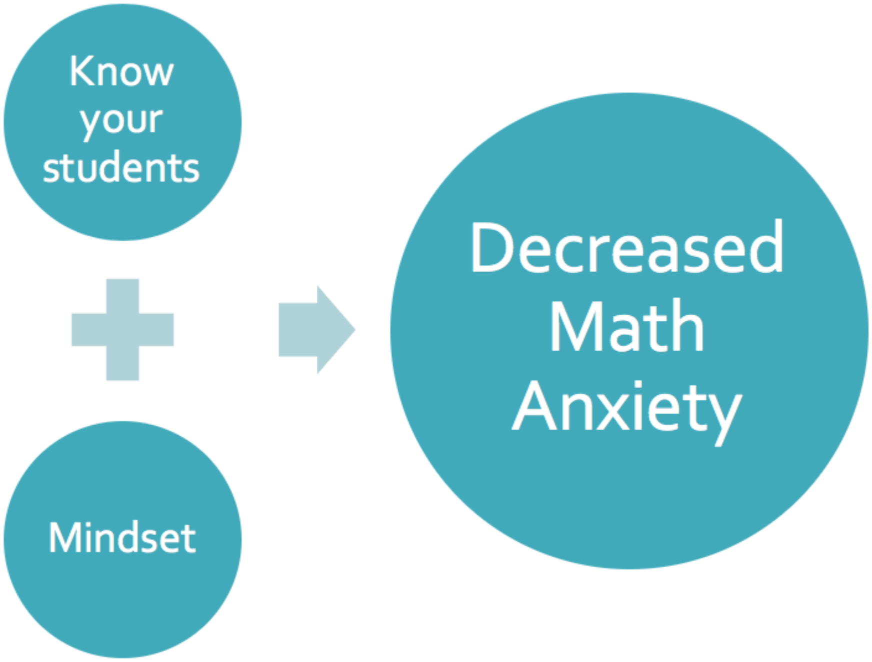


Figure 19. Two overall themes to decrease math anxiety. The figure demonstrates the two overall themes that emerged from all interview questions. Know your students are mindset are believed to decrease math anxiety.

Discussion of Key Findings

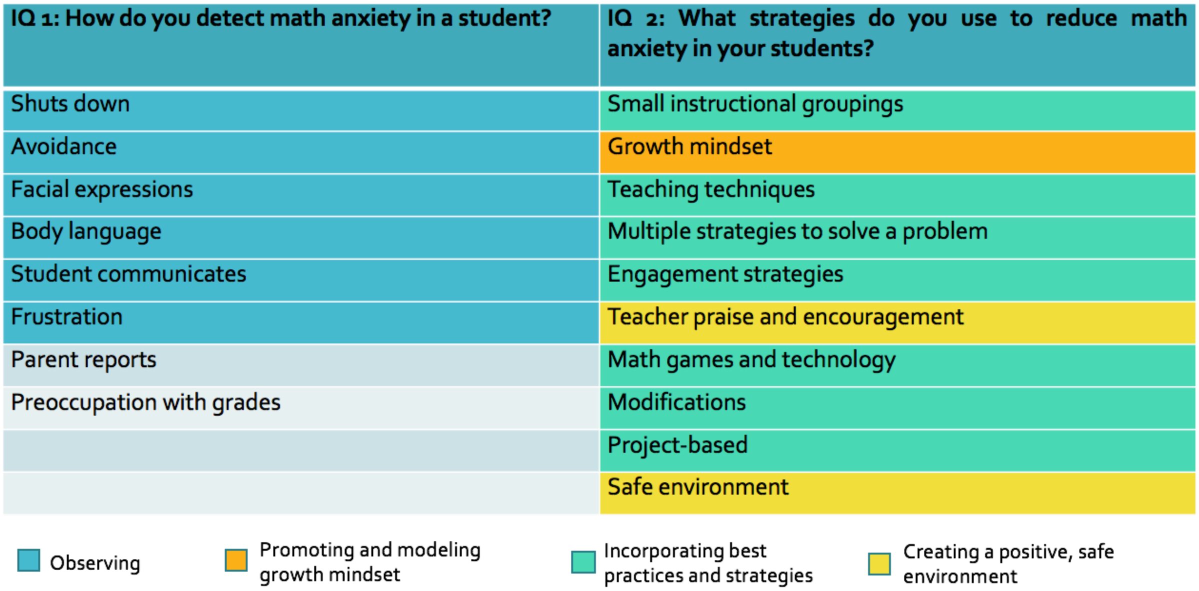
The following section provides a more in-depth discussion of the themes that were derived from the interview questions and relate to each research question.

Results for research question one. Research question one asked, "What strategies and practices do teachers employ to reduce math anxiety?" An analysis of the themes obtained from the interview questions indicate that the key strategies and practices employed by teachers to reduce math anxiety center around the following four areas (see Table 11):

- The amount of time a teacher spends observing her students.
- Incorporating a variety of teaching techniques, methods, and strategies.
- Promoting and modeling growth mindset in the classroom.
- Creating a positive, safe environment.

Table 11

Key Findings for Research Question One



IQ 1: How do you detect math anxiety in a student?	IQ 2: What strategies do you use to reduce math anxiety in your students?
Shuts down	Small instructional groupings
Avoidance	Growth mindset
Facial expressions	Teaching techniques
Body language	Multiple strategies to solve a problem
Student communicates	Engagement strategies
Frustration	Teacher praise and encouragement
Parent reports	Math games and technology
Preoccupation with grades	Modifications
	Project-based
	Safe environment

🟦 Observing

🟧 Promoting and modeling growth mindset

🟩 Incorporating best practices and strategies

🟨 Creating a positive, safe environment

Discussion of research question one. The key findings of research question one indicate the amount of time a teacher spends observing her students is directly related to how well she knows her students and knows if they have math anxiety. The better she knows her students, the better prepared she is to incorporate the best practices and strategies and reduce math anxiety. Participants shared multiple best practices and strategies to reduce math anxiety as explained in chapter four, including teaching for conceptual understanding. Blazer (2011) explains that conceptual understanding is critical. Students need to understand a mathematical concept instead of relying solely on memory.

Another key finding is promoting and modeling growth mindset. Participants shared how they teach their students about growth mindset through books, bulletin boards, quotes, and songs. The teachers emphasize effort and praise effort rather than results. Nine participants specifically shared how they purposefully make mistakes when they are modeling math problems on the board. They want their students to understand mistakes are part of learning and that brains grow when mistakes are made (Moser, Schroder, Heeter, Moran, & Lee, 2011). Participants believe growth mindset has such significance, especially in the area of math, that they spend class time teaching it (Boaler, 2013a; Dweck, 2008).

A final key finding is creating a positive, safe environment. Participants shared that a positive environment filled with praise encourages growth mindset as explained above. In addition, when students feel safe, they are more likely to ask questions, talk to their peers and in their small groups, and participate in engagement strategies. Participants shared how their classrooms are not quiet places anymore. They are filled with movement, rotations, math games, constructive talking, academic language, manipulatives, and technology (see Figure 20).

