SELF-REGULATION IN ADDRESSING MATH ANXIETY IN HIGH-ACHIEVING STUDENTS IN AN AFFLUENT ASIAN AMERICAN COMMUNITY

by
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A dissertation submitted to Johns Hopkins University in conformity with the requirements for

the degree of Doctor of Education

Baltimore, Maryland
August 2023

Abstract

Adolescent learners in a high-achieving school in an affluent, predominantly Asian and Asian American community in a suburb of Silicon Valley, California, face a myriad of stressors and challenges impacting their math achievement. Existing literature suggests parenting styles, ability-grouping practices, and self-beliefs including math anxiety are a few of the salient factors impacting adolescents' math achievement. A mixed methods needs assessment was conducted to understand the portrait of a struggling math student through the lens of 16 teachers using a mixed methods design. Results indicated divergent beliefs surrounding math education and a sense of pressure for children to take advanced math classes. Self-regulatory interventions such as mindfulness exercises have been shown to reduce math anxiety. Expressive writing was used as an intervention on math anxiety in 69 seventh-grade students in a mixed methods convergent parallel intermittent time series design. Parents ($N = 16$) were interviewed to provide insight into their children's math learning experiences. Students' math anxiety levels were not significantly related to the expressive writing. Students' writing content included themes of parents' expectations, peer relations, perceptions of math teachers and classrooms, and reflections around math anxiety. A range of themes also appeared in parent interviews including parents' experiences with schooling in other countries, navigating their children's school system, and emphasizing performance, well-being, and/or effort in their children. Further research examining antecedents to math anxiety and additional interventions to reduce math anxiety are suggested.

Keywords: math achievement, math anxiety, Asian American, high-achieving students, mixed methods

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JOHNS HOPKINS
SCHOOL of EDUCATION

Doctor of Education Program

Dissertation Approval Form

Student's Name: Kimberly Lam

Date: August 2, 2023

Dissertation Title:

Self-Regulation in Addressing Math Anxiety in High-Achieving Students in an Asian American, Affluent Community

The student has made all necessary revisions, and we have read and approve this dissertation for submission to the Johns Hopkins Sheridan Libraries as partial fulfillment of the requirements for the Doctor of Education degree.

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Acknowledgments

To my family:

Mom, the sacrifices you have made in my lifetime are so abundant that I am still learning of the vastness of your love. I couldn't have done this without you.

Cau Giap and Co Mi Anh, your unfailing support overwhelms me with gratitude. You are the best family I could ask for.

To my friends:

Connie and Jason, thank you for cheering me on every day and for believing in me.

To my colleagues and advisor:

Mustangs, during days of extreme isolation and frustration while writing this dissertation, you brought me joy.

Blue Jays, you are forever preserved in my heart for all we've gone through. V, D, and A—we did it! Now let's take on some wicked problems.

Dr. Brown, thank you for pushing me until I was proud.

Dedication

This dissertation, though a piece of scholarly work, is in many ways the partial memoir of a child of Vietnamese immigrant parents growing up in affluent Silicon Valley, sharing the lived experiences of struggling with her identity as an Asian American female and low-achieving math student turned high self-conceptualized math teacher, scholar, and woman.

I dedicate this dissertation to any individuals or organizations who aim to dissect the monolithic, model minority narrative of Asian Americans to create space for stories of triumph, joy, and heartbreak, so that being Asian American is no longer an oxymoron.

It is not uncommon for people to express strong opinions about math, especially math learning, when I share that I am a math teacher. Unfortunately, most self-proclaim they have "never been good at math," for which I deeply lament. At some point, their math self-belief deteriorated and never recovered. I dedicate this dissertation also to any individuals or organizations who seek to improve the math identity of our citizens, especially our youth. To both recipients, go confidently knowing that I will tirelessly support these endeavors alongside you.

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Executive Summary

Problem of Practice – Background and Context

Adolescent learners in a high-achieving public middle school in an affluent, predominantly Asian and Asian American community in a suburb of Silicon Valley, California, face a myriad of stressors and challenges impacting their math achievement. Neal and Neal's (2013) networked ecological systems and Bandura's (1986) social cognitive theory were used as theoretical frameworks to understand students and their math learning. Salient environmental factors include Asian American cultural identity and the associated model minority myth, and affluence as a socioeconomic factor, along with peer relations, parenting style, teachers' instructional practices, and ability-grouping. The focus on the student examined their math self-beliefs.

Needs Assessment

A needs assessment was conducted to understand the portrait of a struggling math student through the lens of 16 teachers using a mixed methods explanatory sequential model. Teachers answered a questionnaire adapted from two national surveys. Semi-structured interviews with six teachers revealed divergent beliefs surrounding math education. Teachers reported supporting students' executive functioning skills and frequent communication with families. Pressure from the community for children to take advanced math classes was a common theme in interviews.

Theoretical Framework – Interventions

The needs assessment revealed factors leading to math anxiety, which became the primary construct in conducting the literature review for potential interventions. Because math anxiety has systematic and institutional roots, interventions primarily focus on strategies for coping with math anxiety. Schunk and Zimmerman's (2000) self-regulated learning is a common educational theory used to understand how to support students with their academic and behavioral goals. Cognitive behavioral approaches aim to equip learners with coping strategies to mitigate math anxiety and include mindfulness exercises such as breathing exercises, positive affirmations, and expressive writing.

Research Purpose and Objective

The purpose of the intervention study was to investigate the effects of expressive writing as an intervention on math anxiety in students in advanced math levels at a public middle school in an affluent Asian American community. In addition to the intervention, the study sought to give students an opportunity to voice their experiences with learning math in a competitive and rigorous environment. Parents were also interviewed to provide insight into students' math learning experiences to understand better how to support students.

Research Design

A mixed method convergent design was used to determine the impact of expressive writing on math anxiety. Reaching the intended population and participant responsiveness were examined to ensure fidelity of implementation. District placement criteria were used to determine if students were members of the target population for the study. A survey item preceding the expressive writing asked students to rate their level of responsiveness to the intervention.

The independent variable was expressive writing, and the dependent variable was math anxiety level. The research questions were, "To what extent did the expressive writing intervention impact math anxiety levels in high math anxious and low math anxious students?" and "To what extent did the expressive writing intervention impact math anxiety levels in Math 7+ and Math 7/8/Algebra?" Math anxiety levels were analyzed using an intermittent time series evaluation after each bout of expressive writing. Semi-structured interviews with parents focused on their personal experience with learning math, their goals for their children, and their observations of their children's math learning.

Intervention

Expressive writing is a therapeutic tool often used as a clinical technique in aiding distress, where individuals write about their current stresses or concerns in a freestyle manner for approximately 7 minutes. Expressive writing aids in offloading thoughts of stress or anxiety, thus freeing up space in working memory to tackle math problems. The literature suggests even one session of expressive writing could be an effective intervention to reduce math anxiety.

Data and Analysis

Descriptive and inferential statistics were used to analyze data from 69 seventh-grade students. A Mann Whitney U test was used to examine differences in participant responsiveness related to exposure and math level. An independent samples *t*-test was used to answer research questions related to math anxiety levels. Thematic analysis coding was used to analyze the qualitative data from the expressive writing intervention and parent interviews.

Findings and Conclusions

Student participants were, in general, responsive to the expressive writing intervention irrespective of exposure count and advanced math level. Of the 69 students, eight were not part of the intended population. No statistically significant relationship between expressive writing and levels of math anxiety was found. Students' writing content included reflections on peer relationships, parent expectations, experiences with math anxiety, perceptions of the math teacher, and comparisons with other math classes. Parents shared their experience with learning math in another country and their perspectives and goals for their children's math achievement.

Chapter 1

Literature Review of the Problem of Practice

Introduction

The demand for mathematical proficiency is prevalent in today's global society, where innovation and problem-solving skills are necessary to function and thrive. Economic leaders in the global economy have expressed concern that U.S. education has fallen behind in competition, leading to questions that the U.S. education system can aid in making high-achieving students ready for technical and skilled labor (Organisation for Economic Co-operation and Development, 2019). Math proficiency has been used to predict individual and national success (Hanushek et al., 2010). According to Hanushek et al. (2010), math skills are increasingly required with job requirements in technical fields and serve as a gateway to educational access.

In primary and secondary students, math achievement is a multidimensional construct affected by intersecting and ongoing factors. Immense resources have been poured into closing the achievement gap for those most affected in rural, impoverished, or racially segregated areas (Bauer & Schanzenbach, 2016; Van Sickle et al., 2020). Researchers have considered the deleterious environments high-achieving students face (Ebbert et al., 2019). As Ebbert et al. (2019) explained, high-achieving students have been absent from narratives focused on interventions for at-risk youth because they are associated with an availability of abundant resources, support, and stability.

High-achieving students' academic success has exempted them from interventions to close the achievement gap. However, a closer look into high achievers' lives has revealed intense pressure to perform in overly competitive environments and the development of mental health issues (Ebbert et al., 2019; Luthar et al., 2021). Examining top-performing students and their math achievements in the United States is vital for maintaining the nation's competitive standing in a global economy.

Asian American students are often labeled as high achievers because of their historical academic success (Shih et al., 2019); therefore, they are overlooked when examining math achievement (Yip, 2021). Despite considerable attention given to the role of ethnicity and race within studies of the achievement gap, Yip (2021) explained that Asian Americans are often exempt from racial narratives concerning educational access. As with high-achieving students, there is less concern with Asian American student achievement because they outperform their ethnic minority and White peers (Assari et al., 2020). Instead, Asian Americans are often used as *the model minority*, proof that success is not gatekept to White Americans.

Theoretical Frameworks

The Networked Ecological Systems Theory

Two theoretical frameworks are used to organize the interactions among the factors and stakeholders involved in the problem of practice. The networked ecological systems theory (NEST) provides a framework to examine the direct and indirect social interactions surrounding a focal individual (i.e., the public middle school student). Neal and Neal's (2013) NEST is adapted from Bronfenbrenner's (1979) ecological systems theory (EST), a widely used theoretical framework for studying an individual's development.

The EST consists of five concentric circles, each representing a physical environment or system. At the center of the microsystem, the innermost circle is the focal individual and their direct settings, such as their school, neighborhood, religious organization, and home setting. The more distal concentric circles signify locations where the focal individual is not involved directly but is impacted by its functions. Outside the microsystem is the mesosystem, where the interactions between the participants of the child's microsystem can be found, such as teacher-parent interactions. The exosystem contains environments in which the child does not participate but is impacted, such as parents' workplaces, school board meetings, and city council meetings. The macrosystem can be understood as the cultural elements affecting a child's development, such as socioeconomic status and ethnicity. Finally, the chronosystem consists of predicted environmental changes throughout a child's life, such as transitions into adulthood and unexpected ones from a pandemic or wartime conflict.

The difference between Bronfenbrenner's (1979) EST and Neal and Neal's (2013) NEST is the prioritization of spatial dimensions over social interactions, whereas NEST does the reverse. Where EST is composed of concentric circles focusing on different environments, NEST contains overlapping circular regions focusing on the social interactions within different settings. Neal and Neal augmented the traditional use of concentric circles because proximal systems like the microsystem are not necessarily nested inside the more distal systems like the exosystem. For example, the child, as the focal individual, is not a member of the school board belonging to the macrosystem but is indirectly impacted by the decisions made by the school board.

According to Neal and Neal (2013), the networked model refocuses the framework on identifying the ecology of a child learner, which is the complex social network established by formal and informal interactions, rather than where those interactions occur. Because the networked model represents social interactions, the macrosystem (legal, political, or cultural phenomena) is absent from the graphical representation because children do not engage socially with these constructs. Still, Neal and Neal did not exclude the macrosystem because phenomena occurring in the macrosystem could shape mesosystemic interactions.

Social Cognitive Theory

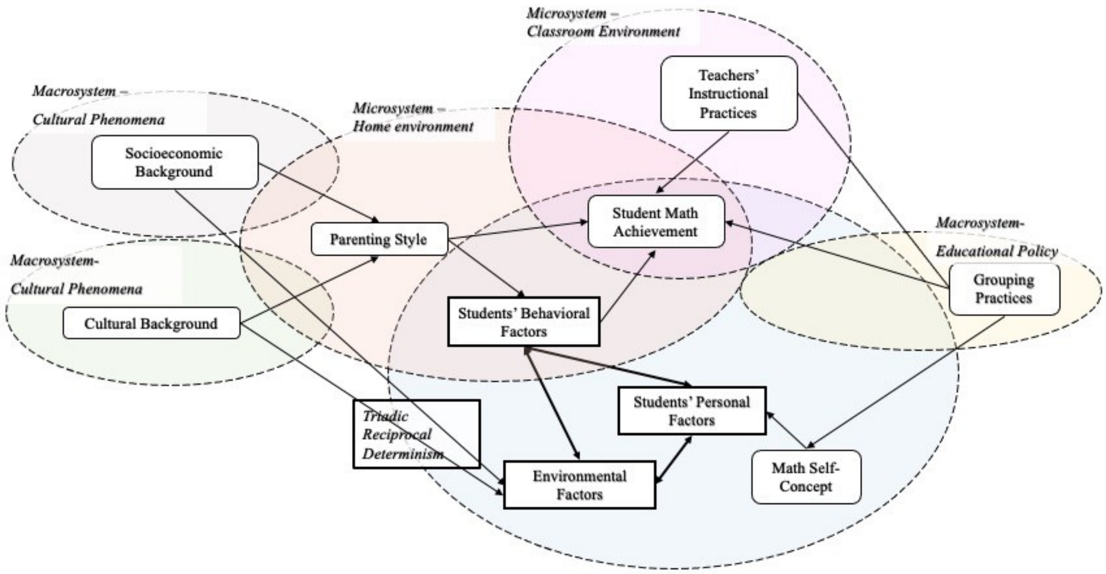
Examining the underlying causes and factors associated with math achievement requires a theoretical framework for learning and development. Bandura (1986) created the social cognitive theory (SCT) to explain human development and functioning through vicarious, symbolic, and self-regulatory processes. The central tenets of the social cognitive theory are offered by a conceptual visualization called triadic reciprocal determinism. This model displays the relationship between behavioral, personal, cognitive, and environmental factors. The reciprocal component establishes the simultaneous influence between the factors; however, simultaneous does not necessarily infer equal distribution. For example, personal and behavioral factors have a reciprocal relationship, but personal factors may have a more substantial impact than behavioral ones.

Additionally, behavioral, personal, and environmental factors do not contribute an equal one-third toward development. The triadic model can be used to examine human development at any stage. According to Bandura (1986), a developing adolescent learner has personal factors such as cognitive, motivational, and affective processes. Environmental factors include vicarious experiences or observing others' experiences and interactions. Behaviors are reinforced or discouraged based on the responses of those around them and the consequences that follow.

The following literature synthesis reviews the factors impacting a public-school student as the focal individual and their math achievement. Neal and Neal's (2013) NEST provides a framework for understanding interactions surrounding the focal individual. Simultaneously, Bandura's (1986) triadic reciprocal determinism as part of the social cognitive theory is used to examine the factors more closely related to the learner.

Figure 1

Integration of Theoretical Frameworks on Student Math Achievement



Note. Adapted from "Nested or Networked? Future Directions for Ecological Systems Theory," by J. W. Neal and Z. P. Neal, 2013, *Social Development*, *22*, p. 728. Copyright 2013 by John Wiley & Sons Ltd.

Synthesis of Literature

Asian Americans and the Model Minority (Myth)

Asian American culture, from the perspective of the theoretical frameworks, is captured by the macrosystem, the ecological system defined as legal, political, and cultural phenomena (Neal & Neal, 2013), and the reciprocal interaction between environment and individual behavior (Bandura, 1986). In this context, Asian Americans primarily consist of populations from East Asia, including China, Japan, Korea, Mongolia, and Taiwan. Southeast Asian countries such as Vietnam, the Philippines, Singapore, and Thailand are also included, as well as the South Asian country of India. The history of Asians in America dates back as early as the mid-19th century during the construction of the Transcontinental Railroad. Today, many Asian and Asian Americans experience a different lifestyle, with high educational attainment, technical career opportunities, and financial stability; therefore, Asian Americans are seen as a beacon of success among minority groups.

Asian Americans are widely accepted as academically high achieving. They are highlighted as the *model minority*, a term used to compare their achievements to other historically marginalized groups, especially populations of color (Hsin & Xie, 2014; Kao, 1995; Mau, 1997). Coined in the 1960s during the Civil Rights Movement, Asian Americans were used as an example of minority groups who could find educational and financial success, implying that other minority groups, Blacks, Latinx, and Native Americans, could access the same success by following the Asian American example (Wu & Battey, 2021). Criticism of the model soon followed, with researchers arguing that using Asian Americans as the paragon for upward mobility in racial groups was harmful and further perpetuated stereotypes (Xu & Lee, 2013). In response, Xu and Lee (2013) condemned the treatment of Asian Americans as a monolithic group, even if they were being positively discriminated against.

Origins of positive stereotyping of Asian Americans as hard-working, subservient, and naturally intelligent surged from the 1965 Immigration and Nationality Act, which selectively allowed Asians to immigrate to America if they held high levels of technical skills (Lee & Zhou, 2014). Seemingly forgotten in the favorable hegemonic narrative was the exploitation of Asian populations in the prior century, including the treatment of Chinese workers as indentured servants as they helped build the Transcontinental Railroad, leading to the Chinese Exclusion Act in response to the influx of Chinese immigrants, the internment of Japanese Americans during World War II, and negative sentiments from the Vietnam War (Gover et al., 2020). The relatively better welfare Asian Americans experience today appears to atone for past transgressions.

Several explanations about Asian Americans and their academic success circulate throughout research, including sociodemographic factors, cognitive ability, and noncognitive ability (Hsin & Xie, 2014; Wu & Battey, 2021). Hsin and Xie (2014) analyzed a sample of the ECLS-K, a national, 6-year longitudinal study to examine whether sociodemographic characteristics, cognitive ability, or academic effort explained Asian Americans' academic advantage. The investigators found no discernible difference between Asian Americans and Whites when they enter school. However, a growing achievement gap in fifth grade that peaked in 10^{th} grade in favor of Asian Americans indicated that cognitive and noncognitive abilities did not strongly explain the achievement gap. Sociodemographic characteristics, such as household income and parents' levels of education, offered the least explanatory power for the achievement gap between Asian Americans and Whites.

Hsin and Xie (2014) argued that affluence and educational attainment still managed to create a network of resources in ethnic communities that reinforced the importance of academic achievement. Asian American students gain the benefits of critical resources supporting education. These resources may include attending extracurricular classes, private tutoring, and preparing for college. Asian American students may also benefit from positive stereotyping associated with the model minority resulting in reinforcing processes underpinning academic achievement. Of the three factors examined, academic effort was strongest in Asian American students compared to their peers in other racial groups, indicating effort was the main mediator toward success. Asian American students were also found to be the least psychologically well-adjusted; the authors suggested that this factor was the cost of such high academic effort.

Asians are not powerless to the model minority narrative and can reproduce it to their advantage. Wu and Battey (2021) studied Chinese and Taiwanese American families and the intergenerational reproduction of the model minority narrative around U.S. schooling approaches to math. Specifically, math curricula, tracking systems, and Asian identity were studied. The participants were 27 K-12 students and 17 immigrant parents from a predominantly Taiwanese-immigrant affluent community in the Northeast United States. Using an ethnographic study spanning 15 months, the researchers collected data through interviews, observations, phone conversations, shadowing families, and materials for college applications.

The combination of institutional and Asian immigrant cultural practices around math education in the United States may contribute to internalizing the model minority narrative in Asian American communities. In Wu and Battey's (2021) study, parent participants from middle to upper-middle socioeconomic backgrounds and science, technology, engineering, and math (STEM) backgrounds compared the approaches in math curriculum and teaching between Asians and Americans. Parents believed American approaches were too slow, insufficient at content coverage, and inadequate in preparing children to answer math problems quickly compared to math education in their home countries. Wu and Battey (2021) believed Asian immigrant parents' backgrounds and educational sentiments explain their decisions to employ extra resources, such as teaching math at home and needing to "get ahead of the U.S. curriculum" (p. 595).

Teaching ahead appeared to reinforce beliefs about the benefits of extra resources. Wu and Battey (2021) found students at the elementary level were finishing their tests faster, getting

100% scores, and feeling math was easy. The students in the study were placed in "high" math classes in middle school when tracking procedures separated students based on ability. Students of like races were subsequently placed together because of supplemental practices enacted in elementary school. One student expressed that if an individual was "not good at math," they "are not Asian," and that "you start to believe that the Asian stereotype is true" (Wu & Battey, 2021, p. 599). Thus, tracking practices promote a socialized aspect of math learning, making cohorts of students throughout middle and high school based on ability. The student participants shared increasing pressure to "try not to look stupid" (Wu & Battey, 2021, p. 599) to their peers and to make high performance appear effortless. Wu and Battey (2021) suggested that this belief constructed a false perception that Asian students were "naturally smart" (Wu & Battey, 2021, p. 599), hiding the strong work habits students employ to gain their high grades.

Neal and Neal's (2013) macrosystem presents the cultural phenomena of the conceptualization of the model minority, a justification to criticize other racial minority groups for freeloading and waiting for handouts when they arrived in the United States. Hsin and Xie's (2014) analysis of the ECLS-K longitudinal study showed that Asian Americans were not just outperforming racial minority groups but also their White peers. The researchers found academic effort, not natural ability, or sociodemographic characteristics, as the main indicator explaining the disparity.

In Wu and Battey's (2021) study, Bandura's (1986) reciprocal relationship between behavior and environment shows the relationship schooling practices and social desirability have on reproducing Asian stereotypes. In Wu and Battey's (2021) study, students of Asian immigrant parents received supplemental instruction at an early age because of poor perceptions of American schooling, resulting in advanced math course placement. The advanced math track became a social conduit in perpetuating the stereotype that Asians are good at math. Students hid their effort to excel in math out of fear of disassociating from their Asian identities, subsequently depicting the inaccurate notion that Asians were naturally good at math.