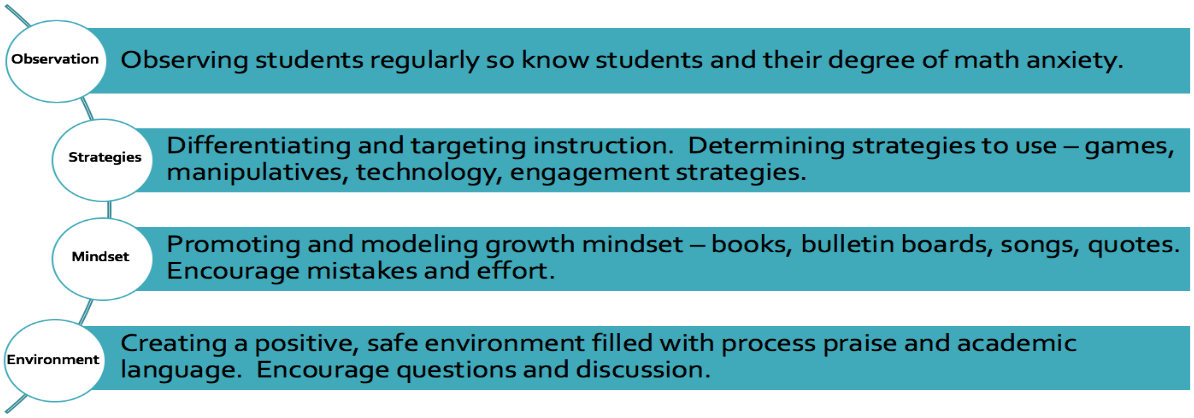


Figure 20. Key findings from research question one. The figure demonstrates the overall themes that emerged from research question one.

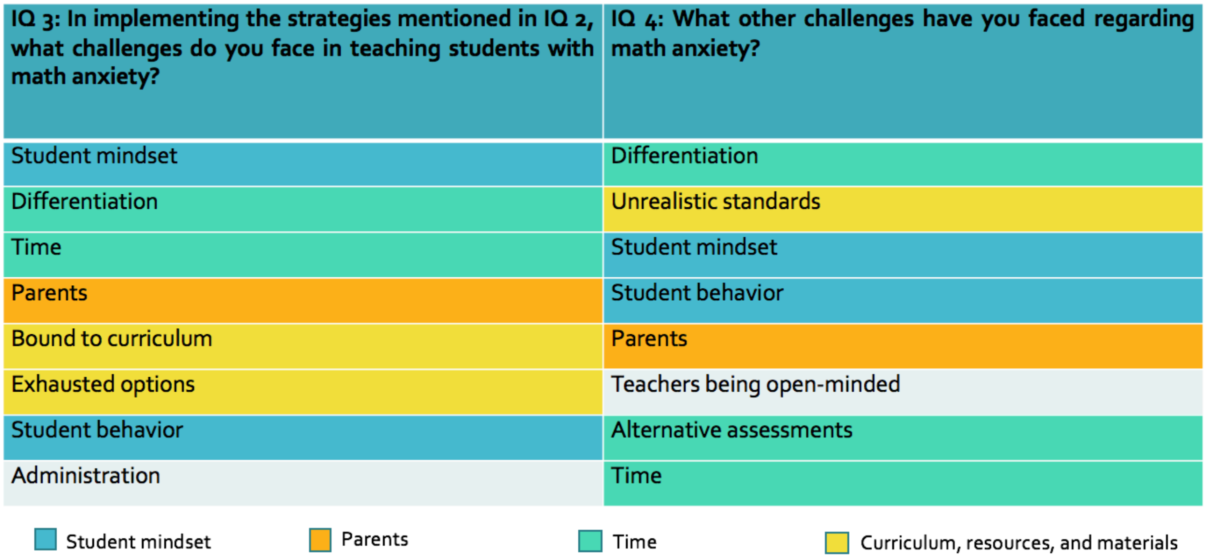
Results for research question two. Research question two asked, “What challenges do teachers face in reducing math anxiety?” An analysis of the themes obtained from the interview questions indicate that the key challenges teachers face in reducing math anxiety center around the following four areas (see Table 12):

- Student mindset
- Parents
- Time
- Curriculum, resources, and materials

Discussion of research question two. The key findings of research question two indicate the broad areas in which the participants face challenges in reducing math anxiety. First, student mindset is a challenge. When a student has a fixed mindset, participants shared that he is paralyzed by fear, does not participate, shuts down, lacks confidence, does not risk, and does not try. Participants shared fixed mindset is frustrating because they witness a student who allows his past failures to dictate his future success. He does not believe his effort contributes to his success (Dweck, 2016).

Table 12

Key Findings for Research Question Two



IQ 3: In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety?	**IQ 4: What other challenges have you faced regarding math anxiety?**
Student mindset	Differentiation
Differentiation	Unrealistic standards
Time	Student mindset
Parents	Student behavior
Bound to curriculum	Parents
Exhausted options	Teachers being open-minded
Student behavior	Alternative assessments
Administration	Time

🟦 Student mindset 🟧 Parents 🟩 Time 🟨 Curriculum, resources, and materials

Second, parents are a challenge that teachers face in reducing math anxiety. Participants shared that some parents do not understand growth mindset and parents may make comments that take away from a growth mindset in their own children. Some parents may experience math anxiety and feel ill-equipped to help their children with homework. They may step in too quickly and not allow their children to make mistakes or struggle with a math problem. Other parents use their lack of math ability as an excuse for their child's math anxiety and frustration. Participants shared that they hoped for the opportunity to teach parents about growth mindset.

A third key challenge that teachers face in reducing math anxiety is time. Time encompasses various areas. Participants shared that there was not enough time in the day to cover all the material, have math rotations, and pull small groups of students needing additional math help. Participants struggle with finding the time to differentiate stations if they do manage to squeeze in math rotations on a given day. One participant shared she is able to differentiate the curriculum at her teacher-directed station, but she is not able to find the time for differentiating her other rotations. Participants also shared how they do not have enough time to create alternative assessments, performance tasks, and entrance/exit tickets. They know these alternative forms of assessment work well with students who struggle with math anxiety (Blazer, 2011; Woodard, 2004); however, the participants do not have the time to create and design.

A final challenge that teachers face in reducing math anxiety is with the curriculum and materials. The standards are extensive, and the pacing guide has teachers moving quickly through the curriculum. Participants feel challenged when the pacing guide indicates to move to the next lesson, but there are not enough students who have mastered the concept yet. Participants also feel pressured with the additional district fluency tests and performance tasks that are required (see Figure 21).