The association of Asian Americans and wealth also contributes to the model minority myth. The Immigration and Nationality Act of 1965 eliminated prior immigration quotas that disfavored Asian populations and radically changed the ethnic composition of Americans. Still, the act was not an open-door policy and prioritized family reunification and those with labor and technical skills. As a result, those with STEM credentials held greater leverage to be accepted, creating a selection bias that portrayed Asians as naturally intelligent in STEM subjects. The cultural and financial resources needed to pursue STEM careers underpin the socioeconomic context associated with Asians and affluence.

Socioeconomic Affluence

Not until recently have students from affluent backgrounds been studied as at-risk youth (Luthar & Becker, 2002). Using Bandura's (1986) reciprocal model, affluence is an environmental factor that impacts academic achievement through the financial and human resources available to the adolescent learner. According to Neal and Neal's (2013) NEST, social patterns comprise the macrosystem, forming interactions that govern relationships. Students attending schools in affluent neighborhoods do not always come from high socioeconomic backgrounds but are affected by the same social patterns.

Luthar et al. (2021) labeled affluence as the fourth highest at-risk adolescent environment, following poverty, trauma, and discrimination. Adolescents growing up in affluent communities are prone to maladjustment and dysfunction stemming from parents' unrealistic and excessive academic expectations (Stiles et al., 2020). As Luthar and Kumar (2018) explained, affluent youths face an emphasis on college admission into top-tier universities, driving them to hyperfocus on academic performance and extracurricular activities to enhance their profiles on college applications. According to the authors, students are overscheduled and overwhelmed, with less time for leisure and recreational activities with peers and family members.

Parents' focus on success has been shown to affect adolescent well-being, particularly high parent criticism and expectations mean high adolescent mental health (Stiles et al., 2020). Stiles et al. (2020) studied adolescent perceptions of maternal and paternal criticism and self-reported psychopathology in 710 high school and private school students in an affluent region of the Midwest United States. In addition to high socioeconomic status, most parents held graduate degrees, were employed, and were from Caucasian backgrounds. Perceived parental criticism was measured using the Multidimensional Perfectionist Scale (Frost & Marten, 1990), and youth internalizing and externalizing problems self-reported answers on the Youth Self-Report (Achenbach & Rescorla, 2001). The data were categorized into three levels of parental criticism and expectations: low, moderate, and high. The data were also categorized into two levels of psychopathology: internalizing (e.g., poor mental health) and externalizing (e.g., aggression, behavior issues). Adolescents who reported high levels also reported the highest internalizing and externalizing problems.

Peer Relations

Peer relations in affluent communities can also serve as an indicator for internalizing and externalizing symptoms and cigarette, alcohol, and marijuana use (Curlee et al., 2019). Peer relations are another environmental factor in Bandura's (1986) model. These relations are part of a focal individual's microsystem, the compilation of interactions that directly involve the individual, as defined by Neal and Neal (2013).

Curlee et al. (2019) used data from the *New England Study of Suburban Youth* (Luthar & Barkin, 2012), a large longitudinal study tracking sixth-grade students until high school graduation, to study peer reputation, substance abuse, internalizing and externalizing symptoms as indicators and academic achievement as outcomes. Participants included 319 sixth-graders, with 41% attrition by 12^{th} grade. Findings were separated into four peer reputation dimensions: popular, prosocial, aggressive, and isolated. *Popular students* were described as individuals seeking peer attention and approval and easily making new friends. *Prosocial students* were defined as friendly, trustworthy, helpful, and polite. *Aggressive students* held antisocial and hostile behavior, whereas *isolated students* were described as left out and having difficulty making friends. Healthy adjustment outcomes, such as high grades, low psychopathological symptoms, and low substance abuse, were linked to students with a prosocial reputation.

In contrast, those with a popular reputation were positively related to substance use. Isolated peers were not associated with high substance use, possibly because of limited engagement opportunities, as Curlee et al. (2019) suggested. A relationship was also absent with isolated peers and high internalizing problems. Aggressive reputation peers were negatively correlated with academic outcomes and positively with externalizing symptoms and cigarette use.

Though the study examined peer reputation, Curlee et al. (2019) contextualized the findings in the wider affluent environment. The authors explained that prior research in affluent communities supported the link between substance use and peer acceptance. Popular students may be more susceptible to substance use to garner peer approval when partnered with low parental monitoring because of high-demanding careers or excessive extracurricular activities.

Despite the social desirability to obtain wealth and privilege, the empirical studies conducted by Stiles et al. (2020) and Curlee et al. (2019) represented two examples of the potentially negative outcomes associated with affluence. Stiles et al. (2020) showed a positive association between parent criticism and expectations in adolescent psychopathology. Curlee et al. (2019) showed peer relations were linked to academic outcomes in affluent communities. Students perceived as prosocial were associated with positive academic outcomes potentially mediated by high psychological adjustment, whereas those perceived as aggressive were linked to negative academic outcomes.

The literature showed that socioeconomic and cultural background factors framed the sociocultural context of high-achieving Asian American students and their academic experiences. Parents were shown as the main stakeholder in affecting sociocultural factors on their children as they made parenting decisions on what to mitigate, replicate, and magnify in their home environments. The next section explores the relationship between parent and child via parents' parenting styles as the main unit of study.

Parenting Style

Parenting styles directly impact children through parent-child interactions, making it an environmental and behavioral factor in the triadic reciprocal model (Bandura, 1986) and one of the key interactions in a child's microsystem (Neal & Neal, 2013). Parenting style is the emotional climate parents establish through their behaviors, attitudes, and communication with the child (Masud et al., 2015). In a seminal study, Baumrind (1972) suggested three parenting styles, which can be conceptualized as authoritative, authoritarian, and permissive. *Authoritative parents* provide support and guidance in a caring and open-minded manner. *Permissive parents* tend to be undemanding, lacking in disciplinary action, and highly responsive, allowing their children to govern social behaviors. *Authoritarian parents* are highly unresponsive, demanding, and rigid in their children's expectations. Positive outcomes are generally associated with authoritative styles; conversely, negative outcomes, such as behavioral issues, poor mental health, and increased family conflict, are associated with authoritarian parenting orientations (Choi et al., 2013).

Filial piety, or a focus on bringing honor to the family, is a core tenant of Asian academic success (Sung, 2010). Sung (2010) interviewed 20 mothers and 20 older adolescents from Chinese and Korean backgrounds. Interviews focused on experiences during developmental stages and how participants were parented. Emotional intelligence was studied in adolescent participants using the BarOn Emotional Quotient Inventory (Bar-On, 1997) and an interview. Emotional intelligence, or the ability to access, generate, regulate, appraise, and express emotion and emotional knowledge (Sanchez-Nunez et al., 2020), was seen as a moderator variable, explaining parenting approaches and children’s mental health. Adolescents with a very low emotional quotient (EQ) were more likely to have disciplinarian parents who used punitive approaches towards consequences, resulting in feelings of guilt and shame. Some students felt these parenting approaches were outdated while others asserted that their parents for tried their best, despite students’ negative feelings that the parenting approach was not best for them. Medium EQ in students was associated with having parents who enacted some authoritarian tendencies but showed more flexibility; over time, communication became more reciprocal rather than directive between child and parent. Only three adolescents had a high EQ, which was associated with parenting that respected the children’s emotions. Reciprocal communication was found to be a common practice, and the children perceived forms of discipline to be fair and reasonable. Sung suggested these findings reveal parents' potential influence on children's emotional intelligence and overall mental health.

Authoritarian parenting is associated with Asian American parenting style because of their restrictive parental control, strictness on discipline, and lack of warmth (Choi et al., 2013). Attributed to the collectivistic culture of Asian families that emphasize a sense of obligation, respect, and obedience to parents and elders, authoritarian styles are employed to accomplish these ideals. Questions have been raised if Asian parenting styles are necessarily synonymous with authoritarian parenting and, if so, if authoritarian approaches imply bad parenting or simply a misunderstood approach. Wang et al. (2021) studied 974 migrant and urban youth from two cities in Eastern China in a longitudinal study focusing on literacy and math skills. Family socioeconomic status and parenting styles were studied as mediator variables. Family socioeconomic status was measured using parents' highest levels of education, highest-ranking occupations, and annual household incomes. The Parenting Styles and Dimensions Questionnaire (Robinson et al., 1995) and students' final examination scores were used to study parenting styles and academic achievement, respectively.

Wang et al. (2021) indicated family socioeconomic status and parenting styles were significantly associated with migrant and urban youth's academic trajectory but not symmetrically in math and literacy. Positive literacy achievement outcomes were associated with authoritative parenting styles in urban youth. Migrant girls from high socioeconomic status backgrounds and urban youth with authoritative parents were positively associated with higher math development. Migrant children developed literacy skills more rapidly than urban children, but the opposite was true for math skills. Wang et al. suggested that the accelerated growth in literacy skills in migrant children may come from a lack of formal schooling in the early years, followed by a motivation to learn language skills to function in daily life and develop their cultural identities. The authors expressed that the lack of significant results associated with socioeconomic status was unexpected, leading them to consider socioeconomic status as a stronger mediator variable in Caucasian demographics because of less socioeconomic status variance. Wang et al. attributed inconclusive findings in math development to cognitive differences. Any findings on math development were connected to migrant children, perhaps to oversampling and more socioeconomic status variance. Still, the authors confirmed authoritative parenting styles were positively associated with academic progress in literacy and math.

Asian parenting styles may not fit in the three original conceptualizations established by Baumrind (1972) because they do not account for differences in sociocultural context. Using data from the Korean American Families Project, Choi et al. (2013) studied Korean parenting constructs such as co-sleeping practices and disciplinary practices in 291 Korean American families. Western parenting factors were also assessed using Parental Authority Questionnaire (Buri, 1991), Parenting Practices Questionnaire (Robinson et al., 1995), Parental Acceptance and Rejection Scales (Rohner, 2004), and the Linking the Interests of Families and Teachers Project and the Pittsburgh Youth Study. The results showed that the parenting style profile of Korean immigrant and Korean American hybrid families combined authoritarian and authoritative elements. Parental warmth, acceptance, monitoring, and parent-child communication were associated with authoritative parenting. Authoritarian aspects included stern communication with few overt expressions of affection.

Additionally, children were expected to adhere to Korean values, such as respecting the hierarchy of family members. Choi et al. (2013) suggested that despite authoritarian parenting style elements among Korean/Korean American families, attributing the cold, unloving, and harsh authoritarian style was unwarranted because setting high expectations alone was not associated with the negative outcomes typically linked to authoritarian-oriented households. Choi et al. found, instead, that providing explicit expectations and order in the household, partnered with parental warmth, acceptance, monitoring, and communication, creates a safe environment where children understand their roles and boundaries.

When examining children's outcomes, the parents' role in the microsystem extends beyond parenting styles. Directly, children develop emotional abilities through the explicit lessons, interactions, and conversations they have with parents, who guide and reinforce their expressive behavior (Sanchez-Nunez et al., 2020). Indirectly, parents' emotional competencies can implicitly impact children as children observe their parents' responses and express their emotional selves. Children's mental health can be linked to their emotional intelligence, which can be directly and indirectly affected by their parents.

Using Fernandez-Berrocal et al.'s (2004) the Trait Meta-Mood Scale-24, Perceived Emotional Intelligence Scale-24 (Sanchez-Nunez et al., 2013), and the Mental Health-5 (Ware et al., 1992) Sanchez-Nunez and colleagues (2020) studied 170 first-year students from a Spanish university. Their parents and any siblings aged 14 years and older were included. Sanchez-Nunez et al. found a positive correlation between level of emotional attention perceived by fathers in their children with the children's self-reported emotional attention, resulting in a negative impact on the children's mental health. This correlation was also present with the level of emotional attention perceived by mothers, except with a positive impact on children's mental health. The authors suggested the difference may be that fathers' over-attending to emotions were marked by mere acknowledgment of emotions, rather than processing them. Mothers, by contrast, engaged in emotional repair, resulting in well-being. The study confirmed the importance of parents' perceptions of their children and the impact of parents on their children's emotional development and mental health within the child's microsystem.

The combination of authoritarian and authoritative parenting styles may translate to different outcomes based on culture. Watabe and Hibbard (2014) studied the two parenting styles and academic achievement motivation in second-, fourth-, and sixth-grade students from the United States ($N = 208$) and Japan ($N = 312$). Children completed the Parental Authority Questionnaire (Buri, 1991) for parenting styles and the Achievement Goal Questionnaire (Elliot & Church, 1997) for academic achievement motivation. The results showed that American children's academic achievement motivation was highly linked to both parenting styles, with higher reporting of the authoritarian style. In contrast, neither style was strongly associated with motivation for Japanese children's academic achievement. Aside from parenting styles, Watabe and Hibbard found that American children reported higher school enjoyment than Japanese children and speculated that there might be a cultural aspect of feeling shame and pressure at school that prevented children from enjoying their educational experiences. Thus, children's educational experiences can be seen as a product of multiple factors, including cultural elements, parenting approaches, and school factors.

Research on parenting styles widely invokes Baumrind's (1972) three conceptualizations of parents as authoritative, authoritarian, and permissive. Belief systems associated with Asian cultures align Asian parenting styles with authoritarian approaches. Wang et al. (2021) studied migrant and urban families in Eastern China and confirmed positive achievement patterns with authoritative parenting styles, showing that Asian parents practice nonauthoritarian parenting approaches. However, Wang and colleagues' results showed socioeconomic status did not impact students' achievement patterns as seen in prior literature, a point the authors contributed to differences in racial demographics.

Asian parenting practices were studied by Sung (2010) and Choi and colleagues (2013). Sung studied East Asian families and found a positive relationship between adolescents' EQ and parents' reciprocal communication and fair disciplinary practices. Choi et al. examined Asian parenting practices as a combination of authoritative and authoritarian parenting styles, suggesting Baumrind's (1972) three profiles might be limited to norms associated with Western culture and ideology that differ from Asian culture, dispelling the myth that Asian parents only implement authoritarian practices detrimental to their children. Another factor contributing to misconceptions of Asian parenting as harsh and cold may be the inadequate translation of parenting style with parental involvement. Asian parenting styles are consistent with ideals but less consistent with tangible behavior, suggesting that concepts like parental involvement often divert back to expectations and cultural beliefs rather than measurable actions (Gibbs et al., 2017). For example, parents' emotional capacities and projections can also directly and indirectly impact children's mental health through emotional intelligence as a moderator variable (Sanchez-Nunez et al., 2020). Wang et al. (2021) found conflicting results on socioeconomic background on achievement, and family social patterns were less impactful than school environment factors in Watabe and Hibbard's (2014) study; therefore, an investigation into school factors is warranted in understanding academic achievement in Asian American students.

Teachers' Instructional Practices

Where the math classroom is the student's environment, the interactions between teachers and their students form the sociocultural environment (Bandura, 1986) and primary interactions in a student's microsystem (Neal & Neal, 2013). Teachers' instructional practices moderate these interactions, often stemming from their beliefs about math instruction and math education. Researchers have long debated the best instructional practices for math education regarding pedagogical decisions and the purpose of math learning (Sweller et al., 2007, as cited in Eriksson et al., 2018). Regarding math subject knowledge, procedural understanding or how math works versus conceptual understanding or why math works have created the basis of the math wars for nearly a century (Schoenfeld, 2004; Tampio, 2017). Those in favor of procedural understanding argue for the functionality of practical math, a tool needed for tasks related to daily life, such as cooking and budgeting one's finances. An argument for conceptual understanding derives from the evolving demands of 21st-century skills and the need to acquire technical and problem-solving skills in STEM to navigate a global economy.

Math teaching styles come in the form of some combination of three orientations: transmission, connectionist, or discovery (Askew et al., 1997, as cited in Askew, 2019). Rooted in traditional direct-instruction methods, Askew (2019) explained that *transmission-oriented teaching* was teacher-centered, as the transmission of knowledge from teacher to student. *Connectionist orientations* activate prior knowledge, grounding understanding in real-world situations, and critical thinking. *Discovery-oriented instruction* is the most student-centered and constructivist in acquiring learning.

According to Askew (2019), in transmission-oriented teaching, students observe the teacher presenting information with examples and then attempt similar problems independently while the teacher monitors their work. Askew defined mastery as a student's ability to do problems fluently and accurately, achieved by repetitive practice. Supporters of transmissive teaching believe the style is straightforward, requiring less pedagogical strategies, and that students receive what teachers consider the most important information. Critics argue transmission styles are less useful in present-day schooling and suggest the antiquated practice of transmitting.

Askew (2019) described connectionist approaches as combining teacher and student-led components. Students attempt problems much sooner, often working on problems with their peers to encourage dialogue. Mistakes and feedback are embraced and made frequently. Where students in transmission-style classrooms do problems like the teacher's example in a repetitive fashion, students in connectionist classrooms do fewer but more challenging problems that often contain multiple approaches and solutions. Assessments put equal weight on logical reasoning as well as accuracy.

Discovery methods rely on real-world applications and hands-on activities. Teachers implementing discovery-oriented instruction act as facilitators as students create meaning in math concepts. Students use strong reasoning skills to enable trial-and-error and collaboration strategies. Teachers hedge students from exploring incorrect ideas and ask problem-posing questions to activate prior knowledge relevant to the task. Students are assessed on methodology and accuracy, but little attention is paid to the efficiency and generalizability of methods. Askew (2019) posited that teachers' orientations were some combination of the three approaches but typically leaned toward one approach more based on their underlying beliefs and values about math and math education.

Teacher beliefs are a multidimensional construct serving as a relevant albeit adjacent factor in understanding student achievement. Studies examining the most salient aspects of teachers' beliefs will be considered. Muijs and Reynolds (2015) studied teacher beliefs in the form of transmission-discovery-connectionist ideals, along with subject knowledge, teacher self-efficacy, and teacher behaviors and their association with student achievement. Teacher effectiveness was assessed using the change in numeracy test scores in 2,148 primary school students from the United Kingdom from the beginning to the end of the school year. Teachers (*N* = 103) were observed twice a year to collect data on teacher behavior using items on teacher knowledge and global teacher behaviors. Teachers also answered a questionnaire containing elements of the transmission, discovery, and connectionist approaches originally constructed by Askew et al. (1997, as cited in Askew, 2019) and five items on self-efficacy. The results showed that most teachers subscribed to connectionist beliefs and were least likely to transmission-oriented beliefs. Both orientations were negatively correlated with discovery-oriented beliefs. Connectionist beliefs were positively associated with achievement, whereas transmission-oriented beliefs did not correlate with outcomes.

Interestingly, discovery orientation negatively correlated with achievement outcomes. Two clusters were created to generalize the data: effective and less effective teachers. Effective teachers were associated with high scores on teacher behaviors, connectionist beliefs, subject knowledge, and self-efficacy, with low scores on discovery and transmission orientations. The researchers suggest effective teaching relating to connectionist beliefs serves as a reciprocal relationship. Muijs and Reynolds (2015) defined the connectionist paradigm as focusing on connecting "students' prior knowledge and other areas of the curriculum, cognitively challenging students in order to allow them to develop their thinking skills, allowing student input into the lesson, using real life materials, examples, and contexts and correcting misconceptions" (p. 27). It follows that teachers who associate strongly with the connectionist paradigm have various instructional and content-based tools to employ in the classroom, allowing them to manage students' behaviors and mathematical misconceptions. Student behaviors stem from and contribute to a high teaching self-efficacy and strong subject knowledge, enabling them to weave multiple approaches and mathematical concepts while preparing them for academic progress and attainment.

Instructional practices using lecturing, relating math to students' daily lives, and memorizing formulas and procedures correlate to academic achievement. Eriksson et al. (2019) used data from the Third International Mathematics and Science Study (TIMSS) to analyze instructional practices and students' math achievement. The TIMSS collected data at an international level, with the researchers sampling entire classes and linking students' and teachers' survey results together. Student achievement data from eighth graders from the 2003 and 2007 studies were used, including 45 and 50 countries, respectively, and the 2011 and 2015 studies from Sweden. Treating socioeconomic backgrounds and peer effects as control variables, the researchers found an increased presence in listening to lectures and memorizing formulas in Swedish math classrooms, which related to strong positive effects on students' math achievement, whereas connecting math to daily life had a negative effect. The 2007 wave of the TIMSS contained data from 50 countries. Strong positive effects on math achievement were found in classrooms where the teacher employed memorizing formulas and procedures, and negative effects with connecting math to daily life but with potential contamination effects both within and between country differences.

Instructional practices are a key moderator variable in creating the student's microsystem (Neal & Neal, 2013) and the reciprocal relationship between the student's environment and behavior (Bandura, 1986). The debate about the best math education practices has been ongoing since math education reform (Schoenfeld, 2004). Instructional practices have several dimensions, labels, and rationales. Classroom practices can range from teacher-centered lecturing to student-centered discussions on connections and application. Askew (2019) suggested that these practices combine three types of math instruction: transmission, connectionist, and discovery orientations. Muijs and Reynolds (2015) investigated the beliefs underlying the three types of math instruction and found connectionist practices stemmed from strong beliefs of self-efficacy and high subject knowledge. The researchers suggested connectionist beliefs, and therefore practices associated with those beliefs, served a reciprocal relationship with effective teaching, where teachers had diverse instructional strategies available inside the classroom. The mathematical content covered ranges from math encountered in daily life to the pure abstract. Eriksson et al. (2019) found increased reporting from 2011 to 2015 of lecturing and memorizing formulas practices in Swedish classrooms as part of the TIMSS data, showing a strong positive correlation with students' math achievement. The teacher largely decides instructional practices, but other factors contribute to the math classroom environment. The next section examines grouping students on like ability to understand any associations in framing the math learning environment.