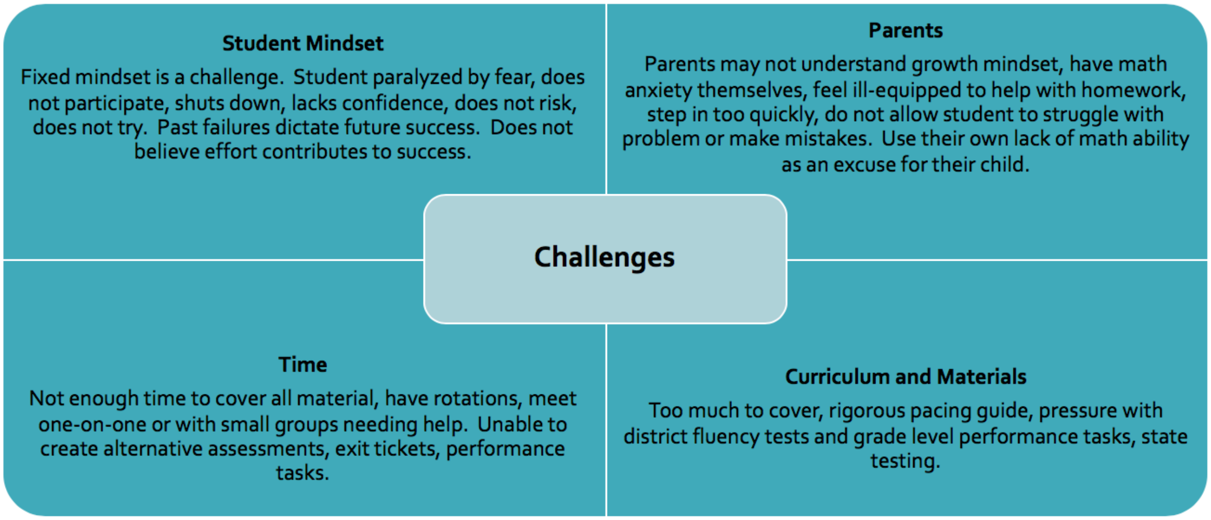


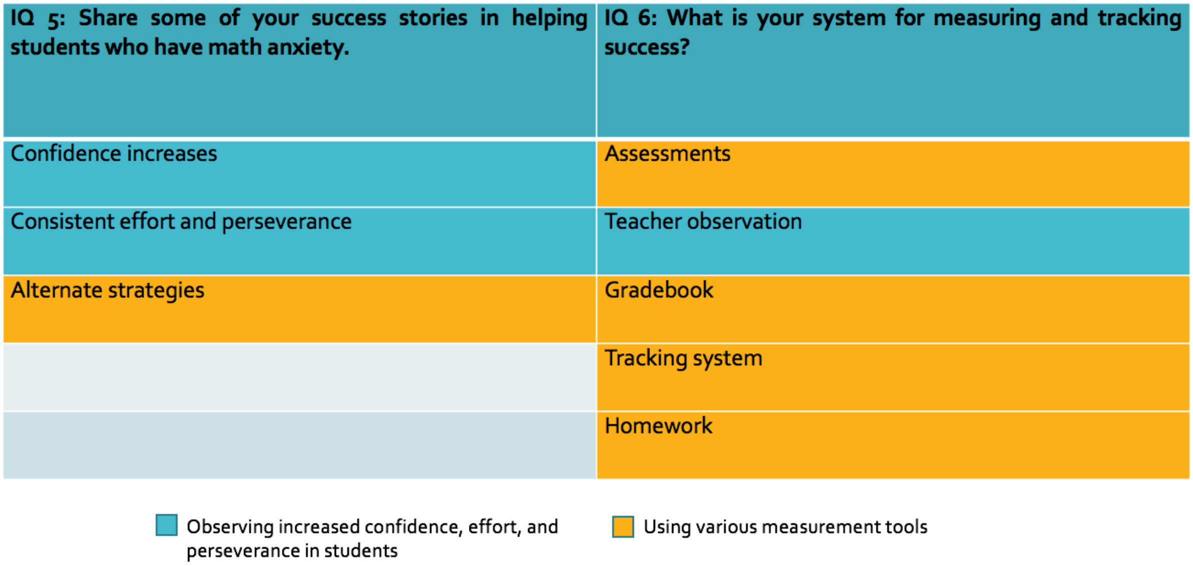
Figure 21. Key findings from research question two. The figure demonstrates the overall themes that emerged from research question two.

Results for research question three. Research question three asked, “How do teachers measure the success of their practices in reducing math anxiety?” An analysis of the themes obtained from the interview questions indicate that the key methods teachers use to measure their success in reducing math anxiety center around the following two areas (see Table 13):

- Observing increased confidence, effort, and perseverance in students.
- Using various measurement tools.

Table 13

Key Findings for Research Question Three



IQ 5: Share some of your success stories in helping students who have math anxiety.	**IQ 6: What is your system for measuring and tracking success?**
Confidence increases	Assessments
Consistent effort and perseverance	Teacher observation
Alternate strategies	Gradebook
	Tracking system
	Homework

🟦 Observing increased confidence, effort, and perseverance in students

🟧 Using various measurement tools

Discussion of research question three. One key finding of research question three demonstrates how teachers measure their success in reducing math anxiety by using observation. As mentioned, participants spend daily time observing their students. If participants observe increased confidence, effort, and perseverance in their students, then they know their practices are successful in reducing math anxiety. Participants observe increased confidence by an extremely quiet student raising his hand to ask a math question, a girl with an underdeveloped number sense holding up her white board with an answer, and a struggling student solving a problem on the board in front of the class. Increased self-confidence helps students have the efficacy to believe they can succeed in math (Ashcraft, 2002; Jameson, 2014).

A second key finding relating to how teachers measure their success in reducing math anxiety is incorporating various measurement tools. All participants discussed the use of their gradebooks. Depending on the grade level, participants record grades differently; however, they all track student progress. When participants analyze student grades, they are able to track progress and see growth over time. The participants also analyze student data by creating spreadsheets and pie graphs, and they filter by sub-group. Finally, participants rely on anecdotal records to record mini-successes such as observing a student explain place value or explaining to her peer how she solved a particular problem (see Figure 22).