Ability-Grouping

Ability grouping serves as a factor in the focal student's macrosystem (Neal & Neal, 2013) and shapes the composition of students in math classrooms based on similar cognitive abilities. Grouping students based on academic ability activates all three components of Bandura's (1986) triadic reciprocal determinism because students' cognitive factors are used to place students in their leveled math classes, and students behave reciprocally with like-ability peers in math classrooms differentiated for their levels with likeability students.

Ability grouping, sometimes called placement tracking, set-attainment grouping, or within-class grouping, is defined as "the assignment of students to different types of education-kind of school, curricula, subjects, classes-according to their ability, interests, or attitudes"

(Terrin & Triventi, 2023, p. 51). According to Terrin and Triventi (2023), ability grouping is another debated topic from the math wars era because of its consequences for academic achievement; educational pathways in secondary and higher education; and, eventually, economic outcomes.

The meta-analysis performed by Terrin and Triventi (2023) and a second-order meta-analysis by Steenbergen-Hu et al. (2016) summarized the historical and evolving context of grouping practices. According to both analyses, supporters argued that students learned when grouped with similar-ability students because less differentiation was required, and teachers could focus on content appropriate for a student's level. Others criticized the disparity of access and resources allocated to the different levels, particularly marginalized and disadvantaged students. Terrin and Triventi (2023) and Steenbergen-Hu et al. (2016) found a main conclusion drawn from reviewing studies on ability grouping that indicated many benefits belonged to high-achieving groups. However, Terrin and Triventi (2023) and Steenbergen-Hu et al. (2016) suggested re-examining the advantages high-achieving students could receive from ability grouping in math at the cost of potential long-term issues with academic self-concept.

High-achievers and gifted students are a few classroom groups to receive differentiated instruction fostering their exceptional academic level. However, concerns about poor socioemotional development in contained classrooms raise questions about the benefits of grouping students based on ability (Terrin & Triventi, 2023). Campbell (2021) criticized ability grouping practices as inaccurate and easily influenced by social factors, including demographic characteristics and socially embedded norms. As Campbell (2021) noted, "There is error and misallocation in placement, and placement influences children's experiences and progress." (p. 564).

A noncognitive factor that may explain the benefits of ability grouping in high-achieving students is teacher judgments, which may act as a mediator variable on math achievement (Campbell, 2021). The Pygmalion effect (Rosenthal & Jacobson, 1968), or the effect of distorted expectations a leader has on their followers, is a form of self-fulfilling prophecy where teachers expect higher performances from a group of students over another, leading to a phenomenon where the high expectations group makes greater progress for unknown reasons, even in the same amount of time. Campbell (2021) studied math ability grouping and students' self-conceptualizations via teacher judgments as a moderating variable. Math self-concept is one of three categorizations of math self-beliefs, self-efficacy, and anxiety (Kaskens et al., 2020). Data from the U.K. Millenium Cohort Study, a national longitudinal study, were gathered from 4,463 students from age 5 until 11. Analysis showed math ability grouping and teacher judgments at age 7 predicted grouping at age 11. Children grouped in low-ability classes had 2.5 times the odds of a negative math self-concept, and children whose teachers judged them below average in math had three times the odds compared to the highest group. Campbell suggested that teachers' high expectations of high-ability students were more likely to translate to increased time on lesson planning, providing students with more feedback, exposing students to higher-order questions, and positively managing students' behaviors. Thus, teachers might be high-expectation or low-expectation learning based on class type rather than students' ability.

Ability grouping is a policy implemented at a school district level, making the practice a factor impacting the adolescent learner's macrosystem (Neal & Neal, 2013). High-achieving students who are grouped create a classroom environment that interacts with students' factors, a part of the reciprocal nature of the environmental and personal factors in Bandura's (1986) reciprocal model. Supporters of ability grouping suggest differentiated teaching is appropriate for students with high cognitive capabilities because students benefit from differentiated teaching that meets their exceptional needs (Terrin & Triventi, 2023), whereas opposers criticize ability grouping for its negative associations at a personal and societal level (Campbell, 2021; Terrin & Triventi, 2023). In studying ability grouping and students' math self-concept, Campbell (2021) found teacher judgments predicted grouping and math self-concept in elementary school students. In addition to the other two components under math, self-beliefs are examined to understand their association with math achievement.

Math Self-Beliefs

Math self-beliefs are characteristics of an adolescent learner, the focal individual of NEST (Neal & Neal, 2013), and are a personal factor in Bandura's (1986) triadic model. Math self-efficacy, anxiety, and self-concept are three components of self-beliefs that serve as the strongest noncognitive predictors of math achievement, accounting for approximately 16% of the variance in math achievement (Lee, 2009, as cited in Morony et al. 2013; Organisation for Economic Co-operation and Development, 2003). Morony et al. (2013) defined self-efficacy as "a person's belief in their ability to bring about desired specific outcomes" (p. 2), as originally constructed by Bandura (1986). Morony et al. (2013) defined self-concept as "a student's self-comparison to his or her immediate peers" and anxiety as "physiological and affective responses when performing or thinking about a [math] task" (p. 2). Morony et al. (2013) replicated the multicultural PISA (Organisation for Economic Co-operation and Development, 2003) findings to investigate confidence as another noncognitive self-belief construct. Morony et al. (2013) studied 7,167 secondary school students from nine countries in Europe and East Asia using an online survey composed of items from the PISA 2003 Student Questionnaire and the Memory and Reasoning Self-Concept scale (Kleitman & Stankov, 2007). Morony et al.'s (2013) results corroborated the PISA study at both the between and within-country level suggesting the highly generalizable nature of self-beliefs as a noncognitive construct. The investigators found confidence was more closely related to accuracy and test performance, which were considered cognitive factors, with self-beliefs as explanatory variables, thereby provoking the idea that confidence could mediate between noncognitive and cognitive factors indicative of math achievement.

Kvedere (2014) replicated findings using Morony et al.'s (2013) instrument to study 3,077 Latvian ninth-grade students. Cluster analysis revealed two approximately equal groups of students, those with positive and negative math self. Positive math self included high math self-efficacy and self-concept, with low anxiety, and was more prominent in boys than girls. In contrast, negative math self included low math self-efficacy and self-concept, with higher anxiety. A significant finding revealed high math self-efficacy in students attending educational programs for minorities, showing a potential benefit of ability-grouping practices. Kvedere (2014) implored math educators to acknowledge the importance of students' math self-parameters because they impacted students' acquisition of math and to "pay as much attention to students' perceptions of capability as to actual capability" (p. 2689).

Kaskens et al. (2020) studied teacher competencies with math self-beliefs and development to consider how math teachers could mediate children's math self-beliefs and development. Teacher competencies include creating a positive and productive learning environment, clear instruction, various teaching strategies, and efficient classroom management. Math development includes arithmetic fluency and mathematical problem-solving, the two main cognitive factors predicting future math development (Kaskens et al., 2020). Participants were 37 teachers and 610 fourth-grade children from 27 elementary schools in the Netherlands. Math achievement was assessed using the Speeded Arithmetic Test (De Vos, 2010) for arithmetic fluency, a criterion-based math test for mathematical problem-solving (Janssen et al., 2005), math self-beliefs using the Mathematics Motivation Questionnaire for Children (Prast et al., 2012), and the International Comparative Analysis of Learning and Teaching (Van de Grift, 2007). For actual teaching behavior of teachers in their math lessons, the Teachers' Sense of Mathematical Knowledge for Teaching Questionnaire (Kaskens et al., 2016) and the Teachers' Sense of Self Efficacy Scale (Tschannen-Moran & Woolfolk Hoy, 2001) were used. Of the math self-beliefs, only math self-concept predicted arithmetic fluency. The authors explained this finding could be because of fourth graders having more experience with arithmetic than mathematical problem-solving. Because the authors could not replicate findings for other self-belief components, they suggested math self-concept as the most stable predictor of math achievement.

Kaskens et al. (2020) found a few surprising findings. Teacher factors were shown to associate with children's math development negatively. Math teaching self-efficacy unexpectedly had a negative relationship with children's development in math problem-solving. The authors found that teachers focused on transmission-oriented teaching and were ill-equipped for spontaneous learning with diverse approaches, an explanation the researchers extracted from Muijs and Reynolds's (2015) work on teacher beliefs, instructional practices, and effectiveness. Kaskens et al. (2020) suggested teachers reporting high math teaching self-efficacy might not entirely understand the nature of math problem-solving at the elementary level, thereby inadvertently not teaching complex problems leading to low development in math problem-solving in children. High mathematical teaching knowledge resulted in math development, an expected result because teachers likely knew the importance of fractions and operations with numbers for math development and engaged in direct instruction associated with transmission-style teaching.

The PISA (Organisation for Economic Co-operation and Development, 2003) results showed math self-beliefs: math self-efficacy, self-concept, and anxiety are the strongest noncognitive predictors of math achievement. Morony et al. (2013) replicated these findings in European and East Asian countries. In studying confidence as a construct, they found a potential mediator between the noncognitive factor of math self-beliefs and the cognitive factor accuracy. Kvedere (2014) also corroborated the PISA (Organisation for Economic Co-operation and Development, 2003) findings with Latvian secondary students, adding that high math self-efficacy, high math self-concept, and low math anxiety were present in half the participants but were more prominent among boys. Kvedere beseeched math educators to take heed of noncognitive factors and their significant impact on math achievement. Kaskens et al. (2020) studied teacher competencies on math self-beliefs and math development. Only math self-concept was found to predict math development in Kaskens et al.'s study, suggesting that math self-concept was the most stable among the three math self-belief components. Their hypotheses on teacher competencies were unmet, and contradictions were attributed to ineffective teaching, as discussed by Muijs and Reynolds (2015).

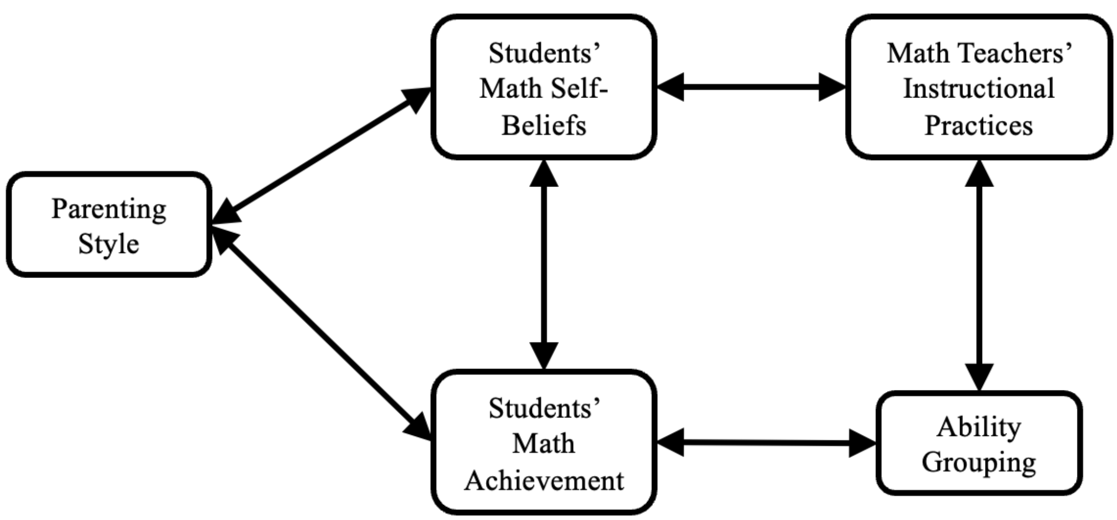
Conclusion

This literature review provided a vignette of a high-achieving adolescent math learner in a predominantly Asian and Asian American affluent context through the theoretical frameworks of the networked ecological systems theory (Neal & Neal, 2013) and social cognitive theory (Bandura, 1986). The discussion included the sociocultural contexts that Asian Americans faced as the model minority, pressures associated with affluent communities to perform academically, and diverse family experiences based on various parenting styles. After closer examination of the math classroom, the existing literature provided empirical evidence of significant associations with the type of math teaching instructional practice and ability grouping on math achievement. Still, regarding noncognitive factors, math self-beliefs, such as math self-efficacy, self-concept, and math anxiety, were the strongest predictors of math achievement.

Figure 2 shows the following conceptual framework and represents the most salient and observable factors in students in the context of the problem of practice. A needs assessment study was conducted to understand the interactions of these factors based on math teachers' views. The study design and findings are discussed in Chapter 2.

Figure 2

Conceptual Framework of Salient Factors of Literature Review in the Problem of Practice



Chapter 2

Needs Assessment

Introduction

The literature, as discussed in Chapter 1, provides empirical evidence for the multitude of ways student math achievement is influenced. The problem of practice under examination involves high-achieving students in an affluent, predominantly Asian American community in Silicon Valley, California, and the potential associated risks of maladjustment, psychopathology, and math achievement issues. Neal and Neal's (2013) networked ecological systems theory (NEST) provides a framework to understand the diverse interactions in a focal student's ecology, potentially impacting their math achievement. Bandura's (1986) social cognitive theory provides a model for understanding individual development. The student profile in the problem of practice under examination was represented by a high-achieving student attending a public middle school in an affluent and predominantly Asian American suburb of Silicon Valley, California.

Context of the Study

The needs assessment occurred at a high-achieving public school district serving Kindergarten to eighth grade in Silicon Valley, California. Enrollment for all grades totaled 16,718 students, with 15.8% English Language Leaners and 5.1% socioeconomically disadvantaged. The population is predominantly Asian (72.5%), White (14%), and Hispanic or Latino (5.2%). Students consistently exceed expectations in English language arts and mathematics on standardized state testing. Only the five middle schools in the district were considered for the needs assessment. The total enrollment in the middle schools was 5,713 students.

Statement of Purpose

The purpose of the needs assessment was to understand factors contextualizing students' math attainment, as presented in the literature. Factors included math teachers' instructional practices, parenting styles, and students' math achievement. Teachers were surveyed and interviewed using a mixed-methods research design because they could provide insight into all three constructs.

Research Design

Students' math achievement is a complex and multidimensional construct best studied through quantitative and qualitative methods. Purely quantitative research on students' math achievement would lack contextual understanding of salient factors, while studying math achievement with qualitative methods risks overemphasizing nuanced results not indicative of the wider population (J. W. Creswell & Plano Clark, 2018). A mixed-methods approach is often the best approach in studying adolescents and their math achievement because integrating both quantitative and qualitative methods allows each method to compensate for the weaknesses of the other.

The needs assessment used an explanatory sequential mixed-methods research design (J. W. Creswell & Plano Clark, 2018). The study gathered quantitative data on students' math achievement and teachers' beliefs about math education. The quantitative survey results informed the qualitative component, a semi-structured interview with consenting teachers.

Study Aims

Two instruments were combined to gather information to inform the interview questions for the qualitative component. Table 1 provides an overview of the guiding research questions related to the literature review's constructs and measures.

Table 1

Alignment of Research Questions to Constructs

Research question	Construct	Indicator	Citation
RQ1: How do middle school math teachers evaluate their struggling students?	Students' math achievement	"The teacher questionnaire was designed to illuminate questions on the quality, equality, and diversity of educational opportunity by obtaining information in … the teacher's evaluations of the student" (p. ELS-2).	ELS:2002
RQ2: How do middle school math teachers report their instructional activities?	Teachers' instructional practices	"The teacher questionnaire was designed to illuminate questions on the quality, equality, and diversity of educational opportunity by obtaining … information about the teacher's background and activities" (p. ELS-2).	ELS:2002
		"The questionnaires asked about the teachers' education …, the frequency they do various instructional activities, difficulties in providing instruction, curriculum topics covered, assessment practices" (p. 2.2).	Third International Mathematics and Science Study – Repeat, 1999

Method

An explanatory sequential design entails using quantitative methods to inform the qualitative component (J. W. Creswell & Plano Clark, 2018). Using the Qualtrics survey platform, an online survey (see Appendix A) adapted from the Education Longitudinal Study of 2002: Base-Year Teacher Questionnaire (ELS:2002-BYTQ; Ingels et al., 2004) and the Third International Mathematics and Science Study – Repeat (TIMSS-R, 1999; Martin & Mullis, 2000) was sent to teachers' school email addresses. The survey results were statistically analyzed using IBM SPSS Statistics (Version 27) software.

Based on the analysis, qualitative interview questions were created to address residual wonderings and areas for additional contextualization. Participants who answered the online survey were invited to a semi-structured interview. The questions used to frame the interview were extracted from the two questionnaires used for the survey to maintain construct validity.

The interview occurred on an online conference application, Zoom. The interview was audio recorded using the application, Voice Recorder. The interview was then transcribed to text software, Otter.ai, for qualitative coding.

Participants

The main stakeholders of a student's math achievement are the student, their parent(s), and their math teacher. However, only math teachers were recruited to participate in the study. Teachers offer a range of high-quality observations and assessments of students' math performance. Students' reactions and behaviors toward math occur mostly in the school setting. It is a common practice for teachers in the current context to hold parent/teacher conferences to discuss behaviors and achievements. Therefore, teachers have insight and observations with both students and parents. Teachers can provide valuable information on their teaching practices. Though teachers' judgments are not perfectly accurate, their knowledge provides an overview of the problem of practice.

Teachers were recruited to capture student information as approved by the Johns Hopkins University Homewood Institutional Review Board (JHU-IRB). Purposeful sampling was used to solicit participation from middle school math teachers working in the district—a large school district serving Kindergarten to eighth grade in an affluent suburb of Silicon Valley, California. A recruitment email was sent by the director of instruction, who worked closely with math teachers at each site in the district, in the Spring of 2020. The middle school includes sixth- to eighth-grade instruction. Because it is common for sixth-grade teachers to teach multiple subjects, such as math and science, only seventh- and eighth-grade teachers, who only taught one subject, were recruited. Fifty-seven middle school math teachers were contacted through their school emails.

Measures

Select items from the ELS:2002-BYTQ and the Third International Mathematics and Science Study – Repeat (TIMSS-R) were combined into one instrument to capture student achievement and math teachers' instructional practices. The ELS:2002-BYTQ assesses students' trajectories, while the TIMSS-R specializes in content and cognitive dimensions in math and science (Orletsky et al., 2015). Though the instruments have strong independent psychometrics documenting their reliability and validity (Rock & Pollack, 2002; Schult & Sparfeldt, 2016), they were not cocreated or used for the same purpose, compromising the final questionnaire. The potential of unusual or perplexing results provides even more reason for an explanatory sequential mixed-methods design, intending that the qualitative strand would explore findings in depth and bridge the two phases (J. W. Creswell & Plano Clark, 2018).

Education Longitudinal Study of 2002: Base-Year Teacher Questionnaire

The ELS:2002-BYTQ was created to conduct a nationally representative longitudinal study of 10th graders in 2002 and 12th graders in 2004 (Ingels et al., 2004). The study was focused on students' educational and workforce trajectories beginning in high school and college access and attendance. A rigorous evaluation of the study, including the questionnaire, was conducted to ensure strong psychometric measures. Ingels et al. (2004) established strong validity and a reliability coefficient of 0.92.

In addition to students, parents, math and English teachers, and school administrators were surveyed. The survey administered to teachers was the ELS:2002-BYTQ. Questions from the ELS:2002-BYTQ were used to answer both research questions. The first research question regarding teachers' evaluations of students was assessed using questions about course placement, homework habits, attention and behavior in class, and parent involvement. The second research question addressing instructional activities was assessed using questions about beliefs about success and math ability. As discussed in Chapter 1, instructional practices were closely related to teachers' beliefs as they drove teachers' behaviors and pedagogical decision-making (Muijs & Reynolds, 2015).

The teacher questionnaire originally contained 42 items partitioned into two parts: student information and teacher background and activities. The student information section asked teachers to report on every student on their current class roster. Because of feasibility and IRB restraints, non-essential questions were omitted. These questions included reporting on the student's English class, teacher demographics, level of education, professional development training, and use of technology. The final instrument sent to participating teachers contained 20 questions, 18 of which were extracted from the ELS:2002-BYTQ. Teachers were instructed to consider a representative student who typically struggled in their math classes and respond to the questions with the student in mind to capture the underlying factors behind the student's low or underachievement. Because of the variety of questions on the ELS:2002-BYTQ, multiple response options were offered. Some questions were answerable with a "Yes" or "No," while others asked to select the frequency of behaviors, rank statements based on their level of agreement, and choose an option that best described the student.

Third International Mathematics and Science Study – Repeat

The TIMSS-R was originally used to measure math and science achievement in eighth-grade students as part of a regular cycle of international assessments that analyzes achievement trends over time. Martin and Mullis (2000) attest to the strong psychometric properties of the TIMSS-R, including an international median reliability coefficient of 0.89. Additionally, Chen et al. (2006) rigorously evaluated the TIMSS-R, specifically for Asian participants, and concluded strong psychometric properties.

Two TIMSS-R 1999 questions were used to assess the second research question about teachers' instructional practices with items specifically for math teachers. The survey contained 46 questions split into three sections, approximating 50 minutes to finish. The first section was unnamed and contained questions about demographic and professional background, teaching experience and practices, and beliefs about math ability. Section B had a prompt asking teachers to answer the questions based on their current math class. Section C was titled *Professional Development Activities* and contained questions about the teacher's participation in professional development related to math teaching. For the present study, the TIMSS-R was used to address the third research question about teachers' beliefs about students' mathematical performance. Two of the 46 items in the original survey were used in the questionnaire.

Semi-Structured Interview

The questions used in the semi-structured interview were open-ended versions of select questions from the quantitative survey. The three questions related to teacher interactions with students and parents in the survey were insufficient to answer the research questions. The questions were transformed into open-ended questions for the interview. The two questions pulled from the TIMSS-R for the survey served as interview questions in an open-ended format for the same reason. No survey questions asked for identifying information, and the instructions stated that identifying information about the teacher or student should not be revealed.