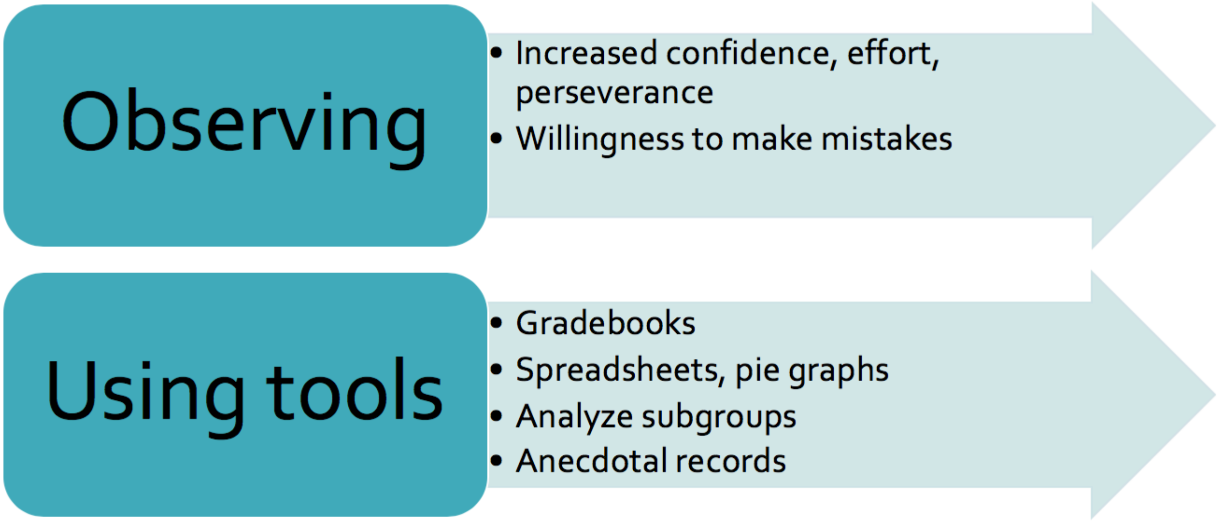


Figure 22. Key findings from research question three. The figure demonstrates the overall themes that emerged from research question three.

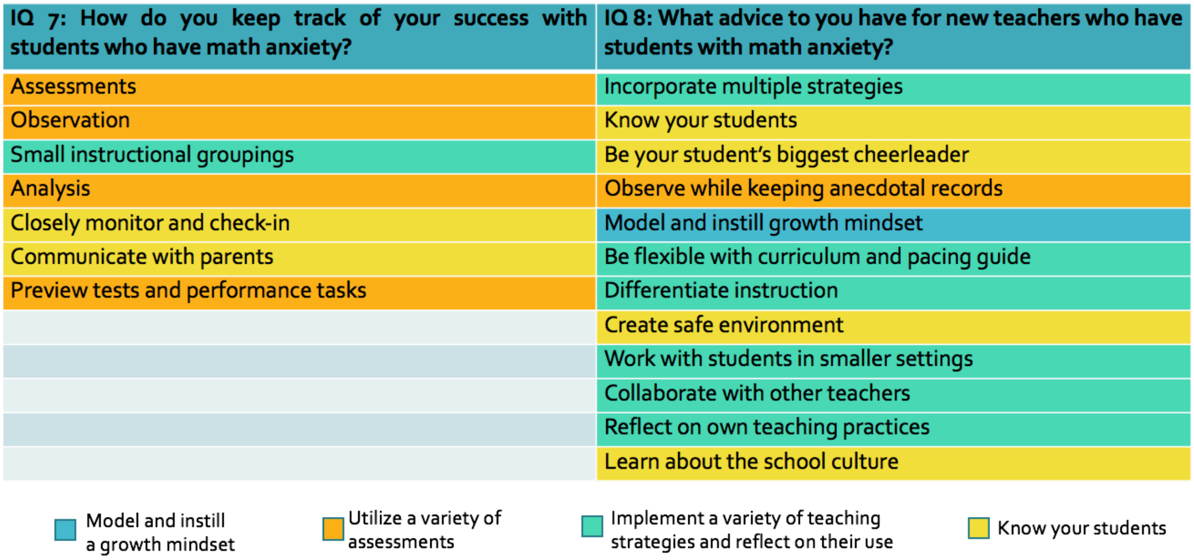
Results for research question four. Research question four asked, "What recommendations would teachers make for future implementation of strategies in reducing math anxiety?" An analysis of the themes obtained from the interview questions indicate that the key recommendations teachers would make for future implementation of strategies in reducing math anxiety center around the following four areas (see Table 14):

- Model and instill a growth mindset.
- Utilize a variety of assessments.

- Implement a variety of teaching strategies and reflect on their use.
- Know your students.

Table 14

Key Findings for Research Question Four



IQ 7: How do you keep track of your success with students who have math anxiety?	IQ 8: What advice to you have for new teachers who have students with math anxiety?
Assessments	Incorporate multiple strategies
Observation	Know your students
Small instructional groupings	Be your student's biggest cheerleader
Analysis	Observe while keeping anecdotal records
Closely monitor and check-in	Model and instill growth mindset
Communicate with parents	Be flexible with curriculum and pacing guide
Preview tests and performance tasks	Differentiate instruction
	Create safe environment
	Work with students in smaller settings
	Collaborate with other teachers
	Reflect on own teaching practices
	Learn about the school culture

🟦 Model and instill a growth mindset
🟧 Utilize a variety of assessments
🟩 Implement a variety of teaching strategies and reflect on their use
🟨 Know your students

Discussion of research question four. The recommendations that teachers would make for future implementation of strategies in reducing math anxiety correlate closely with the best practices findings from research question one and challenges from research question two. First, participants recommend modeling and instilling a growth mindset. Participants recommend modeling not only with students and parents, but also with other teachers. Adults' mindsets certainly influence students' mindsets (Dweck, 2008). Participants shared they can promote a growth mindset by encouraging their students to learn from their mistakes and to persevere through challenging problems. Boaler and Dweck's research also support this finding (Boaler, 2016; Dweck, 2008).

A second key finding for future implementation of strategies in reducing math anxiety is utilizing a variety of assessments. Participants shared their alternative assessment recommendations including anecdotal records, performance tasks, weekly reflections, and math journals. One participant shared it was important to keep a record of the alternative assessments used to ensure variety. In addition, participants emphasized the importance of analyzing the data from the assessments and using the data to drive instruction.

A third key finding for future implementation of strategies in reducing math anxiety is implementing a variety of teaching strategies and reflecting on their success. The best practices and teaching strategies are detailed in Chapter 4 and include small instructional groupings, differentiated instruction, math games, manipulatives, engagement strategies, technology, hands-on activities such as cooking, math journals, and project-based assignments. Participants shared that strategies that move away from traditional paper and pencil are best for engaging students and reducing math anxiety. In addition, participants encourage multiple strategies. They explained that math often has one correct answer, but there are multiple methods to arrive at the solution. They often teach several different methods to their students and allow their students to select the method that makes most sense or works best for a particular problem. Participants also highlighted the importance of reflecting on their own teaching practices. They note what strategies and practices work well, what they would change about a lesson, what concepts are more difficult for students to grasp, and what worked with which students.

A fourth key finding for future implementation of strategies in reducing math anxiety is knowing your students. Participants emphasized the importance of knowing their students, as detailed earlier in chapter five. Participants learn more about their students by observing, communicating, checking-in, and engaging in number talks. When participants know their students well, the teachers are best able to meet students' needs and praise their efforts (see Figure 23).