Procedure

Participant Selection Process

JHU-IRB approved the study. All middle school math teachers in the district were sent a recruitment email, disseminated by the director of instructional leadership and intervention of the school district on behalf of the researcher. The email offered a brief description of the researcher and study, along with an attachment of the JHU-IRB consent form for reference. Participants were informed that their involvement in the study would include a 10- to 15-minute survey and a possible 45- to -60-minute interview conducted online. A link to the survey was included in the email and directed teachers to the questionnaire in Qualtrics. The first question asked teachers to indicate their consent and required a selection to continue the survey. If they indicated that they did not consent to participate in the study, Qualtrics ended their survey and gave validation of receipt message.

Data Collection

Qualtrics

Qualtrics is an online survey application used to collect teachers' responses to the survey. The first question asked for teachers to indicate consent. If the teacher agreed, Qualtrics allowed them to take the rest of the survey. Qualtrics concluded the survey if the teacher did not consent and showed a message thanking them for their participation.

Zoom

Zoom is an online video conferencing application to audio record the semi-structured interview. Teachers interested in being interviewed responded to an additional recruitment email containing the email addresses of 57 math teachers in the district, the entire population. Eight teachers responded, but only six were interviewed because of attrition. The researcher sent a calendar invitation to their work-assigned email using Google Calendar, containing the Zoom link that gave them access to the meeting. Interviews were conducted in the May of 2020. The interview began with requesting verbal consent from the teacher. A PDF of the questions was screen shared during the meeting for participants' reference. The audio recording was converted to text using transcription software, Otter.ai, producing a transcribed document of the audio files.

Data Analysis

Participants

Responses totaled 23 submissions, but 16 entries were analyzed after removing incomplete responses. Of the 16 participants, 12 identified as White, and four identified as Asian. The average years of experience was 11.71 years. Teachers' math background included no math course-taking at the postsecondary level ($n = 1$), some math course-taking but not primary field of study ($n = 10$), and math was the major/minor field of study ($n = 5$). All teachers taught math at the middle school level the previous school year. One teacher taught math to special education students.

Quantitative Analysis

Descriptive statistics were used to analyze the data. One question was removed, "In your opinion, does this student have a learning, physical, or emotional disability that affects his/her schoolwork?" because there were two missing responses. For reporting fidelity, 10 teachers indicated "No," and two indicated "Yes." Two types of questions were asked to evaluate students, "Yes/No" responses (Table 2) and frequency (Table 3). Two remaining questions asked for responses that were neither of these types: "Is this class too difficult, the appropriate level, or not challenging enough for this student?" and "How far in school do you expect this student to get?" Their results will be included in the discussion of the overall results. Four questions asked teachers to report on math instruction, including their beliefs and related instructional activities (Figures 3 to 7).

Qualitative Analysis

Braun and Clarke's (2006) six-step thematic analysis and Hsieh and Shannon's (2005) summative content analysis were used to analyze the qualitative data. Braun and Clarke (2006) developed thematic analysis as a systematic approach to analyzing qualitative data accessible to novice researchers and free from theoretical limitations. Qualitative researchers use this method to produce rigorous and high-quality data analysis. The first phase is to familiarize oneself with the data and make conjectures of patterns and meaning. As mentioned in the procedure section, in vivo coding was used in the initial code generation, the second phase of thematic analysis. Once generated, the third phase sorted codes into themes that connected the relationship and meaning among codes. The fourth phase included a comprehensive review of the data set. The fifth phase is meant for analyzing the broader narrative of the interviews and how the themes produced a coherent story which could be communicated as findings of the study, or the sixth phase. Hsieh and Shannon's (2005) content analysis is used to understand the prevalence of repeated phrases and keywords in interviews, field notes, or other documented media. The summative content analysis quantifies qualitative data by recording the frequency of keywords providing information on the distribution of the codes, giving readers an idea of the proportion of certain codes that arose in interviews.

Vaismoradi et al. (2013) discussed using content and thematic analysis in a research study. According to the researchers, employing only content analysis may leave out contextual information because it only presents a frequency of codes. Certain codes tend to occur more frequently if participants are from a homogenous group. Though the process of conducting thematic and content analysis is similar, they contend implementing both provides a potential understanding of the data set not available when conducting only one type of analysis.

Otter.ai was the application used to transcribe audio recordings. The note-taking feature of the application was used to conduct the first cycle coding using in vivo codes and direct extractions from the transcript of interviews. Similar phrases or answers were grouped based on pattern coding for the second coding cycle (Miles et al., 2014). The last coding cycle used a priori codes derived from the literature review and research questions to interpret the overall qualitative data broadly.

Results

Quantitative

Table 2

Teachers' Evaluations of Students – Yes/No Questions

Question	Yes		No	
	n	%	*n*	%
Does this student usually work hard for good grades in your class?	3	19	13	81
Does this student seem to relate well to other students in your class?	10	63	6	38
Is this student exceptionally passive or withdrawn in your class?	6	35	10	63
Has this student fallen behind in schoolwork?	14	88	2	13
Have you or will you recommend this student for academic honors, advanced placement, or honors classes?	0	0	16	100

Note. N = 16.

Table 3

Teachers' Evaluations of Students – Frequency Questions

Question	Never		Rarely		Some of the time		Most of the time		All the time	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
How often does this student complete homework assignments for your class?	0	0	6	38	8	50	2	13	0	0
How often is this student absent from your class?	5	31	7	44	4	25	0	0	0	0
How often is this student tardy to your class?	5	31	4	25	5	31	2	13	0	0
How often is this student attentive to your class?	0	0	2	13	8	50	5	31	1	6
How often is this student disruptive in your class?	12	75	2	13	1	6	1	6	0	0

Note. N = 16.

Figure 3 shows teachers' responses for students to achieve their goals, with red-alike colors representing student elements and green-alike colors representing teacher elements. In Figure 4, green represents a sentiment aligned with the growth mindset, and red represents sentiments aligned with a fixed mindset to show math ability (Dweck, 2006). Figure 5 shows the distribution of underlying beliefs. Items were organized based on the researcher's interpretation of their alignment with Askew's (2019) math teaching orientations: transmission (reds), discovery (oranges), and connectionist (greens) to visualize trends in teaching orientations.

Figure 3

*Math Teachers' (*N *= 16) Responses to Teacher and Student Elements to Successful Students*

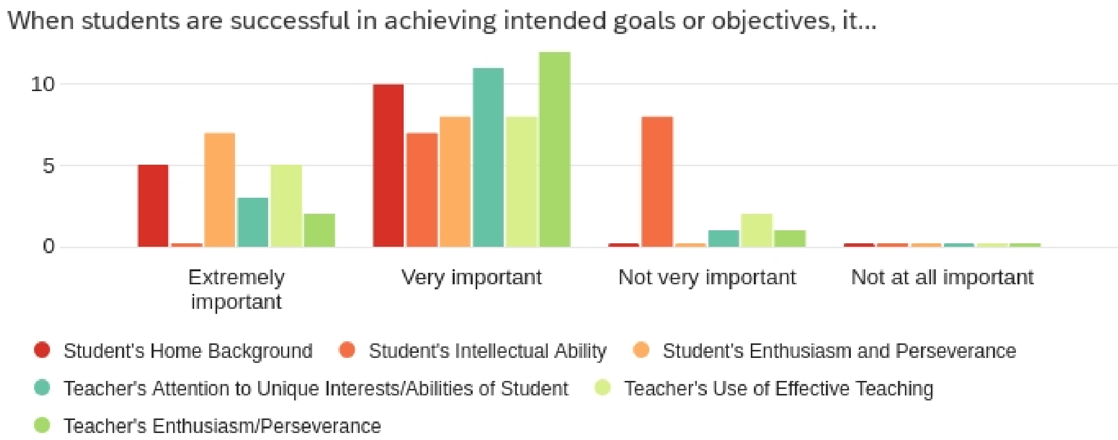


Figure 4

*Teachers' (*N *= 16) Beliefs about Math Ability*

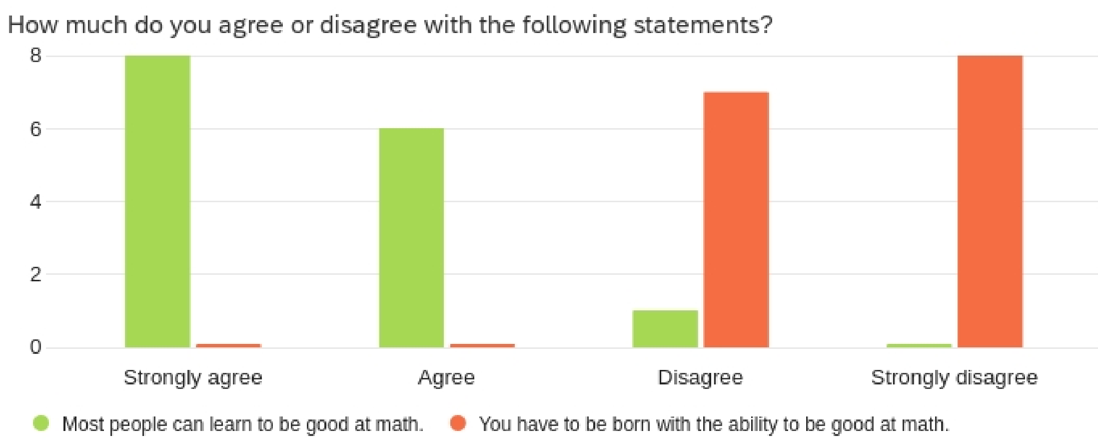
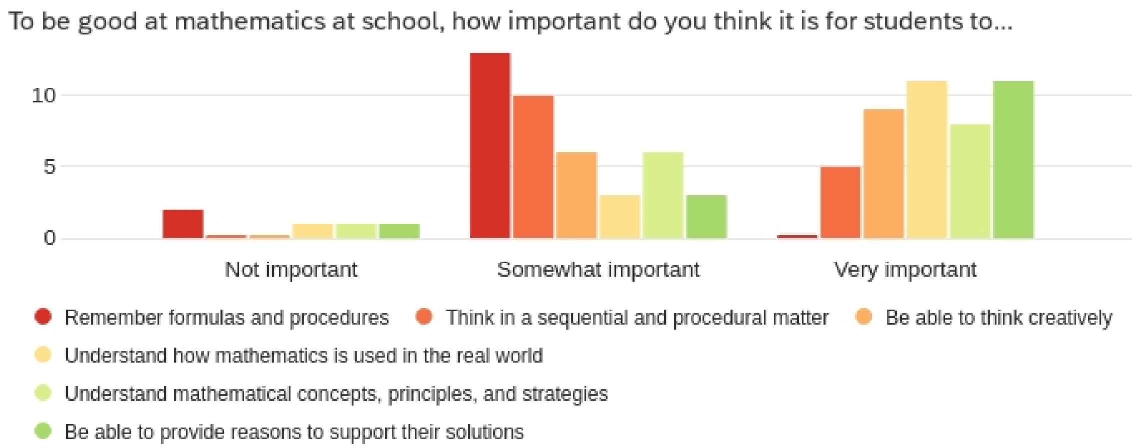


Figure 5

*Teachers' (*N *= 16) Instructional Practices and Orientations*



Teachers were asked to answer questions about student evaluation with a representative struggling student in mind. Teachers did not report behavioral issues such as tardiness, absences, or being disruptive. According to the teachers, students mostly struggled with coursework completion, social adjustment, and paying attention. Of the 16 teacher responses, half of the teachers indicated the course was too difficult. In contrast, the remaining half reported that it was an appropriate level, but none of the teachers indicated recommending the student for honors courses. Predicted trajectories of the student's academic achievement ranged from high school graduation to graduating from a 4-year college, but not a master's or professional degree.

Math teachers found enthusiasm and perseverance an important component for both teachers and students for students to find success (Figure 3). Students' home backgrounds and intellectual abilities were prioritized. Teachers' attention to students' unique interests and abilities and effective teaching were also highly prioritized. Interestingly, math teachers, including special education teachers who taught math, were almost equally split between believing math can be mastered through learning and being born with the ability (Figure 4).

Teachers agreed least with transmission-style practices, such as remembering formulas and procedures and thinking sequentially. Discovery-orientation beliefs including thinking creatively and using math practically was considered as the second important. Connectionist-orientation was considered the most important which included understanding concepts, principles, and strategies, and being able to support one's reasoning.

A diverse student population was represented in the interviews considering only six teachers participated. Students in special education, remedial math classes, and advanced math classes were represented by their math teachers. Similarly, the students came from sixth, seventh, and eighth grade and three out of the five middle schools in the district.

Teachers' semi-structured interviews were consistent in evaluations of struggling students. Six teachers agreed to be interviewed, including five math teachers and one special education teacher. Math teachers reported consistent and ongoing communication with parents as a sign of the child struggling. One teacher reported, "emails, with both the student and with the mother, all times of the day, early in the morning, 10 o'clock at night." All six teachers reported what they believed was the student's motivation, including disinterest, frustration, and fear. Additionally, all interviews contained elements of parent pressure, students' lack of executive functioning skills, and various support strategies.

The topic of support strategies provides a glimpse into teachers' beliefs about math education. Summative content analysis showed the theme of support strategies was the most frequently mentioned, followed by parent-teacher interactions, teacher-student interactions, and student motivation. Strategies included spending more individualized time with the struggling student, employing frequent check-ins for understanding, and updating families on progress.

Teachers' beliefs about math education diverged on almost every dimension. Some teachers found value in algorithms and procedures. Others thought they were antiquated and didn't do justice to mathematics. Some believed individuals could have a natural talent for math, while others believed effort and practice were the primary predictors of math learning. Interestingly, all teachers attributed their beliefs to their personal experiences with learning math and whether math came easily to them at a young age. Even with divergent beliefs, four of the six teachers expressed appreciation for new approaches in math education, but at varying degrees. A sixth-grade teacher said they wished these approaches were available as a young learner instead of the rote learning they experienced. A seventh-grade teacher, a former engineer, said they saw value in the approaches when referring to discovery teaching methods. The seventh-grade teacher states that at some point, "you just need to teach them the math."

Parent-teacher interactions were the second most discussed theme; teachers were more emotional when discussing interacting with parents, showing visible frustration, confusion, and sympathy. When disagreements arose, the teachers explained, they were always based on a misalignment of the student's ability. Parents tended to think highly of their child's ability, while teachers tended to think the child was struggling. Following Baumrind's (1972) three parenting styles, one parent was perceived as permissive. The math teacher implied the parent was too trusting when the child said they had finished their homework. The same parent initially denied teachers' concerns about the son struggling academically but conceded after several notifications. At that point, the parent "struggled knowing how to support," said one math teacher. Five of six teachers said they expect the parents to override this decision and put their child in advanced math anyway. A sixth-grade teacher said, "Why is there this constant need to push? It seems like it's year after year, and in the 14 years I've been here, that it's a constant ‘accelerate, accelerate.’ What’s the reasoning behind it?” The exception came from the sixth-grade teacher who taught special education. They explained that the parents felt emotional about putting their students in advanced math: “I think the parents are just scared; I think they have a lot of emotional trauma from seeing their child struggle in the gen ed class.”

The findings from the needs assessment were consistent with the factors impacting students’ math achievement discussed in the Chapter 1 literature review. Teachers’ instructional approaches and personal experience with math learning appear to combine transmission, connectionist, and discovery-oriented approaches, as Askew (2019) offered. As teachers shared their interactions with students, evidence of students’ math self-beliefs was revealed. For example, one teacher noticed a difference in a struggling student when they transitioned from distance learning to an in-person class format: “I do feel like there’s at least trust between us now that he’s not scared … [to] come to class.”

One topic evoking a particular emotive response was ability grouping, also called placement and tracking. Parent-teacher interactions appeared to surround placement procedures, another factor supported by the literature. Elements of Baumrind’s (1972) authoritarian, authoritative, and permissive parenting styles were also perceived by math teachers.

Conclusion

The needs assessment captured the vignette of a struggling student in the context of the problem of practice and a few of the ways teachers support the student and interact with their parents. Based on teachers’ responses, behavioral issues were not a primary concern. Although interactions with parents were productive, there seemed to be frequent disagreement on evaluating the struggling student’s ability resulting in dissenting opinions on math placement assignments. Though teachers’ instructional practices were more aligned with connectionist views and least with transmission-orientated approaches, they were evenly divided on beliefs about math ability being a learned or innate trait.

Future Directions

Instructional practices, ability grouping, and parenting styles appear as the most reported factors when discussing support for a student struggling in math. However, these constructs are systemically rooted in educational and societal norms and are beyond the purview of this research. Consideration of interventions and treatments should be feasible to conduct and contain the potential to impact students and their math learning experience positively. Interventions may include professional development for teachers to evaluate the efficacy of their instructional strategies, offering coping mechanisms to students to battle negative emotions related to math, and giving parents tools to make an informed decision about enrolling in advanced courses.

Chapter 3

Intervention Literature Review

Introduction

Results from the needs assessment indicate multiple factors contributing to students' math performance and experiences in math classes at the middle school level. In their interview, teachers reported students' difficulty engaging and sustaining motivation to do math. Teachers also discussed the competitive culture involving math performance at the advanced levels, where students struggle with maladaptive perfectionism to quell parent and peer pressure in high-level math.

As presented in the literature review of Chapter 1, motivation and perfectionism are a few of the factors associated with math anxiety (Tsui & Mazzocco, 2006). According to PISA 2012 test results (Organisation for Economic Co-operation and Development, 2012), math anxiety is a prevalent global problem affecting adolescents and adults. Math anxiety that arises in early schooling can lead to long-term avoidance of math, varying from daily tasks involving calculations to career pathways requiring a knowledge background in mathematical foundations. Individuals unable to perform calculations related to daily functioning may experience embarrassment. Avoiding career pathways with math foundations or prerequisites limits individuals to some of the most lucrative and financially stable careers. Hanushek and Woessmann (2008) found that high achievement in math and science was associated with larger rates of increased economic productivity, suggesting that math anxiety could have national and global repercussions.

Luttenberger et al. (2018) suggested interventions focus on addressing the emotional, cognitive, and physiological responses resulting from engaging in math tasks to understand how to prevent and reduce math anxiety. Because math anxiety can present itself in all stages of life, intervention leaders must equip individuals with tools and strategies to regulate it on their own. Schunk and Zimmerman's (2012) self-regulated learning is a theoretical framework that supports using strategies and exercises to obtain learning goals. In self-regulated learning, individuals actively contribute to their goals and exercise control toward achievement.

Theoretical Framework

Self-Regulated Learning

Self-regulated learning is a common educational tool to assist students with their academic and behavioral goals (Dignath & Büttner, 2018). Schunk and Zimmerman (2012) define self-regulated learning as "learning that results from students' self-generated thoughts and behaviors that are systematically oriented toward the attainment of their learning goals" (p. 59). Students use "self-regulated learning to generate thoughts, feelings, and actions that help reach their goals" (Dignath & Büttner, 2018, p. 2). Individuals gain agency by enacting processes toward their goals through awareness and feedback (Zimmerman, 1990). In education, students learn to organize their understanding and take advantage of opportunities in their learning environment to make academic progress. Self-regulated learning contains five theoretical perspectives: the operant theory, information processing theory, developmental theory, social constructivist theory, and social cognitive theory.

Operant Theory

Skinner (1953) created the operant theory to associate environmental stimuli with desired behaviors through conditioning and reinforcement, manifesting as rewards and punishments. Children are rewarded with praise, toys, and other incentives such as being excused from chores, having playtime, or socializing with friends. In self-regulated learning, individuals negotiate between behaviors that result in rewards or punishments. For example, students may participate based on their teachers' responses. Severely critical teacher responses would illicit less participation, while praise and encouragement would condition students to continue participating. Students experimented in choosing what behaviors to exhibit, how to exhibit them, and whether they accurately assessed the associated outcomes.

According to Schunk and Zimmerman (2012), three subprocesses of self-regulated learning through the operant perspective are self-monitoring, self-instruction, and self-reinforcement. Self-monitoring assists in aligning self-assessment with actual outcomes. Self-monitoring provides tools to document the frequency and duration of behaviors or watch a self-recording to evaluate one's progress in objective and measurable ways. Self-instruction refers to strategies for teaching academic, social, and motor skills to enhance comprehension and achievement. Examples of strategies may involve asking students to determine the task, identifying and examining pertinent details, and summarizing their findings of this process in one sentence. Lastly, individuals who reward themselves after implementing a specific behavior use the last subprocess of self-reinforcement. Where self-regulated learning offers strategies to obtain learning goals, information processing theory explains their efficacy.

Information Processing Theory

Information processing theory uses metacognitive awareness and strategies to mediate self-regulated learning. Information processing theory encodes information ingested through working memory to be added to an existing schema and stored in long-term memory for later retrieval (Schunk & Zimmerman, 2012). Metacognitive skills inform the individual of a task's difficulty level, capabilities to complete it, and strategies to execute it. Learners actively compare their behaviors against expected standards and resolve discrepancies using learning strategies and comprehension monitoring. Learning strategies are cognitive plans to reach mastery of content and typically used organizing information, making connections of new material with prior learning, and rehearsal of understanding. Individuals exercising metacognitive awareness use learning strategies such as summarizing content just learned, elaborating concepts to make them more meaningful, questioning to understand connections and applications, and self-quizzing. As individuals automate strategies and behaviors, they seek more tools to enable them, leading to development.