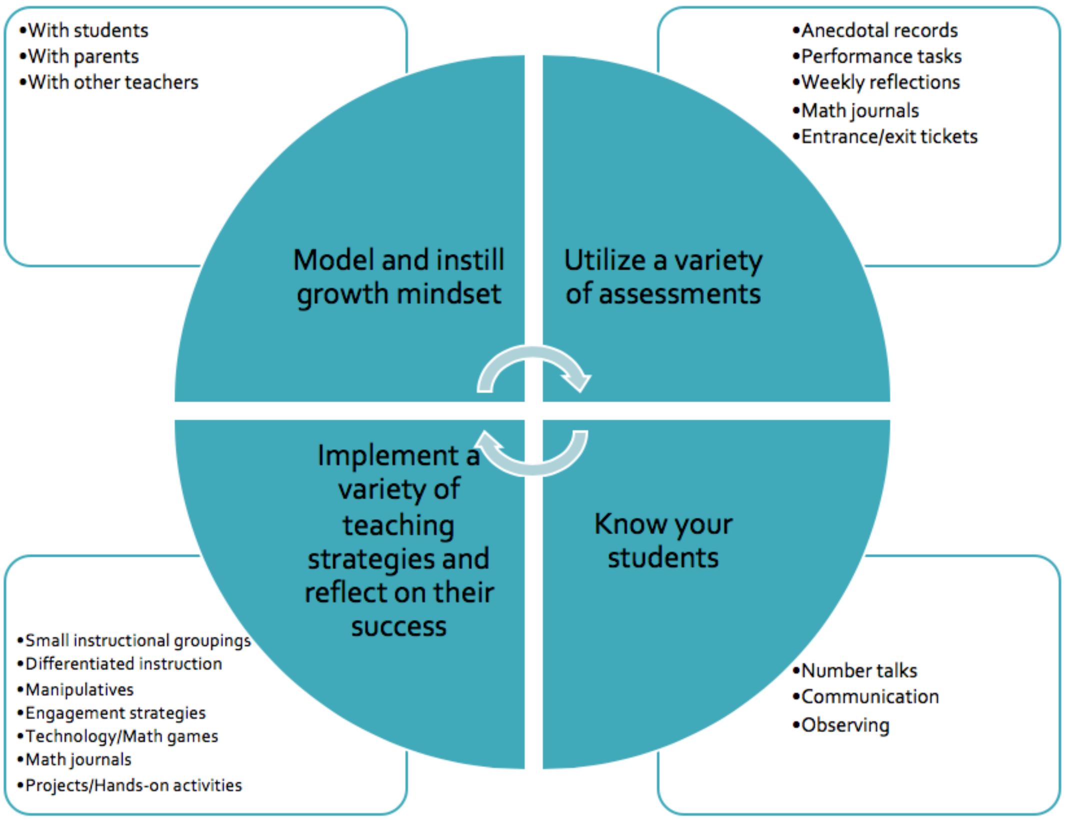


Figure 23. Key findings from research question four. The figure demonstrates the overall themes that emerged from research question four.

Implications of the Study

The intent of this research was to determine the best practices teachers employ to reduce math anxiety. The research findings are broadly applicable to the field of math anxiety and can be specifically applied to subgroups. The significant implications for teachers, parents, teacher-education programs, and STEM policy initiatives will be detailed below.

Implications for teachers. The implications for teachers are multidimensional. Given the profound impact that teachers have on students with math anxiety, this study's findings will help teachers seeking to reduce math anxiety in their students. Teachers can immediately incorporate the best practices and strategies in their own classrooms including one-on-one instruction, small group instruction, partner work, peer tutors, math games, manipulatives, technology, engagement strategies such as number talks and white boards, math journals, differentiated instruction, and multiple problem-solving strategies. The best practices are all more successful when done in the context of a safe classroom environment with an abundance of attention and encouragement.

In addition, this study's findings and the literature will help educate teachers on the difference that mindset makes on math achievement. Since growth mindset reduces math anxiety and increases math achievement, teachers can promote and model growth mindset in their classrooms. The findings provide practical ways for growth mindset training such as bulletin boards, vocabulary, quotes, and books. At the same time, teachers can focus on process praise and praising for effort instead of praising for grades or high achievement. Teachers can also encourage mistakes and teach students how mistakes actually help their brains to grow.

Finally, lead and mentor teachers can use these findings to educate other teachers and parents. They can educate other teachers about mindset. Even if another teacher is not ready to implement growth mindset training in her classroom, she can work on having a growth mindset herself, so she can best help ensure her students' success. Also, a team of teachers can conduct parent nights to educate parents on growth mindset and how best to help their child with math homework. An individual teacher can even add information about math anxiety and growth mindset in their weekly or monthly parent newsletter.

Implications for parents. Parents may not realize words they say in passing may be detrimental to their children. The research findings have implications for parents because parents can learn to say, "I'm so proud of you. You studied so hard for the test and made multiple attempts to solve the challenge problem." Parents can also understand that no math gene exists. Even if the parent struggled with math, it does not mean the student will always struggle. The student may need more time and has not learned the concept yet. Parents impact their children and it is important that parents have a positive attitude toward math.

Implications for teacher-education programs. There are two significant implications for teacher-education programs resulting from this study. First, multiple-subject teaching programs should have a math anxiety component in their math methods course. Preservice teachers should have the opportunity to learn about math anxiety, understand how to detect it, and understand how to address it. They can use the direct advice for new teachers that the participants in this study shared.

In addition, this study's findings provided multiple alternative strategies to running a successful classroom and reducing math anxiety. Instead of a professor lecturing the preservice teachers on how to teach math, the professor can run the class as if it were an elementary classroom. The professor can have rotations, incorporate model engagement strategies, use manipulatives, and play math games. The preservice teachers can learn by doing.

Implications for STEM policy initiatives. Finally, the research findings have implications for STEM policy initiatives. More and more elementary schools and school districts have started STEM programs. Within these programs, teachers and policy makers can add a math anxiety and growth mindset component. By reducing math anxiety, more students can have the option to pursue more training and courses in STEM field.

On a state or national scale, advertisements and commercials can be designed to promote growth mindset and provide helpful math homework tips for parents. They can air on PBS, cable television, or a radio network. It is important that parents, teachers, and communities have a united front when talking about math and reducing math anxiety.

Recommendations for Teachers and Parents

The purpose of this study was to determine best practices and strategies in reducing math anxiety. The literature review and teacher interviews provided a variety of approaches that teachers can continue to implement or begin to implement in their daily instruction to make a concerted effort in helping reduce math anxiety in their students. Many of the strategies can be implemented at home, so parents can work with their children as well. Teachers and parents can work as a team to best support students in reducing math anxiety, while encouraging and increasing growth mindset.

Recommendations for teachers. The data provide best strategies that teachers can immediately incorporate in their classrooms to help reduce math anxiety. While some educators may be familiar with these practices, other teachers may face the challenge of time when designing activities such as alternative assessments, differentiated centers for math rotation, and entrance/exit tickets. To help educate teachers on best practices to reduce math anxiety and to overcome the challenges of time, differentiation, and alternative assessments, the researcher recommends a math anxiety inservice for teachers led by a qualified presenter. The inservice should be held during professional development time so teachers are not asked to attend an additional meeting outside the school day. The inservice should be introduced with a brief overview of math anxiety, including the development of and consequences of the phenomenon. In addition, time would be spent explaining the difference between growth and fixed mindset. Teachers will also need to complete a math anxiety scale to help determine their level of math anxiety and a mindset quiz to help gauge their degree of growth mindset versus fixed mindset.

The presenter should use various engagement strategies during the workshop such as think-pair-share, word splash, white boards, and thumbs up/thumbs down to model engagement strategies that the teachers can directly incorporate in their classrooms the following day. Various hands-on math games should be played using dice and playing cards, and discussions should take place on how to differentiate the games across grade levels and math readiness. Teachers may have the option to engage in a sample number talk to practice reasoning their way through a mathematical situation. It is recommended that ample time is set aside for creative development to collaborate with colleagues, develop classroom posters and graphics, and/or write entrance and exit tickets. A reflective math growth mindset journal including various graphics and quotes should be given to all teachers and the last five minutes of the inservice used for self-reflection. All teachers would leave the inservice with their reflective journal, a list of growth mindset book recommendations to read with their students, a packet of entrance/exit tickets that can be used with their students and are adaptable across grade levels, a list of engagement strategies with descriptions, number talks, and math game instructions and templates. It is highly suggested that teachers use their reflection journals on a weekly basis to note successful strategies, student observations during math, adaptations to make on various math lessons, and personal reflections based on changes they see when consciously focusing on engaging all students and modeling growth mindset.

Recommendations for parents. Similar to the teacher inservice, the researcher recommends conducting parent workshops led by a qualified presenter in the community at schools, places of worship, and parent association meetings. The goal of the parent workshops is to teach parents about growth mindset versus fixed mindset, play math games that parents can play at home with their own children, model higher-order thinking skills questions, and discuss how parent's fear of math and own math anxiety affect children negatively. The presenter should begin by sharing several scenarios about math anxiety that parents would find relatable. It is recommended that parents would have the opportunity to meet other parents at their tables and to share their own experiences with math. To help determine their level of math anxiety and to help gauge their degree of growth mindset versus fixed mindset, it is suggested that parents complete both a math anxiety scale and a mindset quiz. The presenter would then read a children's literature book illustrating a math topic, such as *The Greedy Triangle* by Marilyn Burns that explores shapes and basic geometry principles.

Following the introductory portion of the workshop, the presenter should guide the parents to the games portion. During this segment, parents would play four hands-on math games with a partner at their table. Playing with a partner models how the parent would play the game with his child. All games use simple materials such as dice, and spinner, and playing cards. At the end of each game, the presenter should model questioning and strategy discussion, so the parent can connect with the child in the same manner. The presenter should also offer multiple ways to differentiate the games for age and current ability. At the conclusion of the workshop, it is recommended that all parents would have the opportunity to write down their takeaways and what they plan to implement immediately at home. All parents should leave the workshop with a list of growth mindset phrases to use, a list of children's literature books divided my math strand, a list of children's growth mindset books for read alouds, directions to the hands-on math games, a set of dice, a deck of playing cards, a spinner template, and a list of higher order thinking questions. Holding a parent workshop would help overcome the math anxiety challenge of parents since education and practice is the best way to change behavior. Parents may learn how to better assist their child with math homework, praise effort and the process, and encourage mistakes. A follow-up workshop would be scheduled if there is sufficient interest.

Recommendations for Future Research

While this research study focused on best practices for reducing math anxiety in first through sixth grade children, it creates opportunities for additional research. The following are recommended as future areas for research:

- More in-depth study to explore best practices in reducing math anxiety. Expand the number of school districts to target various districts across Orange County.
- Design a study that uses students as participants to explore student feedback regarding math anxiety. Students take a math anxiety inventory to determine level of math anxiety. Implement best practices and strategies from this study for one semester. Students take another math anxiety inventory and compare.
- Design a longitudinal study of students, teachers, and parents. Measure math anxiety at the beginning. Implement the best strategies to reduce math anxiety in the classroom. Provide growth mindset training with the students for one year. Follow-up with another math anxiety inventory.

Final Thoughts

The researcher had a genuine desire to interview the teachers for this study. The participants were transparent and provided well-thought responses. They were eager to help and share what practices they currently used in their classroom. For some of the participants, they were not able to incorporate one or more of the best practices in their classroom due to time or resources. However, they still knew it was worthwhile to share.

As the focus on STEM education continues and the need for STEM careers increase, more students are needed to succeed in math courses. Since math anxiety is a large predictor of math achievement, it is important to work with teachers and parents to reduce math anxiety in students.   The primary goal is for students to feel safe while learning, confident of their abilities, and believe they can succeed in math with continued effort and perseverance. Students need to think and talk about numbers, engage in their own learning, and discuss problem-solving strategies with their peers. Students should understand mathematics conceptually instead of memorizing algorithms and procedures. All students have the capability to increase their confidence and to succeed in math. Thinking mathematically will propel students into the future.

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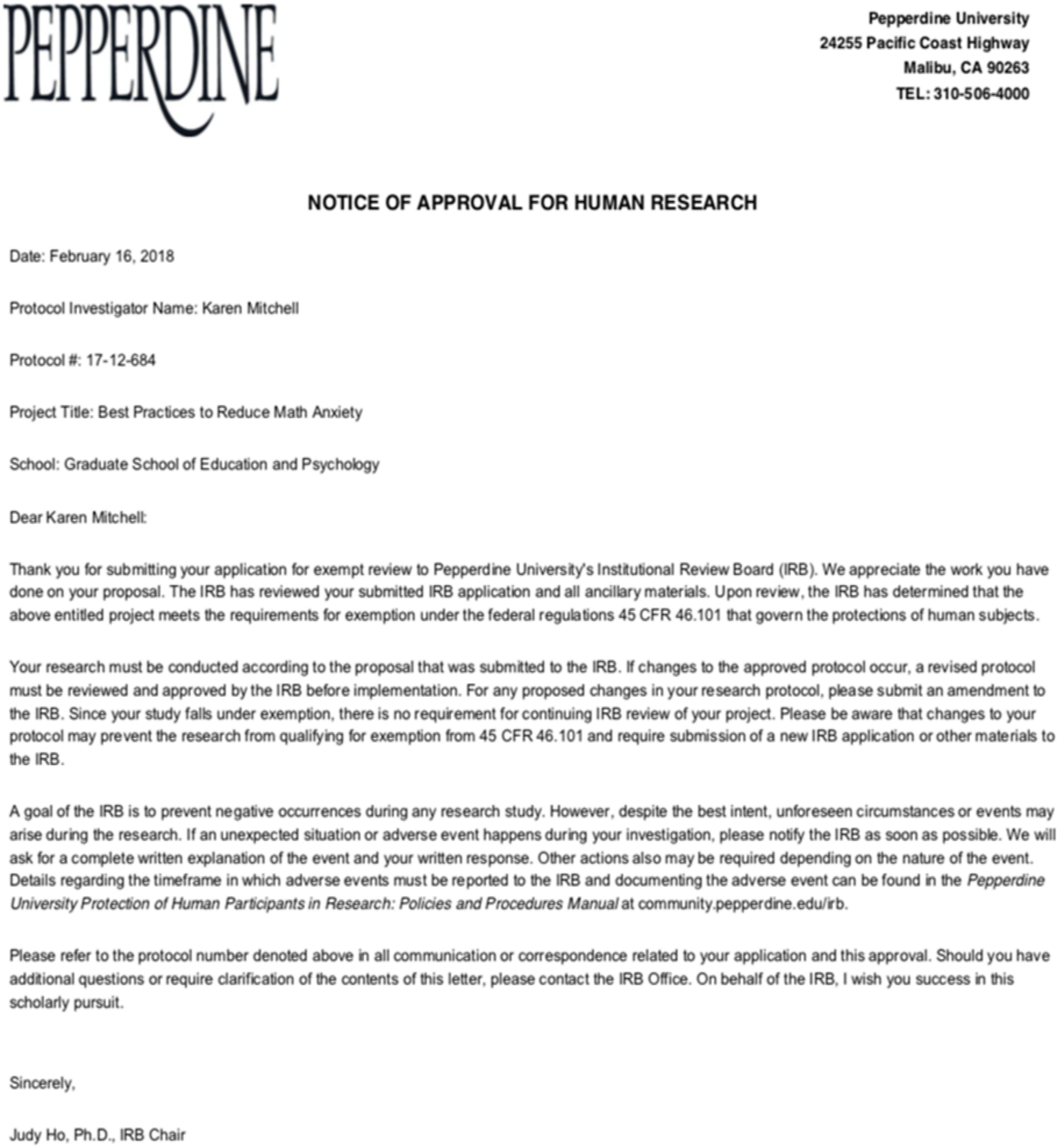
APPENDIX A