Developmental Theory

The developmental theory focuses on cognitive changes that allow learners to exercise greater self-regulation. Development can occur naturally through biological factors or social support systems such as family and schools. In general, self-regulation begins with social stimuli through teaching, modeling, and verbal feedback and, over time, becomes increasingly intrinsic and self-motivated. Examples of cognitive changes include impulse control, acquiring speech and language functions, and using them to communicate wants and needs. Through communicating, learners engage in reciprocal interaction with other individuals, leading to a socialization process that acts as a conduit to further development.

Social Constructivist and Social Cognitive Theories

The social constructivist and social cognitive theories emphasize learning as a construct of the socialization processes occurring in the learner's environment. Social constructivism, commonly associated with developmental psychologist Vygotsky (1962), focuses on language mediating self-regulation. Vygotsky coined the zone of proximal development, or the abilities a child can perform when assisted by others, typically teachers, peers, or parents. The supporting individuals provide "scaffolding," another tenet of Vygotsky's theory, which gives the learning individual access through modeling and guidance, resulting in eventual independent capabilities by the learner.

Self-regulated learning is a powerful tool for students to generate thoughts, feelings, and actions that enable them to achieve their academic and behavioral goals (Dignath & Büttner, 2018). As explained in Chapter 1, math anxiety interrupts an individual's ability to generate appropriate plans for executing math tasks by consuming working memory resources, the immediate information storage in the information processing theory. Because working memory is required to execute math tasks, math anxiety leads to poor math performance. Over time, the undesirability of low math performance reinforces individuals to avoid math, even in simple calculations and daily life. Students are also prone to feel anxious about math if their parent or teacher exhibits math anxiety, suggesting socialization is an underlying factor in the presence of math anxiety in children. Thus, interventions that provide students with tools to cope with and mitigate math anxiety are worthwhile.

The following literature synthesis reviews interventions, paradigms, and research gaps in understanding how to reduce or prevent math anxiety. Math anxiety is a multidimensional construct that involves physiological responses, such as increased heart rate; cognitive impacts, such as depletion of working memory resources; and behavioral responses, such as avoiding math or feeling anxious when doing math (Ashcraft & Krause, 2007). According to Luttenberger et al. (2018), math-anxious individuals experience three states of anxiety: emotional, cognitive, and physiological. Emotional responses include feelings of nervousness, worry, and fearful thoughts. Math anxiety affects cognitive capabilities by interfering with working memory resources needed for the math task. Individuals who experience math anxiety report physiological responses, such as increased heart rate, upset stomach, and tension.

Interventions

Self-regulated learning is only helpful in the classroom if both students and teachers believe in its purpose and efficacy (Dignath & Büttner, 2018). The researchers investigated teachers' promotion of self-regulated learning strategies in primary and secondary math classrooms and compared their findings with teachers' beliefs and knowledge about self-regulated learning. Twenty-eight consisting of 12 primary and 16 secondary teachers, from a midsized city in Southwest Germany, participated in a video study where their classroom was observed to collect data. Teachers were then interviewed after the observation. Researchers found more indirect promotion of self-regulated learning from primary teachers and direct promotion from secondary teachers. Secondary teachers focused on teaching strategies to help self-regulate while primary school teachers focused on creating a classroom culture with embedded self-regulated principles. Cognitive strategies were emphasized in self-regulated learning elements, whereas metacognitive and motivation strategies were seldom taught. There were no correlations between teachers' self-reported beliefs and knowledge of self-regulated learning and the observation of their class. The authors suggested an intervention of explicit instruction on self-regulated learning that emphasizes cognitive, metacognitive, and motivational elements in both primary and secondary school to increase the practice, consistency, and efficacy of self-regulated learning.

Interventions Related to Math Instruction and Strategies

Educators can implement three interventions in their classroom to help students cope and reduce their math anxiety: the Self-Regulation Empowerment Program (SREP), teaching math strategies, and examining the opportunity to learn (OTL). The SREP is a prescribed program aimed at low-achieving and at-risk students. The SREP equips students with self-regulation and executive functioning skills, such as time management and learning strategies (Cleary et al., 2017). Math strategy training focuses on improving math ability and has far-transfer potential to reduce math anxiety (Passolunghi et al., 2020). Like math strategy training, Guo and Liao (2022) found educators should examine the OTL to reduce math anxiety by improving students' math performances.

The Self-Regulation Empower Program

The SREP is a comprehensive psycho-educational intervention program that can assist with low motivation, below-average academic performance, and intentional strategies to make academic progress. The principles of the program are founded on constructivist and social-cognitive theories that focus on "cultivating strategic behaviors and reflective processes in students, particularly in situations following failure or minimal progress toward personal goals" (Cleary et al., 2017, p. 74). The SREP program is administered to small groups several times weekly over 4 months. The program is used to teach strategy learning and practice, which involves teaching different ways students can enhance their learning, such as drawing pictures, organizing their thoughts, and managing their time.

Cleary et al. (2017) studied 42 students from a seventh-grade algebra class at an urban middle school. Students were selected to participate if they received report card grades below a B, a standardized mathematics test score indicating marginal to proficient, and teacher nominations of students who showed deficiencies in motivation or regulation. The participants were part of a school intervention class. Four groups of five to six students received the SREP curriculum, and the rest were treated as the control group who received only the school-based intervention program. The researchers used three types of self-regulated learning measures: a student self-report questionnaire called the Self-Regulation Strategy Inventory-Self-Report, a free-response hypothetical scenario from the Self-Regulated Learning Interview Schedule, and free-response self-regulated learning microanalytic question asking students to reflect on factors that affected their performance.

Using statistical analysis with SPSS, Cleary et al. (2017) found a statistically significant positive correlation in achievement among SREP students. The SREP participants displayed more adaptive self-regulating learning processes than the control group, but the statistical analysis did not corroborate this observation. The authors also analyzed the social validity of SREP among students, parents, and teachers to see how satisfied they were with the program. Descriptive statistics showed stakeholders found the program highly acceptable and important. Students reported greater confidence in general, which explains the lack of significance from the self-efficacy questionnaire.

Cleary et al. (2017) believed a strength that contributed to the social validity was the researchers' partnership with school personnel in implementing and administrating the program. The authors noted previous research of the same intervention involved trained research assistants to implement SREP, whereas their current experiment trained the students' teachers to carry out the program. Having interventions executed by teachers increase student engagement compared to external researchers who work with the students briefly (Rossi et al., 2018).

Training Methods

An additional intervention teachers can implement is the math strategy training Passolunghi et al. (2020) used to study math performance and math anxiety. Passolunghi et al. used a quasi-experimental study examining the effects of combining two training methods on math anxiety and math ability. Three training methods were used to study 224 fourth-grade students from five schools in northern Italy. Training with cognitive strategies was used to evaluate math anxiety, math strategies training for math performance, and a third training as a control group.

Training methods began with discovery methodology and transitioned to strategy application over time. A pre-test evaluation on fourth-grade students was conducted, followed by 8 weekly training sessions of 60 minutes. A post-test evaluation was conducted approximately 15 weeks after the pre-test evaluation. Cognitive strategies began with 2 weeks of playful activities on recognizing one's emotions, then transitioned to 2 weeks of playful activities on emotions related to math learning, then on to 3 weeks of strategies reducing math anxiety, and a final week of program synthesis. Similarly, math strategies began with 2 weeks of playful activities on two operations, then 2 weeks on two other operations, then 3 weeks on strategies to improve math ability, and 1 week of synthesis. The control group used the same structure with reading and drawing comic strips.

Four assessments were administered to evaluate verbal IQ (PMA Verbal Meaning subtest; Thurstone & Thurstone, 1981), sources and level of general anxiety (RCMAS-2; Reynolds et al., 2012), math anxiety (AMAS; Hopko et al., 2003), and math abilities (MAT-M3; Amoretti et al., 2007). A multivariate analysis of covariance (MANCOVA) was conducted with the three training (math anxiety, math strategy, or control) groups, pre-test scores as covariates, and gain scores as dependent variables. Passolunghi et al. (2020) found that math strategy training was associated with improved math ability and lower levels of math anxiety.

In contrast, the math anxiety group experienced lower levels of math anxiety but no associations with math ability. Neither experimental group resulted in far-transfer with general anxiety as predicted because the authors attributed general anxiety to personality rather than relating to academic performance. Passolunghi et al. (2020) suggested that training in cognitive math strategies had the potential for both near and far transferability, meaning the effects of the training could permeate both similar and dissimilar contexts. Math ability training may result in near-transfer because of the OTL, improving students' self-efficacy and reducing math anxiety.

The Opportunity to Learn

Though individuals can experience math anxiety with simple mathematical tasks, it is especially present with complex tasks that require problem-solving skills (Guo & Liao, 2022). Guo and Liao (2022) explained the importance of allowing students to learn problem-solving skills so that students are adequately prepared to execute complex math tasks, thereby experiencing a similar decrease in math anxiety, as found in the study by Passolunghi et al. (2020). The OTL aligns with teaching and assessment. Students should only be assessed in a content area if they have had an OTL (Gee, 2008). Guo and Liao (2022) studied OTL's direct and indirect effects on math anxiety through problem-solving as a mediator variable. The authors used the PISA from 2012, which assessed 15-year-old students' academic achievement, specifically in math. Guo and Liao used the data of 1,676 students from 155 schools in Shanghai-China and 1,511 from 160 schools in the United States. Paper and computer-based tests were used to measure math performance and problem-solving performance. Math performance was measured using a paper-based assessment with multiple-choice problems totaling 110 items on quantity, data, change and relationships, and space and shape domains. Problem-solving performance was measured using a computer-based test of 42 items focused on reasoning skills and problem-solving processes unrelated to specific mathematical knowledge.

Guo and Liao's (2022) findings supported their hypothesis and corroborated the results from Passolunghi et al. (2020). Using a two-level random intercept model and math anxiety, problem-solving performance, and math performance as outcomes, Guo and Liao (2022) found direct and indirect effects of OTL, as measured by math content coverage. Significant direct effects of OTL were found with problem-solving and math performance, and indirect effects on math anxiety in both Shanghai-Chinese and American students. The authors reasoned that more OTL gives students a feeling of control over their performance, lessening anxiety. The positive effects of OTL found in Guo and Liao (2022) suggest that increased content coverage can reduce math anxiety in Western and Eastern school settings.

The OTL is not a unique intervention but an approach toward instructional quality. Though Guo and Liao (2022) suggested tutoring and remediation programs outside the classroom can increase students' OTL. The authors emphasized the value of math teachers' ability to examine and increase OTL in their classrooms by activating students' prior knowledge and building upon existing schema with deep learning in mind. Problem-solving skills are not procedural but can still be modeled and supported through multiple representations. Incorporating the OTL requires educators to align their teaching to their assessments and provide evidence of when and where the students had the OTL so they can perform the task alone.

Providing methods related to math ability and OTL problem-solving skills impacts math anxiety indirectly, as shown in Passolunghi et al.'s (2020) and Guo and Liao's (2022) studies. Math instruction that equips students with skills to approach increasingly complex problems influences increased math performance. Success in math translates to higher self-efficacy and reduces anxious feelings toward math. Thus, focusing on the quality of math instruction and improving students' math performance can disrupt students' math anxiety through far transfer. Passolunghi et al. (2020) found that training to reduce math anxiety directly influences students' math anxiety levels, suggesting interventions explicitly directed at math anxiety may be worthwhile investigating. The SREP, training methods, and the OTL are programs that support students in different areas, from study strategies to problem-solving skills, to increasing opportunities to learn. The interventions also require different levels of engagement from teachers and other school faculty, as well as time to implement and other resources. The SREP has the most time commitment because it involves consistent small group or individual sessions to support students based on their needs. A school counselor or psychologist typically facilitates individualized sessions.

Training methods, such as MathWise, also take considerable time to implement. Fuchs et al. (2008), the creators of MathWise, describe a 17-week commitment with twice weekly sessions program. The training content is also limited to elementary math concepts and would not meet all students' levels of math attainment. The OTL does not take class time to implement but requires teachers to use their time outside of class, such as prep periods or staff learning days, to align their assessments with their instruction to increase learning opportunities. Among the three interventions, self-regulated learning is significantly facilitated by school staff. The next section explores interventions that give students tools to self-regulate.

Mindfulness Interventions

Mindfulness is considered a self-regulation strategy where individuals moderate their attention intentionally to focus on present tasks through nonjudgmental reflection (Opelt & Schwinger, 2020). The four tenets of mindfulness are the separation from thoughts, observing oneself, acceptance of emotions, and the present moment (Edmunds, 2013). Mindfulness exercises have shown benefits in clinical and nonclinical studies, adolescent and adult populations, and various contexts, including healthcare and education (J. D. Creswell, 2017). Three interventions that incorporate the advantages of mindfulness are mindfulness and the growth mindset, mindfulness-based stress reduction, and expressive writing. Broadly, mindfulness exercises give individuals tools to manage negative emotions and feelings. When combined with strategies to promote the growth mindset, individuals hold the agency to change both proximal and distal feelings of anxiety.

Similarly, mindfulness-based stress reduction strategies use mindfulness exercises but are focused on structured breathing. Expressive writing is an exercise to offload negative thoughts to free up attentional space for other tasks. Relative to math instruction and strategies interventions, mindfulness exercises are easier to implement, take less time and other resources, and can be used by students without a facilitator.

Mindfulness and the Growth Mindset

Deep breathing, thought control, and positive affirmations are common mindfulness exercises. When partnered with the growth mindset, interventions can equip individuals with coping mechanisms with negative thoughts and agency to shift negativity toward productive thinking. The growth mindset is "a belief that construes intelligence as malleable and improvable" (Ng, 2018, p. 20). The opposite of the growth mindset is a fixed mindset, or the idea that intelligence is innate and immutable, even with effort. Samuel and Warner (2021) administered an intervention to help students regulate their math anxiety and improve self-efficacy to capitalize on the benefits of mindfulness and the growth mindset.

Forty first-year students from a public community college in New York were studied using an embedded-experimental mixed-method design with a focus group and pretest-posttest dependent measures. Half received the intervention, and half were treated as the control group. The intervention started with a video presenting definitions and principles of mindfulness and the growth mindset. Each class period began with a deep breathing exercise with closed eyes and a prompt to stay focused in the present instead of letting thoughts wander about what may happen in the future to mitigate anticipatory anxiety. The instructor and students then recited five positive affirmations in unison. During the lesson plan, the instructor reminded students to remain engaged at the moment and take deep breaths if students began feeling anxious. The instructor also reinforced the growth mindset's tenets, including openness to feedback, focusing on effort and endurance, and reframing negative statements about math into positive statements.

The authors used the Revised Math Anxiety Rating Scale (Alexander & Martray, 1989) to assess math anxiety, the Math Self-Efficacy Scale (Betz & Hackett, 1983), and focus groups to collect their data. Using SPSS, a within-group analysis with a paired sample *t*-test showed math anxiety decreased in the intervention group. A thematic content analysis (Braun & Clarke, 2006) was used to analyze the qualitative data from the focus groups. The authors coded five themes: (a) the instructor authorizing and participating in the intervention; (b) deep breathing is a calm, fresh start to class; (c) saying the affirmations makes one believe them; (d) a sense of control; and (e) routine. The researchers continued the experiment the following semester. Because of attrition, 16 students participated, including new students and students from the previous experiment. The focus group in the second iteration of the experiment mentioned two new themes: low math test anxiety and confidence in math. The authors found the intervention successful in helping students reduce math anxiety in both anticipatory experiences, including being nervous about taking a math class or performing on an upcoming test, and present experiences, including engaging in math lessons and solving math problems. Breathing exercises, one of the study’s five themes, is a simple technique that is easy to teach and practice in virtually all situations.

Mindfulness-Based Stress Reduction

Mindfulness exercises, such as breathing exercises, aim to interrupt negative emotions and feelings so that individuals can feel a sense of control and regulate their physiological symptoms. Samuel and Warner (2021) incorporated deep breathing, an exercise focused on breathing patterns and attention toward one's surroundings and senses. Similarly, mindfulness-based stress reduction can treat math anxiety by freeing up cognitive resources required for math tasks (Brunyé et al., 2013).

Brunyé et al. (2013) used mindfulness exercises combined with L-theanine supplements, an amino acid associated with feelings of relaxation, to treat math anxiety in a quantitative study with a within-groups, randomized control trial design. Participants included 36 undergraduate students at Tufts University. The two independent variables were types of breathing and L-theanine dosage. The authors used the Mathematics Anxiety Rating Scale (Suinn & Winston, 2003) to assess math anxiety and the Brief Mood Introspection Scale (BMIS; Mayer & Gaschke, 1988) as the dependent variable. Participants were split into two groups based on their Mathematics Anxiety Rating Scale score: low and high math anxious groups. Mediator variables were assessed, including openness to mindfulness exercises using the Mindful Attention Awareness Scale (Carlson & Brown, 2005) and the Five Facet Mindfulness Questionnaire (de Bruin et al., 2012) and working memory using the Operation Span (Unsworth et al., 2005). Arithmetic problems were used to ensure mathematical capability was not a factor in math performance. The subjects had SAT scores above 500. The breathing exercises were modeled after Arch and Craske (2006) and lasted 15 minutes for each exposure. Participants listened to an audio recording that instructed them through the breathing exercise, including posture and gaze. The rest of the instructions were based on the assigned treatment of the group.

Brunyé et al. (2013) split the breathing exercises into three types, one for each group. The instructions for focused breathing included attention to sensations of inhaling and exhaling and reminders to refocus in case individuals' minds wander. Unfocused exercise instructions asked participants to think freely and not make any effort to focus on anything. The last exercise, the worry exercise, instructed participants to think intently about hypothetical situations to induce anxiety, such as cancer or global warming.

Brunyé et al. (2013) implemented the treatment in a laboratory in six sessions, with at least 2 days between sessions. Participants were required to fast for 12 hours before each session, which took place in the morning. Upon arrival, participants were administered a baseline BMIS. Then they received either L-theanine if they were in the treatment group and a placebo if they were in the control group, with 12 ounces of water. Allowing 35 minutes for L-theanine absorption, individuals performed the breathing exercise assigned to them. They took the BMIS for the second time, worked on a 20-minute arithmetic task, and took the BMIS for a third time.

Using statistical analysis, Brunyé et al. (2013) conducted *t*-tests on mood and math accuracy in groups with low and high math anxiety. The pre-test results confirmed that participants with high math anxiety performed lower on standardized achievement tests than those with low math anxiety. The high math anxiety group also showed lower working memory capacity, confirming the attentional control theory (Eysenck et al., 2007) that anxious thoughts occupy working memory resources needed for task performance. An ANOVA test showed the highest feelings of calmness after the 15-minute breathing exercise with the focused group, followed by the unfocused group, then the worried group. In the post-test after the breathing exercise, the high math anxiety group showed a 9% boost on their arithmetic test compared to a

6% boost in the unfocused condition. Still, it underperformed by 8% compared to their low math anxious peers.

Samuel and Warner (2021) and Brunyé et al. (2013) showed the benefits of breathing exercises as a form of self-regulation during anxiety or concern. Samuel and Warner (2021) found breathing exercises partnered with verbal positive affirmations decreased students' anxiety about future events, such as an upcoming test, and present situations, such as engaging in math lessons. Brunyé et al. (2013) found that structured and focused breathing exercises helped lower anxiety. Both interventions focused on breathing exercises were inexpensive and quick to implement, with almost immediate benefits in reducing stress. Another strategy students can easily employ in stress-inducing situations is expressive writing, detailed in the next section. Similar to breathing exercises, individuals using expressive writing experience near-immediate effects.

Expressive Writing

Emotion regulation is a form of self-regulation that seeks to identify, label, and disclose emotional experiences (Smyth et al., 2008). Expressive writing is a therapeutic tool in psychosocial interventions where individuals write about their current stresses or concerns in a freestyle manner for 15 to 30 minutes daily. Expressive writing is often used as a clinical technique in aiding distress, depression, and illness-related behavior (Smyth et al., 2008). Park et al. (2014) studied the effectiveness of expressive writing as an intervention for math anxiety. The authors suggested expressive writing aids in offloading thoughts of stress or anxiousness, thus freeing up space in working memory to tackle math problems. Eighty students from a midwestern university were prescreened to determine their math anxiety levels using the Math Anxiety Rating Scale by Alexander and Martray (1989). Participants were initially given six high-demand math problems and six high-demand word problems to elicit any math anxiety. The participants then took the next 7 minutes to write openly about their thoughts and feelings. Immediately after, the students took a math exam consisting of 60-math problems and 60-word problems.

After analyzing the data, Park et al. (2014) found expressive writing, even in only one session, was an effective intervention to reduce math anxiety. Students in the experimental group had lower reaction times on the math exam and lower mathematical errors, indicating improved math performance. The analysis showed statistical significance for those with high and low math anxiety but only with high-demand math problems. The authors suggested simple reflective writing tasks before a test or other highly anxious math situations be used to immediately reduce the impact of math anxiety on a student's ability to perform. Expressive writing is a coping mechanism students can use when they experience math anxiety at school, but it does little to prevent the existence of math anxiety.

Summary of Interventions

Math anxiety manifests in cognitive and physiological symptoms that negatively affect individuals leading to an avoidance of math-related subjects and tasks. As theorized by Schunk and Zimmerman (2012), self-regulated learning gives individuals agency to plan and execute processes toward their goals through a feedback loop of awareness and strategies. Because math anxiety and performance interact bidirectionally, interventions focused on increasing math performance can mitigate and prevent math anxiety by improving self-efficacy. Interventions related to math instruction and general academic success are teacher-led, as seen in the interventions SREP, math ability training, and the OTL.

Interventions based on cognitive behavioral therapy, such as mindfulness exercises, appear as the most common and effective to address math anxiety directly. Mindfulness exercises, including the breathing exercises and positive affirmations found in mindfulness and the growth mindset, focused and structured breathing in the mindfulness-based stress reduction intervention, and the therapeutic approach found in expressive writing, are simple and effective ways to cope with negative emotions and feelings and reduce negative physiological symptoms associated with math anxiety. The interventions discussed in this review showed promise in addressing the effects of math anxiety, a pervasive issue in almost all populations.