IRB Approval Notice



PEPPERDINE

Pepperdine University
24255 Pacific Coast Highway
Malibu, CA 90263
TEL: 310-506-4000

NOTICE OF APPROVAL FOR HUMAN RESEARCH

Date: February 16, 2018

Protocol Investigator Name: Karen Mitchell

Protocol #: 17-12-684

Project Title: Best Practices to Reduce Math Anxiety

School: Graduate School of Education and Psychology

Dear Karen Mitchell:

Thank you for submitting your application for exempt review to Pepperdine University's Institutional Review Board (IRB). We appreciate the work you have done on your proposal. The IRB has reviewed your submitted IRB application and all ancillary materials. Upon review, the IRB has determined that the above entitled project meets the requirements for exemption under the federal regulations 45 CFR 46.101 that govern the protections of human subjects.

Your research must be conducted according to the proposal that was submitted to the IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit an amendment to the IRB. Since your study falls under exemption, there is no requirement for continuing IRB review of your project. Please be aware that changes to your protocol may prevent the research from qualifying for exemption from 45 CFR 46.101 and require submission of a new IRB application or other materials to the IRB.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite the best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the IRB as soon as possible. We will ask for a complete written explanation of the event and your written response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the IRB and documenting the adverse event can be found in the *Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual* at community.pepperdine.edu/irb.

Please refer to the protocol number denoted above in all communication or correspondence related to your application and this approval. Should you have additional questions or require clarification of the contents of this letter, please contact the IRB Office. On behalf of the IRB, I wish you success in this scholarly pursuit.

Sincerely,

Judy Ho, Ph.D., IRB Chair

APPENDIX B

IRB Citi Certificate

CITI PROGRAM

Completion Date 06-Dec-2017
Expiration Date 05-Dec-2022
Record ID 25089335

This is to certify that:

Karen Mitchell

Has completed the following CITI Program course:

GSEP Education Division	(Curriculum Group)
GSEP Education Division - Social-Behavioral-Educational (SBE)	(Course Learner Group)
1 - Basic Course	(Stage)

Under requirements set by:

Pepperdine University

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?w31e49b0d-00a4-4539-934f-01a4997d8d60-25089335

APPENDIX C

Informed Consent Form

PEPPERDINE UNIVERSITY

Graduate School of Education and Psychology

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH ACTIVITIES

Best Practices to Reduce Math Anxiety

You are invited to participate in a research study conducted by Karen Mitchell, MS and Farzin Madjidi, EdD at Pepperdine University because you are a first through sixth grade teacher with a CA Teaching Credential and at least three years of teaching experience. Your participation is voluntary. You should read the information below and ask questions about anything that you do not understand, before deciding whether to participate. Please take as much time as you need to read the consent form. You may also decide to discuss participation with your family or friends. If you decide to participate, you will be asked to sign this form. You will also be given a copy of this form for you records.

PURPOSE OF THE STUDY

The purpose of the study is to…

- Determine the strategies and practices teachers employ to reduce math anxiety.
- Determine the challenges teachers face in reducing math anxiety.
- Determine how teachers measure the success of their practices in reducing math anxiety.
- Determine the recommendations teachers would make for future implementation of strategies in reducing math anxiety.

STUDY PROCEDURES

If you volunteer to participate in this study, you will be asked to…

Participate in a 60-minute interview where you will be asked the following interview questions:

IQ 1: How do you detect math anxiety in a student?
IQ 2: What strategies do you use to reduce math anxiety in your students?
IQ 3: In implementing the strategies mentioned in IQ 2, what challenges do you face in teaching students with math anxiety?

IQ 4: What other challenges have you faced regarding math anxiety?
IQ 5: Share some of your success stories in helping students who have math anxiety.
IQ 6: What is your system for measuring and tracking success?
IQ 7: How do you keep track of your success with students who have math anxiety?
IQ 8: What advice do you have for new teachers who have students with math anxiety?

Your participation in the study will last for the 60-minute interview. The study will last for approximately two months. The study shall be conducted in coffee shops or local meeting places. If you are not able to meet for an in-person interview, the interview can take place using a web-conferencing tool such as Skype or Facetime. The interview will be audio-recorded. If you do not wish to be audio-recorded, then you may not participate in the study.

POTENTIAL RISKS AND DISCOMFORTS

The potential and foreseeable risks associated with participation in this study include:

- Risk to professional reputation if there is a breach of confidentiality.
- Boredom or fatigue during the interview process.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

While there are no direct benefits to the study participants, there are several anticipated benefits to society which include:

- Students will experience less math anxiety and increased math achievement.
- More students may be engaged in science, technology, engineering, and math (STEM) courses and pursue careers in STEM fields.
- Teachers will use the results to underscore the importance of identifying math anxiety early and develop strategies to reduce it.
- Parents can implement strategies in their home to help reduce their children's level of math anxiety.
- All teacher-education programs that have a STEM component - multiple subject elementary programs and single STEM subject programs - can incorporate lessons on math anxiety, so teachers understand that success in math requires not only content but also the right mindset.

CONFIDENTIALITY

I will keep your records for this study confidential as far as permitted by law. However, if I am required to do so by law, I may be required to disclose information collected about you. Examples of the types of issues that would require me to break confidentiality are if you tell me about instances of child abuse and elder abuse. Pepperdine's University's Human Subjects Protection Program (HSPP) may also access the data collected. The HSPP occasionally reviews and monitors research studies to protect the rights and welfare of research subjects.