Rationale of the Proposed Intervention

Of the interventions described in the literature review, expressive writing is the most appropriate for implementation to address the problem of practice. Expressive writing is an inexpensive and easily accessible intervention that may reduce math anxiety and provide students with an additional self-regulatory tool. It does not require specialists to implement, and there is little to no training for teachers to use in the classroom. Though electronic devices are used in the intervention study, they primarily serve the purpose of data collection and are not necessary when implemented for the benefits alone. The benefits of expressive writing on math anxiety are not uniform because individuals acquire it at different points of their lives and various degrees of severity. However, many individuals benefit from expressive writing in some capacity (Baikie et al., 2012).

Chapter 4

Intervention Procedure and Program Evaluation Methodology

Math anxiety is one of three components of math self-beliefs, a category of non-cognitive factors that strongly predict math achievement, as found through empirical literature. Interventions commonly used to reduce math anxiety include self-regulation, such as mindfulness exercises, academic support, such as time management tips, or strategies to study. In their semi-structured interview, math teachers participating in the needs assessment for this study shared supporting children with managing their workload, understanding math problems, and modeling math problems. Math teachers also shared the prevalence of academic pressure students face to perform in math.

As discussed in Chapter 3, expressive writing is a simple self-regulation intervention effective in reducing math anxiety. Self-regulation strategies, such as expressive writing, have been empirically shown to reduce the harmful effects of math anxiety impacting students' math achievement (Park et al., 2014). Self-regulation strategies are not acquired naturally in development and must be taught or modeled (Schunk & Zimmerman, 2012). Students exercising self-regulation strategies have stronger self-efficacy, emotional control, and self-awareness, enabling them to set realistic goals and regulate biological resources negatively impacting achievement.

Purpose of Study

The purpose of this study was to investigate the effects of expressive writing as an intervention on math anxiety in high-achieving students in a public middle school in an affluent suburb of Silicon Valley, California. Parents were also interviewed to provide insight into students' math learning experiences to understand better how to support students. A mixed-method design was the most appropriate approach to studying math anxiety because of its complexity. Mixed-method approaches involve integrating quantitative and qualitative methods to compensate for the weaknesses of each other (J. W. Creswell & Plano Clark, 2018). For example, quantitative measures may overgeneralize or reduce the complexity of math anxiety, and qualitative data may overrepresent subjective interpretations. Therefore, merging both provides an opportunity to capture the multidimensionality of math anxiety that may not be revealed through quantitative and qualitative methods alone.

A convergent design (J. W. Creswell & Plano Clark, 2018) was used to determine the impact of expressive writing on math anxiety. The convergent design uses quantitative and qualitative strands to examine related constructs. Both strands are weighted equally, but results were analyzed independently. J. W. Creswell and Plano Clark (2018) stated that researchers use convergent designs to obtain triangulation by comparing qualitative and quantitative methods, thereby fortifying conclusions and capturing trends and nuance.

Process Evaluation

Researchers can use a process evaluation to examine the implementation of a program and the relationship between the elements of the program and the intended outcomes (Saunders et al., 2005). Saunders et al. (2005) suggested that the results of program implementation often focus on outcomes and effectiveness and overlook the program's so-called black box.

The expressive writing program examined two components of the process-evaluation plan: reach and participant responsiveness. Reach refers to the study of the intended target population (Saunders et al., 2005), and participant responsiveness measures how participants react to the intervention and their level of engagement (Dusenbury et al., 2003). After the end of the program, students were invited to participate in an online discussion. They were asked to share their experiences with math anxiety and the expressive writing intervention.

Process Research Questions

RQ1: To what extent is the intervention performed on the target population of high-achieving students enrolled in either advanced placement courses offered to 7th-grade students?

RQ2: To what extent are students responsive to the intervention?

Reach

Reach is one of the six components of a comprehensive process evaluation (Saunders et al., 2005) and is defined as the "proportion of the priority intended beneficiaries who participate in the program" (Rossi et al., 2018, p. 99). Linnan and Steckler (2002) described reach as the extent the target group receives the program. The intervention's target population was students enrolled in middle school's highest advanced placement level, as described as one group of "inputs" in the logic model (see Appendix A). Reach was operationalized by examining district placement data for eligibility in the advanced course.

Participant Responsiveness

Participant responsiveness is one of five measurable elements of Dusenbury et al.'s (2003) conceptualizations on implementation fidelity. The outcomes of strong program implementation can still be affected by participants' engagement levels and those who implement the program. Participant responsiveness was used to examine engagement, acceptance, compliance, and interest levels in this study (Carroll et al., 2007) and was assessed using observations and questionnaires.

Process Evaluation Indicators

Placement Criteria Data

Seventh-grade students enrolled in advanced math comprise the study's target population, as be seen under "Participants" in Appendix A. Course grades, standardized tests, and teacher recommendations compose the placement criteria in advanced math courses. Student performance data on each measure and their eligibility for advanced placement were accessed through a district-made spreadsheet. Students were placed in their next year's math course based on the data unless a parent overrode the placement assignment and self-selected the math course for their children.

Student Survey

To collect information about participants' responsiveness to the expressive writing intervention, students answered a 3-point Likert-scale question, "I desire to participate in the expressive writing activity today." Students answered the question after entering their names, math classes, and periods on Google Forms. The question was a required item before accessing the expressive writing prompt. After data collection for the expressive writing intervention program had been completed, students were invited to participate in an anonymous online discussion using Google Docs to share their experiences with the program.

Expressive Writing Outcome Evaluation

A convergent mixed-methods design (J. W. Creswell & Plano Clark, 2018) was used to study an expressive writing intervention in high-achieving students. The independent variable was expressive writing, and the dependent variable was the level of math anxiety. One-on-one parent interviews were conducted to understand students' math anxiety and learning experiences. Interviews were conducted during the intervention because their responses were not dependent on student results. Based on convergent study designs, quantitative and qualitative strands occurred simultaneously.

An interrupted time series (ITS) is a comparison group design where participants act as control groups (Rossi et al., 2018). According to Rossi et al. (2018), ITS is appropriate for studies where outcome measures can be obtained before and after an intervention and contain time-limited or age-specific parameters, such as school age. Students answered a math anxiety survey twice before the intervention was implemented. The two survey scores were averaged to represent a baseline value. Data collection occurred after each exposure or other incremental unit of time during the intervention. Though not in the formulation of an ITS design, additional control groups were used for additional comparisons with treatment outcomes.

The expressive writing intervention began with two pre-tests to gather baseline data about students' current levels of math anxiety before starting the intervention. Students self-reported their math anxiety levels in a 9-item survey using a 5-point Likert scale, as described in the measures section. Students took the same survey and reported their math anxiety after each exposure session to assess the short-term effects of expressive writing. After comparing the survey data and the qualitative coding of writing submissions, an assessment was made regarding the convergence or divergence of the data sets.

Outcome Evaluation Research Questions

RQ3: To what extent did the expressive writing intervention impact math anxiety levels in high math anxious (HMA) and low math anxious (LMA) students?

RQ4: To what extent did the expressive writing intervention impact math anxiety levels in Math 7+ and Math 7/8/Algebra?

Method

The logic model (see Appendix A) shows an overview of the method, including the inputs, outputs such as activities and participants, expected student outcomes, assumptions, and external factors.

Participants

Non-probability sampling was used to recruit participants. Because enrollment in an advanced math course was a requirement, purposive sampling was used. Convenience sampling with students at the researcher's school to assist in managing the intervention was also used. Students must have been enrolled in seventh grade at the school site and in either of the two advanced math tracks with the researcher as the teacher to be eligible for study participation. The school site was a middle school in a large public K-8 school district in Silicon Valley, California. The school's enrollment was 1,070, and the district's was 15,663.

A total of 166 seventh-grade students were recruited, 84 females and 82 males, 150 Asian, 7 identified as multiple ethnicities, 4 White, 4 other, and 1 African American. Of the 166, three students were English language learners, and three identified as special education. As expected of advanced math students, grade point averages were high (84% 3.5+, 12% 3–3.5, 4% 2.5–3, and 1% 2–2.5). The students comprised five math classes: two of Math 7+ and three of Math 7/8/Algebra. One class in each subject was randomly selected as the control group, while the remaining courses received treatment. Parents of eligible students were recruited separately (see Appendix B) to participate in an interview. Consent forms were uploaded to Google Forms for parents to review and to indicate their decision for student assent and parent consent.

Recruitment began in early April and lasted 2 weeks. The researcher, the classroom math teacher, announced the commencement of the study to students so that they would be aware of upcoming emails they and their parents would receive about the study. Students were allowed to ask questions about the present study and general research. On the fourth day of recruitment, an informational session was held virtually for parents and their students to attend to learn about the study and to ask questions. The meeting lasted approximately 45 minutes, and 11 parents and two students were in attendance.

Of the 166 students, 69 received parental consent to participate in the study, including 35 females and 34 males, and 23 Math 7+ and 46 Math 7/8/Algebra students. Parents ($n = 14$) consented to be interviewed, including seven parents of Math 7+ students and seven parents of Math 7/8/Algebra students. The attrition of one parent, whose child was in Math 7+, occurred because of scheduling challenges, so 13 parents were interviewed virtually.

Measures

Modified Abbreviated Math Anxiety Scale

The empirical study by Park et al. (2014) that the current study aims to replicate used the Math Anxiety Rating Scale – Abbreviated Version (MARS-AV; Alexander & Martray, 1989). The MARS-AV is a 25-item questionnaire the researchers used to establish baseline anxiety levels and analyze reaction time and accuracy on math tests after each exposure. However, since math tests at the school site in the present study differ in difficulty, the number of problems, and content matter, it would not have been appropriate to analyze the effects on test performance at a statistical level. Thus, where Park et al. used their instrument to measure math anxiety as a pre-test, the present evaluation design used the math anxiety instrument as a pre-test to establish baseline control data and was administered after each exposure, in line with an ITS study.

The Modified Abbreviated Math Anxiety Scale (mAMAS; Carey et al., 2017) is a derivative of the instrument used in Park et al.'s (2014) study. Park et al. used the Math Anxiety

Rating Scale – Abbreviated Version (MARS-AV), a 24-item survey developed by Alexander and Martray (1989), an adaptation to the original full-length 98-item MARS by Richardson and Suinn (1972). Hopko et al. (2003) created a further abbreviated version, the Abbreviated Math Anxiety Rating Scale (AMAS), a 9-item survey with more robust psychometric properties. Because the AMAS was developed using university undergraduates, Carey et al. (2017) created a reliable and valid version, the Modified Abbreviated Math Anxiety Rating Scale (mAMAS), for adolescents ages 8 to 13. Reliability in measuring math anxiety was very high, with an internal consistency of 0.89 for the scale and 0.83 for subscales. Construct validity was found acceptable (≥ 0.60), and divergent validity for math anxiety (> 0.40 confirmatory factor analysis). Because the study participants were middle school-aged students, the mAMAS (see Appendix C) was the most appropriate derivative of the original instrument.

Expressive Writing

Each dose of the intervention began with the following expressive writing prompt on students' Google Form (see Appendix D), adapted from Brewster and Miller's (2022) expressive writing intervention on math anxiety:

> Please take the next 7 minutes to write as openly as possible about your thoughts and feelings regarding the mathematics class that you are about to have. In your writing, I want you to let yourself go and explore your emotions and thoughts as you are getting ready to start the mathematics class. You might relate your current thoughts to the way that you felt during other similar situations at school or in other situations in your life. Please be as open as possible as you write about your thoughts at this time. You may write about the same general issues or experiences on all days of writing or about different topics each day. All of your writing will be completely confidential. Don't

> worry about spelling, grammar, or sentence structure. The only rule is that once you begin writing, you continue until the time is up. (Brewster & Miller, 2022)

Google Docs

An online discussion using Google Docs collected qualitative information from students in the intervention group. Student participants' names were listed alphabetically and assigned a number. Ten students were selected using a random number generator to participate in the online discussion to keep the discussion on the topic. Open-ended questions adapted from Hudson and Day's (2012) study on expressive writing in athletes were used as discussion prompts (see Appendix E). The questions focused on understanding participants' experiences with math anxiety and the expressive writing intervention. Follow-up questions were used to ask students to comment on whether they would use expressive writing as a coping strategy in the future and if their anxious views of math have changed since the beginning of the study.

Parent Interviews

Interviews with parents who consented to participate were conducted virtually while the intervention was implemented. An image of math anxiety (see Appendix F; Learn With Confidence, 2020) provided a visual of key elements of math anxiety, including negative experiences and thoughts, poor math performance, and lack of confidence. The interview consisted of open-ended questions (see Appendix G) adapted from Jay et al.'s (2018) study on parental involvement in their child's math learning, also shown next to the math anxiety image. Parents were asked to review the image and questions at the beginning of the interview and were allowed to begin with the question they were most interested in discussing; otherwise, the researcher began with the first question. The interview was audio-recorded and transcribed for qualitative coding.

Intervention

The intervention was conducted in the Spring of 2023. Students from two sections of the Math 7+ course and three sections of the Math 7/8/Algebra course were recruited. The author of this study taught all sections. Of the two Math 7+ courses, the morning class was the control group, while the afternoon class received treatment. Of the three Math 7/8/Algebra courses, one morning and one afternoon class received treatment, and the third mid-day class served as the control.

An ITS design was used to compare the results of the intervention. An ITS is a quasi-experimental design where participants act as their own control group (Rossi et al., 2018). Participants were observed or tested several times before and during the intervention. Outcomes occurring during the intervention were then compared with outcomes before treatment. Any changes in outcomes were attributed to the treatment. Like other quasi-experimental studies, threats to validity must be mitigated to ensure outcomes are associated with the treatment and not because of other phenomena. A control group is not required in an ITS study but can be used to triangulate data and strengthen analyses (Rossi et al., 2018). Further explanation of threats to validity is discussed in the strengths and limitation section.

An email was sent to parents presenting the objectives and length of the upcoming research (see Appendix H) and included an electronic consent form for their students to participate. The form also asked parents to indicate if they were willing to participate in a virtual interview about math anxiety. Regardless of parental consent status, all students participated in the writing exercise to prevent students from feeling excluded and to avoid denying any student the benefits of expressive writing. Students whose parents did not consent to the study received a control/neutral writing prompt (see Appendix D), and the writing samples of these students were not accessed.

Before the first exposure to the treatment was given, a 2-minute illustrated video (GCFLearnFree.org, 2019) was shown explaining math anxiety and its potential effects on achievement. Students completed a Google Form containing the mAMAS questionnaire to get baseline data (see Appendix C). The 9-item questionnaire used a 5-point Likert scale to gather responses, with 1 being *low anxiety* and 5 being *high anxiety*. Therefore, students' scores ranged from 9 to 45. Following the grouping used in Mitchell and George's (2022) study of math anxiety among primary school students and math performance, students whose scores were 9 to 20 were labeled *low math anxious* or LMA, and students whose scores were 33 and above were labeled *high math anxious* or HMA.

The intervention occurred on days when a math test was planned. Math 7+ classes had tests on April 14, April 28, May 9, May 17, and June 2 of 2023. Math 7/8/Algebra took tests on April 14, April 28, May 16, May 17, and June 2 of 2023. Because of a shortened schedule on May 16, Math 7/8/Algebra students took 2 days, May 16 and 17, to work on their tests.

Each student was provided an iPad and an ID card with their name and QR codes linked to the appropriate surveys or prompts on Google Forms. Students in the control group received a card with a QR code to the mAMAS survey if they participated in the study, and non-participants received a card with a QR code to a neutral survey adapted from the National Survey of Student Engagement (NSSE, 2013) study on student engagement (see Appendix I). Students in the experimental group received an ID card with their names, a QR code for the mAMAS, and a QR code for the expressive writing prompt. Students indicated their names, math courses, math periods, genders, and levels of responsiveness to the writing exercise on the first page of the form and the expressive writing prompt on the second page. Non-participants in the experimental group received a QR code for the neutral survey and a code for the control prompt (see Appendix D).

In line with Park et al.'s (2014) script, students were instructed to write openly about their thoughts and feelings about the upcoming math assessment for 7 minutes. The researcher, who was also the classroom math teacher, ensured students were successfully set up with the experiment, then stepped out of the room to reduce pressure on students as they wrote, and a proctor administered the exercise. After 7 minutes, the proctor informed the researcher to return, and students put aside their cards and iPads to take the test, the mAMAS survey, using a Google Form. Non-participants answered the neutral survey. The intervention concluded after three exposures.

Data Collection

Google Form Responses

Expressive Writing

Each student was provided an iPad with an attached keyboard to type their responses to the expressive writing prompt (see Appendix D) before the test.

Modified Abbreviated Math Anxiety Scale

Students used the same iPad to access the mAMAS using a separate QR code, leading them to the survey using a Google Form. Students took the survey at the test's end before leaving the classroom. The mAMAS was administered to both treatment and control groups twice before the commencement of the intervention to gather data for the control in the ITS study (see Appendix C).

Parent Interviews

One-on-one interviews with consenting parents were conducted virtually during the parents' schedule availability using the Google Calendar appointment feature sent to their email addresses. Parents were informed the interview would last approximately 30 to 45 minutes. One-hour appointment time slots during business hours in a 2-business-week window were made available for parents to sign up based on availability to accommodate potential delays and transition times. Parents could suggest an availability if the appointment slots did not fit their schedule. Taking advantage of the Spring Break recess, appointments began on April 17th and ended on April 28th. Eight parents participated in their interview during Spring Break between business hours, 9 am to 5 pm.

Appointment slots began at 9 am and ended at 3 pm during Spring Break, April 17th to April 21st. Then appointment slots began at 3 pm after school until 5 pm from April 24 to April 28. One parent scheduled an interview within the 2-week window but needed to reschedule the interview to May 1st. Another parent requested an interview for May 11th. Once selected, the researcher and the parent received an email notification of the appointment containing the Zoom interview link. The application, Otter.ai, audio-recorded and transcribed the interview to prepare for coding.

Strengths and Limitations

Internal and External Validity

Shadish et al. (2002) suggested improving external validity in quasi-experiments with two purposive sampling techniques: heterogeneous and typical instances. Sampling in heterogeneous instances aims to reflect the diversity of the population. Typical instances focus on the elements of the study meant to be generalized and chooses participants who represent those elements. However, this study used purposive sampling to recruit students in advanced math classes; the decision to use convenience sampling limited recruitment and implementation with more populations that would represent diverse elements or representations of typical instances. Though there was no ideal sample size to conduct experiments (Lochmiller & Lester, 2017), the sample size adequately represented the population of students taking advanced math. It allowed for rigorous statistical analysis and data saturation for a qualitative deduction.

Though students were randomly assigned an experimental or control group, a randomized control trial experiment is not feasible when studying students since they cannot be treated in isolation. Shadish et al. (2002) suggested quasi-experiments as an adequate alternative where randomized experiments are not feasible. Quasi-experiments test causal hypotheses about treatment effects (Shadish et al., 2002). However, because of the lack of randomized control groups, the defining characteristic of quasi-experiments, rival alternative hypotheses may exist in explaining causal inferences. Attempts to falsify competing hypotheses included reducing validity threats and designing a strong intervention study. The outcome evaluation design was consistent with empirical research examining the effects of expressive writing on math anxiety, intending to replicate similar significant findings. Hines et al. (2016) also used a mixed-model research design to explore expressive writing effects on math anxiety, cognitive processes, stress, and affective states. Park et al. (2014) studied the same construct, intervention, and measure.

In examining internal validity, two threats were present in the study: selection and testing. According to Shadish et al. (2002), selection refers to systematic differences that explain observed outcomes instead of treatment effects and is pervasive in quasi-experiments. However, because of purposive and convenience sampling recruiting, selection bias could not be avoided because the participants were intentionally selected.

Selection bias can be reduced by using a separate control group and comparing participants to themselves before treatment. Because students' math anxiety level scores after treatment were compared with their scores before treatment, they did not have any systematic differences. The proctor would remind students to help maintain the integrity of the study by not speaking about it outside of class until the study has ended to minimize contamination effects. Test effects occur when participants are exposed to a test, and their scores on subsequent tests are influenced because they have already seen it. Adolescents who perceive a questionnaire as low stakes are likelier to answer honestly and accurately, even as early as 1 week later (Levy, 2011). Invalid responses appear when adolescents do not take the survey seriously but have a negligible impact on overall data (Fan et al., 2006).

Procedural Limitations

An anonymous online discussion was intended to be conducted after the study's conclusion during the summer break to gather students' feedback about their experience with the intervention program and solicit their insights on math anxiety. However, upon analyzing the expressive writing responses, students appeared to share their experiences with math anxiety and the intervention in their writing responses. The qualitative data for participant responsiveness were present in the writing samples. Therefore, the researcher decided, independent of the Dissertation Advisory Committee's consultation, to forego the online discussion because of concerns of attrition associated with summer break factors, such as a lack of students checking their emails and low student availability from vacations, internships, and summer camps. After the study's completion, the researcher informed the Dissertation Advisory Committee of the decision.

Data Analysis

The study employed a mixed-methods design to study qualitative and quantitative data (J. W. Creswell & Plano Clark, 2018). Using a convergent design allowed the collection of both strands of data to occur simultaneously. The quantitative data were obtained from student responses on a Google Form containing the mAMAS. The Google Form automatically generated a spreadsheet of submissions, which was then exported to the statistical data analysis package SPSS. Three exposures were planned in the designing of the study. Quantitative data were to be analyzed using an interrupted time series, where math anxiety levels were analyzed after each expressive writing exposure. However, end-of-school year activities such as field trips, state testing, and other school events, as well as attrition, prevented reporting of three exposure scores. Since most students were present for two or more exposures, the interrupted time series analysis was reduced to two exposures, labeled “mid-exposure” and “final exposure.” Students who were present for all three exposures had mid-exposure scores calculated as an average of the first two exposure scores.