The data will be stored on a password protected computer in the principal investigator's place of residence. The data will be stored for a minimum of five years and then will be deleted using an eraser procedure. The data collected will be transcribed by only the researcher and then coded. Your responses will be coded with a numerical identifier and transcript data will be maintained separately. The audio recordings will be erased and destroyed within five years. Any identifiable information obtained in connection with this study will remain confidential.

PARTICIPATION AND WITHDRAWAL

Your participation is voluntary. Your refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study.

ALTERNATIVES TO FULL PARTICIPATION

The alternative to participation in the study is not participating or completing only the items which you feel comfortable.

EMERGENCY CARE AND COMPENSATION FOR INJURY

If you are injured as a direct result of research procedures you will receive medical treatment; however, you or your insurance will be responsible for the cost. Pepperdine University does not provide any monetary compensation for injury

INVESTIGATOR'S CONTACT INFORMATION

I understand that the investigator is willing to answer any inquiries I may have concerning the research herein described. I understand that I may contact Dr. Farzin Madjidi at Pepperdine University, 310-568-5600 or Farzin.Madjidi@pepperdine.edu if I have any other questions or concerns about this research.

RIGHTS OF RESEARCH PARTICIPANT – IRB CONTACT INFORMATION

If you have questions, concerns or complaints about your rights as a research participant or research in general please contact Dr. Judy Ho, Chairperson of the Graduate & Professional Schools Institutional Review Board at Pepperdine University 6100 Center Drive Suite 500 Los Angeles, CA 90045, 310-568-5753 or gpsirb@pepperdine.edu.

SIGNATURE OF RESEARCH PARTICIPANT

I have read the information provided above. I have been given a chance to ask questions. My questions have been answered to my satisfaction and I agree to participate in this study. I have been given a copy of this form.

____

Name of Participant

____ __________________

Signature of Participant Date

SIGNATURE OF INVESTIGATOR

I have explained the research to the participants and answered all of his/her questions. In my judgment the participants are knowingly, willingly and intelligently agreeing to participate in this study. They have the legal capacity to give informed consent to participate in this research study and all of the various components. They also have been informed participation is voluntarily and that they may discontinue their participation in the study at any time, for any reason.

____

Name of Person Obtaining Consent

____ ______________________

Signature of Person Obtaining Consent Date

APPENDIX D

Recruitment Script

Dear [Name],

I am a doctoral student in the Organizational Leadership program within the Graduate School of Education and Psychology at Pepperdine University. As part of fulfilling my degree requirements, I am conducting a study regarding the best practices and strategies to reduce math anxiety in elementary students.

I found your name and email from the XYZ Unified School District website. As a result of your contributions to the field of education, you have been carefully selected to participate. Participation in the study is voluntary and entails a 60-minute interview in person at a convenient location. Confidentiality will be maintained throughout the study. The questions that will be asked in the interview and an Informed Consent Form will be sent to you in advance of the interview. Your participation will be extremely valuable to other teachers, parents, and students in order to reduce math anxiety.

Thank you for your participation,

Karen Mitchell
Pepperdine University
Graduate School of Education and Psychology
Status: Doctoral Student

APPENDIX E

Peer Reviewer Form

Dear Reviewer:

Thank you for agreeing to participate in my research study. The table below is designed to ensure that my research questions for the study are properly addressed with corresponding interview questions.

In the table below, please review each research question and the corresponding interview questions. For each interview question, consider how well the interview question addresses the research question. If the interview question is directly relevant to the research question, please mark "Keep as stated." If the interview question is irrelevant to the research question, please mark "Delete it." Finally, if the interview question can be modified to best fit with the research question, please suggest your modifications in the space provided. You may also recommend additional interview questions you deem necessary.

Once you have completed your analysis, please return the completed form to me via email by Fri, Sept. 30. Thank you again for your participation.

Research Question	Corresponding Interview Question
RQ 1: What strategies and practices do teachers employ to reduce math anxiety?	IQ 1: How prevalent is math anxiety in your classroom? a. The question is directly relevant to Research question – **Keep as stated** b. The question is irrelevant to research question – **Delete it** c. The question should be **modified as suggested**: ____ ____ I recommend adding the following interview questions: ____ ____ ____ ____ IQ 2: What strategies do you use to reduce math anxiety in your students? a. The question is directly relevant to Research question – **Keep as stated** b. The question is irrelevant to research question – **Delete it**

	c. The question should be **modified as suggested**: ____ ____ I recommend adding the following interview questions: ____ ____ ____ ____
RQ 2: What challenges do teachers face in reducing math anxiety?	IQ 3: How do you detect math anxiety in a student? a. The question is directly relevant to Research question – **Keep as stated** b. The question is irrelevant to research question – **Delete it** c. The question should be **modified as suggested**: ____ ____ I recommend adding the following interview questions: ____ ____ ____ ____ IQ 4: In implementing the strategies you mentioned in IQ2, what challenges do you face in teaching students with math anxiety? a. The question is directly relevant to Research question – **Keep as stated** b. The question is irrelevant to research question – **Delete it** c. The question should be **modified as suggested**: ____ ____ I recommend adding the following interview questions: ____ ____ ____ ____

	IQ 5: Are there other challenges that you have faced? a. The question is directly relevant to Research question – **Keep as stated** b. The question is irrelevant to research question – **Delete it** c. The question should be **modified as suggested**: ____ ____ I recommend adding the following interview questions: ____ ____ ____ ____
RQ 3: How do teachers measure the success of their practices in reducing math anxiety?	IQ 6: Share some of your success stories in helping students who have math anxiety. a. The question is directly relevant to Research question – **Keep as stated** b. The question is irrelevant to research question – **Delete it** c. The question should be **modified as suggested**: ____ ____ I recommend adding the following interview questions: ____ ____ ____ ____ IQ 7: What is your system for measuring and tracking success? a. The question is directly relevant to Research question – **Keep as stated** b. The question is irrelevant to research question – **Delete it** c. The question should be **modified as suggested**: ____ ____

	I recommend adding the following interview questions: ______________________________ ______________________________ ______________________________ ______________________________
RQ 4: What recommendations would teachers make for future implementation of strategies in reducing math anxiety?	IQ 8: If there was a student you could go back and help in math, what would you do differently? a. The question is directly relevant to Research question – **Keep as stated** b. The question is irrelevant to research question – **Delete it** c. The question should be **modified as suggested**: ______________________________ ______________________________ I recommend adding the following interview questions: ______________________________ ______________________________ ______________________________ ______________________________ IQ 9: What advice do you have for new teachers who have students with math anxiety? a. The question is directly relevant to Research question – **Keep as stated** b. The question is irrelevant to research question – **Delete it** c. The question should be **modified as suggested**: ______________________________ ______________________________ I recommend adding the following interview questions: ______________________________ ______________________________ ______________________________ ______________________________