The qualitative data were obtained from the student’s responses to the expressive writing prompt from Google Forms. Their writing was coded using Braun and Clarke’s (2006) thematic analysis using grounded theory. Braun and Clarke’s process for coding qualitative data involves six steps: familiarizing oneself with the data and concluding with a final analysis. The same process was conducted with parent interviews.

Parent interviews were recorded and transcribed using Otter.ai. Each transcript was read three or more times until the researcher was satisfied that a broad understanding of the extracts was obtained. Once familiarity with the transcripts was achieved, the researcher annotated the transcripts by highlighting key words and phrases and assigning codes. Three types of codes were used as defined by Miles et al. (2020): descriptive, in-vivo, and a priori. Descriptive codes consisted of words and phrases that summarized the data, whereas in-vivo codes used the participants' own language. Due to the researcher's familiarity with the background research, constructs from existing literature were used to as a priori codes. Pattern coding (Miles et al., 2020) was used as the second cycle of coding to condense codes into categories. The codes were exported to Plectica, a visual mapping software, where the researcher grouped the codes based on common traits such as shared words, emotional expression, and topics of a similar nature. The researcher established overarching themes (see Table 4) to each group of codes to create a narrative report. The third cycle of coding generated extracts to represent the themes. A final review of the themes and quotes were compared with the original transcripts to ensure diverse representation of the participants was achieved.

Table 4

Thematic Analysis of Parents' Semi-Structured Interviews

Themes and dimensions	Extract or descriptor
Cultural comments and differences	Parents commented about schooling in a country outside the United States.
Parents' personal experiences with schooling in a different country	"In the middle school, when algebra was introduced, algebra was taught in native language, with very long, convoluted explanations, and I didn't get it"
	U.S. math poses a problem and asks students to "fix it" using math, making math practical, whereas schooling in China concerns practicing hard questions.
	The teacher would give all the steps in China, but U.S. children have fewer steps.
Comparisons of schooling systems in the United States and other countries.	"IITs (Indian Institutes of Technology) are pretty highly ranked universities in India, and everybody wants to get their kids to it … And they have placement tests for kids in like second and third grade, which means that they will have to be prepared for those placement tests from kindergarten probably. I'm like, laughing at it, but it's unfortunate, right. So that's the level of, you know, heightened awareness and ambition in parents [have]."
	"The way teachers would teach you back home [in Nigeria] with all that stress and fearfulness, coming here, everybody was friendly. It was like you may you have a choice, and it wasn't forced upon you, you weren't afraid of the teachers. It was a much, much better environment than I expected."
Parenting approach	Comments parents made about their motivations and style of parenting.
Relaxed, supportive	"Happiness first, then you can do whatever you want."
Understanding	The parent initiates conversations about math class and peers' performance, but the child deflects the subject. The parents desire the child to be more

Themes and dimensions	Extract or descriptor
	motivated in math but do not want to harm the relationship with the child. The parents trust the child to be autonomous.
Focus on learning rather than performance	"We are going to be thrilled if you get an A. But if you get into B and you're trying your hardest to get that be like, we're going to recognize your effort."
Thoughts about middle school and math instruction	Parents commented about their children's middle school, including math education and placement. "You want to try different things to get a problem … but [a] timed test doesn't give children those options. They have to get it right the first time; otherwise, they don't have enough time to complete the exams. So those are the things I think that creates anxiety." "Whether you like it or not, you have to play along. It is probably not as healthy. You have to look at what is good in this stressful environment and try to gain as much as possible." The parent trusts the school's placement procedure because appealing to a more advanced level would make the child suffer. "Don't even ask me to" appeal for you.
Parents' rationales for success in math.	Comments parents shared about why they want their children to be successful in math. "I think math and learning is the lifetime. It's not like a just like a school, like you graduate from school you can forget, throw the way about the textbook." "If you don't know how to do math, you must pay someone to do the job for you." "Among people who have a certain level of education, you can speak with a common language with them."

Note. Braun and Clarke's (2006) six-step thematic analysis was implemented.

A similar process took place for students' writing samples, except all the coding was done digitally instead of on hard copy transcripts as done with parent interviews. All writing samples were exported to an Excel spreadsheet from Google Forms. The researcher read all the writing submissions, then coded each with one to three descriptor codes. Codes were batched into categories that were reduced to themes. Extracts were chosen to represent the themes, and a final review ensured students' perspectives were captured in the extracts and themes (Table 5).

Table 5

Thematic Analysis of Students' Expressive Writing

Themes and dimensions	Extract or descriptor
Feelings about upcoming test	Students commented about the test they were about to take.
Compared to non-test days	"Everyday when I come into math class I am ready to learn and do not mind regular day to day classes. The ones that make me upset are the test days."
Self-assessing level of preparedness	"The good thing is that we have taken a team test, so I know what kinds of questions to expect on the test."
Classroom environment	Students commented about the math classroom environment.
Teacher's expectations	Strict, but "I understand what [the teacher's] rules and what environment you are trying to set up, and that really helped me."
Teacher's instruction	"The teacher does not spend enough time on teaching, reviewing, and practice in class, rather spending too much time talking about non math related topics." "In the classroom we might just make a joke about anything at possibly any moment … we sometimes incorporate the jokes into our learning process, or how after we've had our funny moment, we always seem to bound back to our learning so that we can stay on task."
Mindfulness practices implemented in the classroom	A visual breathing exercise accompanied by soft, relaxing music is "annoying" to one student and calming to another.
Parent, and peer influence	Students' responses included the math teacher, parent, and/or peer as a person of influence.
Criticism from peers	"They start laughing and saying, "this class isn't even that hard how do you not get an A."
Comparing oneself with peers	"I felt a bit better when some people in my table groups also got the same questions as me." "The fact that everyone else is doing pretty ok … truly means that I actually suck at Algebra." "Everyone in the classroom seems to always know the answer … I think this is because everyone goes to extra math classes after school while I don't go to any."
Parent expectations	"Since my mom told me to up my math grade, I feel some pressure in doing well on this test." "No one is pressuring me, my parents don't get mad or anything if I don't get the best grade; they just tell me to work harder and that the more I practice, I'll get it, but I can't help but feel like I'm still disappointing someone, I sometimes feel like I disappoint my teacher too."
Math self-beliefs	Students' responses included reflections on their math ability and performance.
Cultural identity	"I feel like math is a huge subject that others think Asians should be good at, but if I'm being the most honest, I'm really not that great at math."
Self-efficacy	"I can do things without worrying it would be wrong or will be marked down…Besides, I can get all the help needed."
Math interest and motivators	"I like math because of all the different ways you can solve a question. I think that the satisfaction of getting 100% on a math test is one of the best feelings in the world."
Comparing math classes	Students' responses included other math classes with their current math class, including extracurricular math classes and math courses in elementary school and sixth grade.
Extracurricular math class	"I go to [extracurricular math], and I enjoy that much more now instead of the school math."

Themes and dimensions	Extract or descriptor
Past math courses	"When my parents give me an extracurricular math program, I don't really feel motivated to do the math problems [in the extracurricular math class], because they are much harder." "I also really like that the teacher takes time to make sure everybody in the class has understood the concept and is able to use it. Many of my past teachers did not do this."
Self-regulation	Students' responses reflected coping skills toward negative feelings or experiences related to their math class or math test. "I just try to follow my mantra, "keep your head in the game." One student shared she wears "comfy clothes on test days...". "Math tests … don't make me so stressed … because the rate at which my teacher teaches is not too fast and also I have a large enough memory capacity."

Note. Braun and Clarke's (2006) six-step thematic analysis was applied to the qualitative coding.

Summary

The research literature and the needs assessment support the existence and potential negative effects associated with math anxiety. A self-regulatory strategy, expressive writing, was studied to assist students with coping with anxious feelings. Park et al.'s (2014) study on expressive writing on math anxiety was used as a model in studying high-achieving students in a public middle school in Silicon Valley, California. Reach and participant responsiveness was evaluated to ensure the fidelity of implementation. Purposive sampling was used to recruit students in advanced math classes. Convenience sampling was also used to recruit the researcher's students, who was also their math teacher. A mixed-methods convergent design was used to study students' quantitative data through the mAMAS (Carey et al., 2017) and qualitative data through the expressive writing intervention.

Parents were interviewed while the intervention was being conducted. Using an ITS design, students served as their control group by answering the mAMAS before the intervention began producing baseline math anxiety levels. Additional class sections were used as a control to assist in triangulation. Both treatment and control groups were assessed for math anxiety. However, the experimental group was assessed after each exposure to the expressive writing exercise, where their results were compared to their baseline data.

Chapter 5

Process of Implementation

Recruitment

Recruitment emails were sent to parents for the expressive writing study on Monday, March 27, 2023. The email included the Johns Hopkins University Homewood IRB approved consent form and the details of a virtual informational session presenting an overview of the study and a dedicated time for parents' and students' questions. The virtual information session took place on Thursday, March 30 at 6:30pm on Zoom. One hour was allotted for the information session but concluded after 45 minutes. In attendance were 11 parents and two students. Few questions were asked. Students inquired about my personal interest in the topic and effects of the study on their school grades. The researcher shared her personal experience with math learning and motivation for pursuing the study of math anxiety. Students were reassured the study would not affect their grades or other school performance measures. The researcher shared a brief overview of measures taken to ensure confidentiality, anonymity, and objectivity. Recruitment for students concluded Monday, April 3, 2023.

Recruitment for parent participation in an interview was briefly announced in the student recruitment email. Another announcement was made during the virtual information session. Parents were sent a recruitment email for participating on Monday, April 3, 2023. The recruitment window was intended to close on Friday, April 7, but three exceptions were made with three parents who emailed the researcher with interest in participating in the study. The last parent consented on Thursday, May 4, 2023.

Intervention

Baseline Data

Students were shown a 2-minute video titled "Do You Have Math Anxiety?" (GCFLearnFree.org, 2019) the day after student recruitment closed, Tuesday, April 4, 2023. Students did not have any questions about the video but showed immense interest in the study, specifically about the design and doctoral research in general. The researcher shared details of the study and answered students' questions. Students were told the intervention would begin on their next test scheduled for Friday, April 14, 2023.

On April 14, a math test covering a unit of study with multiple learning objectives was administered to all students. Students were told to answer the survey after they finished the math test. While the students were taking the test, the researcher placed a district-owned iPad on their desk. Students received a card containing their name and a QR code. For the control groups, students' cards had one QR code for the survey. Participating students in the study received a green card with a QR code giving them access to the mAMAS on a Google Form. Non-participating students were given a yellow card with a QR code giving them access to a neutral survey on a Google Form. Students were not told the meaning of the color coding of the cards and were asked to answer the survey assigned to their QR code specifically. The treatment groups received the same color-coded cards except their cards had two QR codes, one on each side. One QR code was labeled, "Do BEFORE the test" and the other, "Do AFTER the test." Students were told to scan the "AFTER" code and expect to answer a survey, not a writing activity. With approximately 15 minutes left in the class period, students were reminded to take the survey before leaving class. Since some students were not yet ready to turn in their test, all students were allowed to take the survey and return to their test. Most students took the opportunity to fill out the survey and returned to their test while some students waited until they turned in their test. The researcher, who is also the math teacher, was in the classroom to troubleshoot device and code issues. Some students were unfamiliar with how to use QR codes and a couple of QR codes were not functional. The researcher possessed an unassigned green and yellow card with both QR codes and scanned the code for the student. This process was repeated 2 weeks later, on Friday, April 28, 2023.

Treatment and Control Data

Math 7+

The expressive writing intervention began on Tuesday, May 9, 2023, with the Math 7+ sections. A special block schedule was utilized for state testing, making classes approximately 90 minutes in length. The morning class which is the control group took the survey after their test while the treatment group did the writing exercise before receiving the test. A social studies teacher with a free period administered the writing exercise with a 7-minute timer while the researcher/math teacher was outside the room. Once the timer ended, the social studies teacher informed the researcher/math teacher who returned inside the classroom. The researcher asked students if they had questions at that time, which they did not. Students were instructed to keep their iPads and QR codes to access the survey upon completion of the test. The test was passed out to students who had the remainder of the period to complete. The school site practices designated testing days of the week for subjects to prevent accidental scheduling of multiple tests on a single day. Math courses are designated for Tuesdays and Fridays. The intervention process was repeated on test days, Wednesday, May 17 and Friday, June 2, this time with the school site's Speech and Language Pathologist as the proctor of the writing activity. The decision to hold a test on Wednesday, May 17, another shortened class period, was made by polling students on when they would like their test scheduled that week, due to other school-related events that would impact their readiness and stress level.

Math 7/8/Algebra

The same implementation process took place for Math 7/8/Algebra students on their next test, Tuesday, May 16, 2023, with some notable differences. Each class on May 16 was shortened periods to accommodate for the bi-weekly implementation of a socioemotional learning curriculum. Students were reassured that the test was shortened to accommodate the writing activity and the shortened period, but students clearly wanted additional time on their test. A pedagogical decision was made to give students additional time the following day to work on the test, unbeknownst to the students until class arrival. All Math 7/8/Algebra students, whether in the control or experimental groups, were asked to take their survey again, either the mAMAS or the neutral survey, after turning in their test for the second time, Wednesday, May 17, 2023. The last implementation occurred on Friday, June 2, 2023. The morning treatment groups were proctored by a sixth-grade science teacher who is now the school's assistant principal. The afternoon treatment group was proctored by the speech and language pathologist.

Parent Interviews

Parents received a recruitment email to participate in an interview to share about their involvement in their child's math learning. Any parents who consented to participate but did not select an appointment slot or availability were sent an email including the scheduler tool and requesting availability information. Appointments were confirmed using Google Calendar which included the Zoom link.

Thirteen parents were interviewed between April 17 and May 11, 2023. Three interviews took place on Monday, April 17, the first day of the school's spring break recess. Two occurred on Wednesday, April 19, three on Friday, April 21, one on Tuesday, April 25, two on Friday, April 28, one on Monday, May 1, and one on Thursday, May 11. One parent scheduled an interview for Friday, April 21 but could not attend and rescheduling issues prevented the interview from occurring.

Findings

Evaluation of the Process

Process evaluation examines the fidelity of implementation of an intervention to ensure outcomes are related to the elements of the program (Saunders et al., 2005). The intervention study was modeled after the expressive writing intervention on math anxiety conducted by Park and colleagues (2014). Two research questions were posed to study two components of fidelity of implementation: reach and participant responsiveness.

RQ1: To what extent is the intervention performed on the target population of high-achieving students enrolled in either advanced placement courses offered to seventh-grade students?

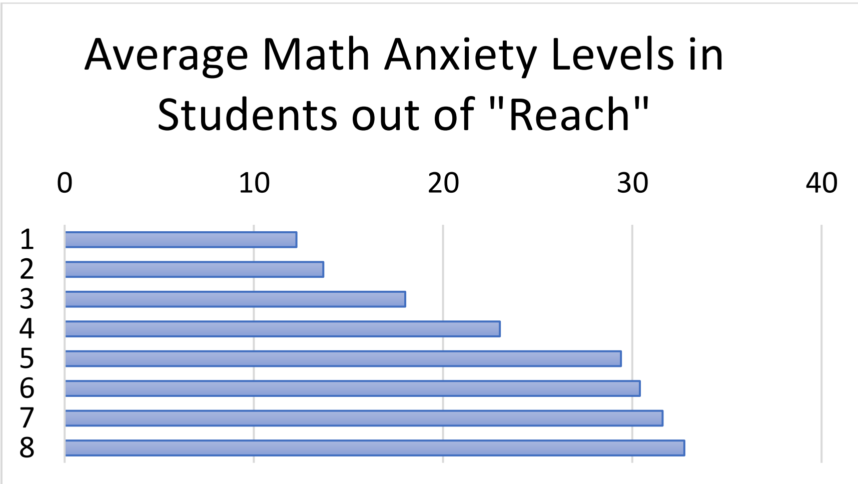
RQ2: To what extent are students responsive to the intervention?

Reach

Reach refers to ensuring the study is administered to the target population (Saunders et al., 2005). Of the 69 student participants, all were enrolled in an advanced math course, a criterion for the purposive sampling conducted for the study. However, based on district placement criteria, eight students were in an advanced math course not aligned with their performance data. Their data was included in the study to observe math anxiety levels potentially related to misplacement (see Figure 6).

Figure 6

Average Math Anxiety Levels in Students Whose Math Course Does Not Match Placement Criteria



Of the eight students who were not in the correct math placement, seven belonged to the experimental group and one belonged to the control group. In the experimental group, those who were out of reach had higher average math anxiety levels than those who were placed per school criteria (see Table 6). The opposite was true for the single student who was in the control group, who had lower math anxiety than the students in the control group who were "in reach."

Table 6

Comparison of "Out of Reach" and "In Reach" Students' Math Anxiety Levels

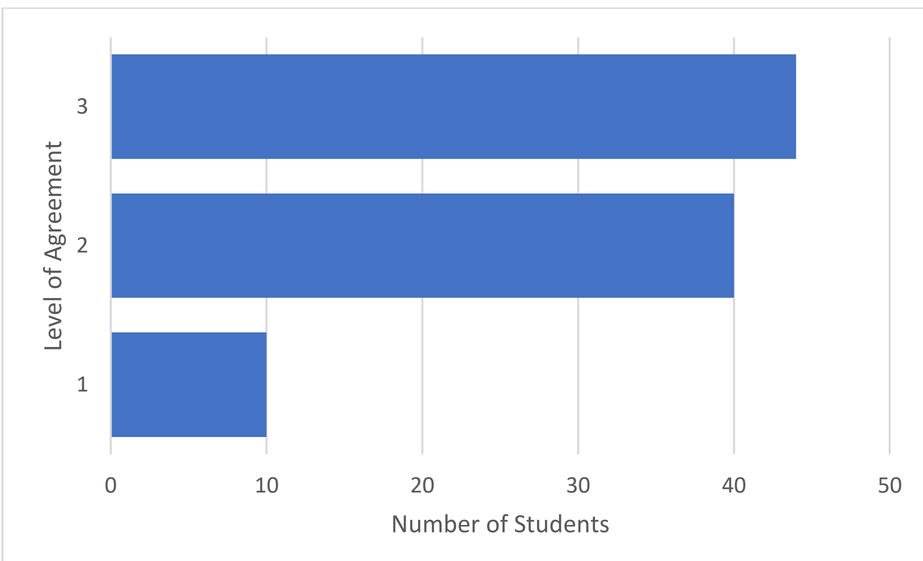
	Reach	*N*	*M*	*SD*	Std. Error Mean
Experimental Group	Out of Reach	7	25.429	7.6726	2.9000
	In Reach	34	21.882	6.2074	1.0646
Control Group	Out of Reach	1	13.666	.	.
	In Reach	26	22.568	7.1032	1.398

Participant Responsiveness

Participant responsiveness measures how participants react to the intervention and their level of engagement (Dusenbury et al., 2003). Two sources of data collection were intended to evaluate participant responsiveness. The first source was students' self-reporting of their level of engagement before participating in the expressive writing exercise. Using a Google form, students were asked to rate their level of agreement on the statement, "I desire to participate in the expressive writing activity today" using a 3-point Likert scale ranging from 1 = *disagree* to 3 = *agree*. Figure 7 shows the total number of responses from the students (n = 43) who participated in the expressive writing exercise. Seen in Figure 7, most students (n = 44) rated "3," indicating they desire to participate in the expressive writing activity.

Figure 7

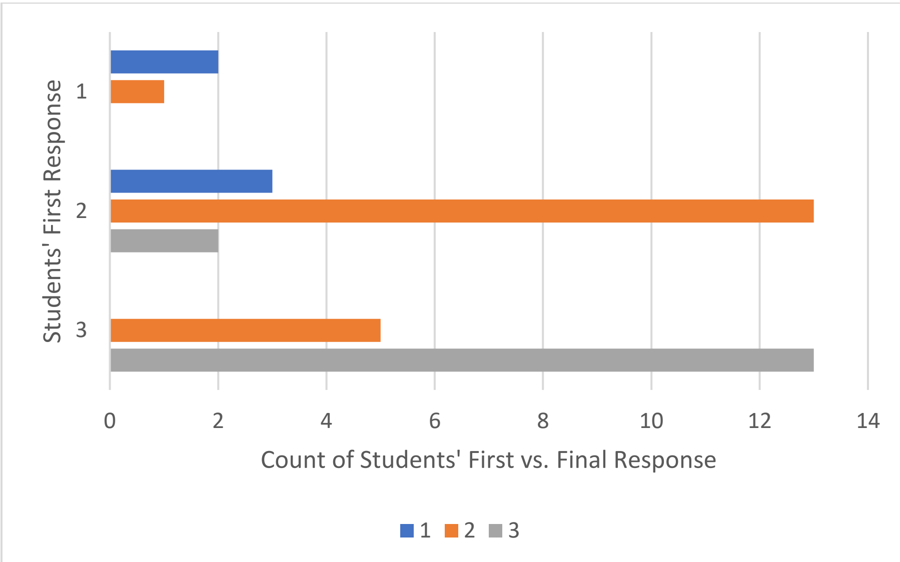
Total Student Responses to Participant Responsiveness Survey Item From Treatment Group



Students were consistent in their responses to the responsiveness survey item. Those who responded "1" on their initial expressive writing exposure tended to respond "1" on their final exposure. The same was true for responding "2" and "3," as seen in Figure 8.

Figure 8

Students' First vs. Final Response for Participant Responsiveness Survey Item



Descriptive statistical analysis did not reveal differences in means between math levels and exposure incidents (see Table 7). Since the quantitative results for participant responsiveness failed the homogeneity of variances assumption, the non-parametric Mann Whitney U test was used to compare the means of the math levels and exposure count. Table 8 summarizes the findings.

Table 7

Descriptive Statistics for Participant Responsiveness Comparing Math Level and Exposure Count

	Math class	*N*	*M*	*SD*	Std. Error Mean
First Exposure	Math 7+	10	2.4000	.69921	.22111
	Math 7/8/A	1	3.0000	.	.
Second Exposure	Math 7+	1	3.0000	.	.
	Math 7/8/A	26	2.3462	.62880	.12332
Third Exposure	Math 7+	10	2.3000	.82327	.26034
	Math 7/8/A	2	3.0000	.00000	.00000
Fourth Exposure	Math 7+	11	2.2727	.78625	.23706
	Math 7/8/A	28	2.3214	.66964	.12655

Table 8

Inferential Statistics for Participant Responsiveness Comparing Math Level and Exposure Count

Exposure	Null hypothesis	Sig.[a,b]	Decision
Exposure 1	The distribution of Participant Responsiveness is the same across categories of Math 7+ and Math 7/8/Algebra	.545[c]	Retain the null hypothesis.
Exposure 2	The distribution of Participant Responsiveness is the same across categories of Math 7+ and Math 7/8/Algebra	.444[c]	Retain the null hypothesis.
Exposure 3	The distribution of Participant Responsiveness is the same across categories of Math 7+ and Math 7/8/Algebra	.364[c]	Retain the null hypothesis.
Exposure 4	The distribution of Participant Responsiveness is the same across categories of Math 7+ and Math 7/8/Algebra	.939[c]	Retain the null hypothesis.

a. The significance level is .050.

b. Asymptotic significance is displayed.

c. Exact significance is displayed for this test.

In the writing samples, mixed emotions towards the writing exercise were represented. One student shared her anxious thoughts, worries, and concerns and towards the end of her writing submission stated, "Writing this kind of calmed me down." which was followed by other affirmations such as, "I can do this!!!" Another student shared that he doesn't like writing essays and that he did not like writing for this exercise.

An unintended engagement indicator was observed by the researcher. Since the researcher is also the students' math teacher, the researcher stepped out of the classroom during the writing activity to mitigate any potential issues of coercion on students' writing. After seven minutes concluded, the proctor notified the researcher to return. Upon return, the researcher found students continued to write even after the seven-minute timer had gone off.

The purpose of the online discussion was to gather students' insights on their engagement on the expressive writing intervention as well as share their experience with math anxiety. Since students were given a briefing on the definition of math anxiety using GCFLearnFree's "Do You Have Math Anxiety" video, students began utilizing "math anxiety" in their terminology. In their expressive writing, two students self-prescribed math anxiety as a current experience. Most students, regardless of math anxiety level, mentioned anxious thoughts about the upcoming math test. Others shared physiological symptoms connected with math anxiety. One student mentioned, "…when I walk into [math] class, my teeth start chattering or I start shaking my leg" and another student reporting his heart rate went up as he works on tests. Another student wrote 308 words, 60 of which were about the student's feeling of thirst and needing water. Although the online discussion did not take place, the written data provided students' feedback about the writing and their perceptions of math anxiety by using the terminology in their writing, describing physiological symptoms, and sharing their anxious thoughts. The data collection was found sufficient without additional, anonymous discussions in another format.

Evaluation of the Outcomes

Students' writing submissions and parents' interviews were coded using Braun and Clarke's (2006) thematic analysis. Inductively, six themes arose from the students' writing and four themes from the parents' interviews. For anonymity purposes, parents' names have been converted to mathematicians, irrespective of gender or cultural background, and students' names have been converted to Greek letters.

Descriptive and inferential statistics were used to analyze the results of the mAMAS survey. An independent sample *t*-test was conducted to compare math anxiety levels between groups Math 7+ and Math 7/8/Algebra, and between low math anxious (LMA) and high math anxious (HMA) students because of the intervention. To run an independent sample *t*-test, the data must meet six assumptions, of which all were met by the study as outlined below.

Assumption 1

The first assumption requires the dependent variable to be measured continuously. This assumption is met because the dependent variable in the study is levels of math anxiety which is measured from zero to 45 using the 5-point Likert scale.

Assumption 2

This assumption is met since there is one independent variable consisting of two categorical, independent groups. The independent variable is the expressive writing intervention and the two groups compared in Research Question 3 are LMA and HMA students, and Math 7+ and Math 7/8/Algebra students in Research Question 4.

Assumption 3

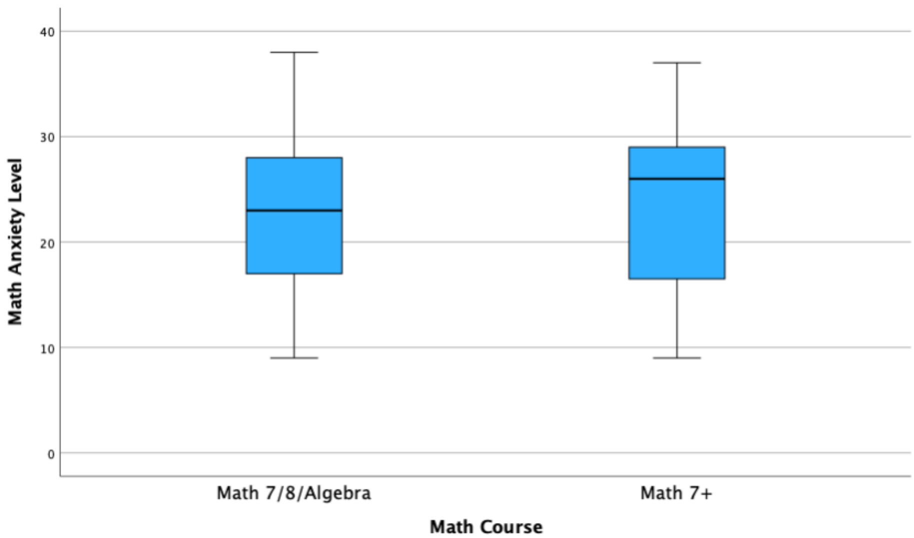
Independence of observations is present in the study since each group has different participants and there is no possibility for overlap. Students' math anxiety levels are classified by a single number which cannot exist in more than one classification of math anxiety levels. Students can only enroll in one math class at a time so they cannot take both Math 7+ and Math 7/8/Algebra.

Assumption 4

No significant outliers exist as shown in box plots (see Figure 9).

Figure 9

Box Plots of Math Anxiety Levels by Math Course



Assumption 5

Visual inspection of Q-Q plots shows the data is normally distributed (see Figures 10 and 11).

Figure 10

Normal Q-Q Plot of Math Anxiety Levels in Math 7/8/Algebra Students

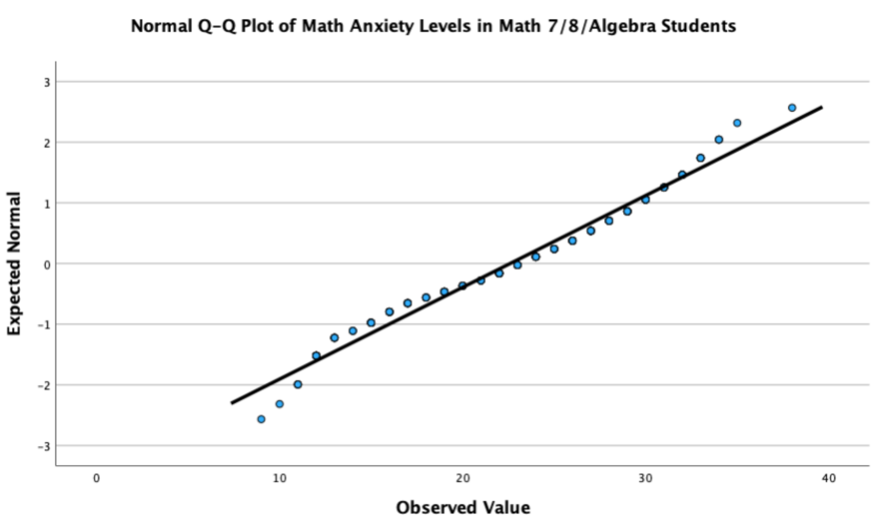
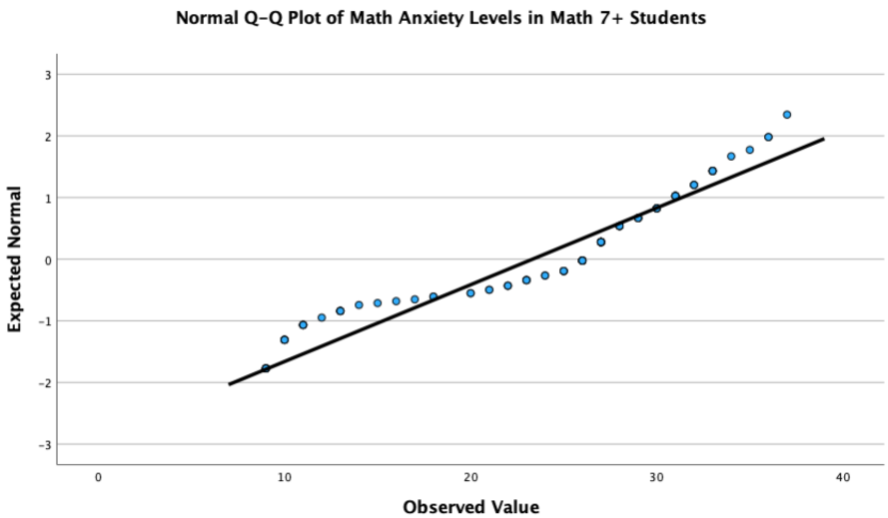


Figure 11

Normal Q-Q Plot of Math Anxiety Levels in Math 7+ Students



Assumption 6

The Levene's test evaluates whether two groups have the same variance of population. If the result of the Levene's test is greater than .05, then the variances are not significantly different than each other. Homogeneity of variance was met by Levene's test for equality of variances (p = .784). Therefore, the population variances regarding the distribution or spread of data are around the mean.

Research Question 3

Mitchell and George's (2022) math anxiety levels were used to classify students as either low or high math anxious students. Scores nine to 20 were classified as low math anxious and high math anxiety was assigned to scores of 33 and above. Of the 69 student participants, 24 students were classified as low or high math anxious. Of the 24 students classified, only one was considered high math anxious with a score of 34.6 (see Table 9). Low math anxious students also scored low on math anxiety in their final exposure given they were part of the treatment group. The single high math anxious student was in the control group.

Table 9

Math Anxiety Level Score in Low and High Math-Anxious Students

Psuedonym	Baseline math anxiety score	Final exposure score
Zorina Abreu	18	
Zhen Abu-Zahra	10.8	
Zhanetta Adeyeye	11.2	
Yunzhe Afonso	30.6	
Yaya Ashkenazi	19	17
Yat-Lun Atri	16	16
Yasuhiro Au	11	12
Yanwen Aurori	12.5	15
Yan Austin	11.5	12
Trent Blakely	14	
Tobias Blattman	18.33333333	
Timothy Bolton	16	
Tiffanie Bosson	13.66666667	
Thomas Brandt	12.33333333	
Thomas Braun	15.75	
Theodore Brodsky	12.4	
Thavin Bromberg	19.2	
Tae Carrillo	9	13
Tadamitsu Carrow	13	9
Suanne Cautero	12	10
Sung Casasayas	9	11
Simon Chau	11	15
Shiv Chayet	18.5	17
Youngjin Ahn	34.6	

In general, student participants were not math-anxious independent of the control or treatment group (see Table 10).

Table 10

Low and High Levels of Math Anxiety in Math 7+ and Math 7/8/Algebra, Control and Treatment Groups

Math course	Low math anxiety		High math anxiety		Other		Total
	n	%	*n*	%	*n*	%	*N*
Math 7+							
Control	4	30.7	1	7.70	8	61.6	13
Treatment	4	36.3	0	0	7	63.7	11
Math 7/8/Algebra							
Control	8	57.1	0	0	6	42.9	14
Treatment	7	22.6	0	0	24	77.4	31

Note. Low and high math anxiety levels established by Mitchell and George (2022).

Research Question 4

Descriptive (see Table 11) and inferential statistics (see Table 12) compared students belonging to the treatment group and their math anxiety levels between the two math courses: Math 7+ and Math 7/8/Algebra. In general, students' math anxiety did not change over time. An independent samples *t*-test showed no statistically significant result regarding differences in students' math anxiety levels before and after the expressive writing treatment (see Table 12).

Table 11

Descriptive Statistics of Math Anxiety Levels of Treatment Group for Math 7+ and Math 7/8/Algebra

	Math class	*N*	*M*	SD	Std. Error Mean
Baseline	Math 7+	10	20.800	7.8712	2.4891
	Math 7/8/Algebra	31	23.032	6.0621	1.0888
Mid-Exposure	Math 7+	11	20.727	7.7245	2.3290
	Math 7/8/Algebra	30	23.633	6.1194	1.1172
Final Exposure	Math 7+	10	20.20	8.535	2.699
	Math 7/8/Algebra	30	24.70	7.013	1.280

Table 12

Independent Sample t-Test Comparing Math Anxiety Levels Between Math 7+ and Math 7/8/Algebra

			Significance				95% Confidence Interval of the Difference	
	t	df	One-Sided *p*	Two-Sided *p*	Mean Difference	Std. Error Difference	Lower	Upper
Baseline	-.941	39	.176	.353	-2.2323	2.3727	-7.0315	2.5670
Mid-Exposure	-1.255	39	.108	.217	-2.9061	2.3153	-7.5891	1.7770
Final Exposure	-1.665	38	.052	.104	-4.500	2.703	-9.971	.971

Note. The significance level is .050.

Math anxiety was lower in males, with a mean of 20.6273, compared to females, who had a mean of 24.4348 at the beginning of the experiment. After the treatment, males continued to score lower in math anxiety, with a mean of 21.56, versus females, who had a mean of 25.71.

Qualitative Data

Data from students' writing and parent interviews were integrated to capture the microsystemic portrait of students' math achievement. Separately, students' writing and parent interviews were coded separately using Braun and Clarke's (2006) thematic analysis. Iterative review of each data set involved reading all transcripts for an overall understanding of the data, then providing initial descriptor codes and jottings, followed by an organization of codes by commonality. Themes were assigned to batches of codes depicting similar messages and a final review of the transcripts was done to ensure parent and students' voices were represented. Students expressive writing revealed six major themes: feelings about the upcoming test, comments about the classroom environment, parent and peer influence, math self-beliefs, comparing experiences in different math classes, and self-regulation. Students' writing was demonstrative in their anxious thoughts and feelings about the upcoming test and in general diverged from their survey results. Parent interviews provided insight on their child's math learning experience through four major themes: cultural differences between schooling in their home country and in the U.S., their parenting approach, thoughts about the middle school and math instruction, and their rationales for students' success in math. The two data sets overlap in two broad areas: cultural influences and perceptions of middle school math. Parenting styles and students' self-regulatory strategies did not overlap since the prompts were participant specific. They each will be discussed separately since they were not common themes. Preservation of students' and parents' quoted remarks as verbatim have been prioritized. In some cases, minor changes have been made to grammar and conversational fillers reduced to help with reporting, while maintaining the highest integrity of the intended meaning of the quote.

Cultural Influences

Both students' writing and parents' interviews contained content about cultural background as an indicator related to performance. Two students, both in the Math 7+ course, included Asian identity in their writing. Student Upsilon wrote, "A lot of students that come from Asian-American backgrounds are stereotyped with parents that only care about grades." An Asian identity appeared to make a connection with performance in math specifically according to student Epsilon, who shared, "I feel like math is a huge subject that others think Asians should be good at, but if I'm being the most honest, I'm really not that great at math." Three parents with children in the Math 7/8/Algebra classes also acknowledged the pressure students associate with an Asian background. Parent Noether stated, "I know for Asian[s], they normally do very well already. But still they will think, I can do better. So, there is that pressure." Parent Gauss wondered how Asian students would weather in a less competitive environment suggesting fostering and pursuit of math-related studies and careers may be easier with less surrounding pressure. Parent Fermat, who is an elementary school teacher in the district, says her classroom is predominantly Asian, and noticed parents of her students never make comments that their children's math is difficult.

Parents' cultural background was a frequent topic of discussion as they shared their experiences with math education in their home country. Diverse backgrounds and educational experiences were represented. Three Math 7+ parents mentioned their experiences. Parent Al-Khwarzimi reported "stress and fearfulness" as commonplace in the schooling of an African country, and lessons with "convoluted explanations" in native languages, reported by parent

Lovelace who grew up in Russia. Parent Sun Tzu attested to rigorous schooling in India, stating that her experience was very strict with an emphasis on math. Parent Fibonacci, from Math 7/8/Algebra, reported children as early as Kindergarten preparing for university placement tests for coveted enrollment in India's highly ranked universities, the Indian Institutions of Technology. Cultural background appeared to impact parents' personal experiences with math education since their schooling took part in a non-U.S. country whereas students acknowledged cultural background in assimilating terms.

Perceptions of Middle School Math

Peer and Teacher Perceptions

Parents' personal experiences with education in their home country contributed to their views on U.S. schooling including criticisms and praises. Several parents of Math 7/8/Algebra students shared their perceptions. Parent Pascal strongly felt the use of timed tests was a source of anxiety in children, arguing its impracticality in real world situations. Teachers in China would show many steps and expect students to do the same, reported Parent Archimedes, who said an underemphasis in showing work is a significant difference to U.S. schooling. Parent Hypatia, however, praised the middle school for being less strict than schools in their home country and focusing on applying mathematical reasoning with real-world problems rather than an overemphasis on speed, algorithms, and number of problems children need to finish.

Students' writing responses also revealed diverse opinions about middle school math on several fronts. Peer relations and perceptions of the teacher and the teacher's instructional practices were salient topics. Peer relations appeared to be competitive, exemplified by three Math 7/8/Algebra students, Omega, who said, "I felt a bit better when some people in my table groups also got the same questions [wrong] as me...," and Gamma, "I would also worry about where I stand in the class. If I am below average, average, or above average." A Math 7+ student, Epsilon, reported interactions of being bullied, "…they start laughing and saying, "This class isn't even that hard how do you not get an A?" Only one student, also in Math 7+, Phi, shared positive opinions about their peers, saying, "I didn't understand…so he helped me understand it; what a nice teammate…"

The teacher and her instructional strategies were described in a plethora of ways. The personality of the teacher was described as funny, helpful, strict, and moody. Omicron, from Math 7+ and Kappa, from Math 7/8/Algebra, mentioned the teacher getting emotional on occasion. The teacher's emotions clearly affected student Nu, from Math 7/8/Algebra, who listed several grievances with the teacher with strong language including, "hate," "should be fired," and "the absolute worst." Kappa described the teacher as strict but, "…I understand what [the teacher's] rules and what environment she is trying to set up, and that really helped me." Lambda, from Math 7/8/Algebra, wrote the math teacher made the effort to make sure all students understood the material, a first for her in her math learning journey. Also, in Math 7/8/Algebra was Pi, who said the class is "not too hard because the teacher doesn't teach too fast." In the same course was Student Xi who disagreed and criticized the teacher for not spending enough time on teaching and too much time talking about non-math related topics. Meanwhile student Theta from Math 7+ appeared to find the off-topic conversations enjoyable, stating, "…we might just make a joke about anything at possibly any moment…we sometimes incorporate the jokes into our learning process…we always seem to bounce back to our learning so that we can stay on task." Also, from Math 7+, Phi said he felt confident in the upcoming test because the teacher "taught it well." Divisive perceptions of peers and teachers were evident in parents' and students' reporting. Parents desired both a strict and stress-free learning environment for their children. Students' peer relations ranged from contentious to competitive to helpful. Perceptions of the math teacher were also polarizing including strong negative language from one student and more agreeable opinions from others.

Perceptions of the Classroom Environment

A clear distinction between test days and non-test days was made in the students' writing. Upsilon from Math 7+ and Alpha-2 from Math 7/8/Algebra said stress related to the class did not occur on "regular days." Writings related to anxiety almost always related to the upcoming test except for Kappa who said she gets nervous answering questions in front of class. Test days brought anxiety due to feeling rushed to finish the test and check one's work. From Math 7/8/Algebra, Delta said she feels her heart rate go up from feeling rushed while taking a test, while Theta from Math 7+ said the time limit of quizzes and tests makes her forget her learning.

Three students from Math 7+, Theta, Mu, and Omicron, and one student from Math 7/8/Algebra, Omega, wrote that the class was fun. All three Math 7+ students said the class was challenging but enjoyable while Omega added the class was interactive and the teaching was clear. Omicron added, "Nothing is really harsh or stern, and it is all just learning." Rho, from Math 7/8/Algebra, said the class felt like a high school course which she felt was preparing her. In general, students associated their anxious thoughts with test days due to the time limits on performing. On non-test days, students felt the class was fun, interactive, but still challenging.

Students' Self-Reflections and Self-Regulatory Strategies

Peer perceptions appeared to affect students' math self-beliefs. Student Epsilon, the Math 7+ student who shared the negative comments peers made towards her, also made statements about feeling stupid compared to others. Student Eta, also in Math 7+, made a more neutral comparison, feeling peers were better at math but she still felt confident. Alpha reflected that she does not look down on others who ask questions but is nervous to ask questions herself. Her reflection also included feeling immense anxiety even though her parents do not pressure her to academically perform.

Extracurricular math classes appeared to affect students' math identity. Two students, Lambda, and Sigma, related their experience in extracurricular math class to the current course. Lambda felt the extracurricular math class moved too quickly and didn't go as in depth as Math 7/8/Algebra. Lambda shared a liking for math after taking Math 7/8/Algebra due to the multiple approaches incorporated and depth of instruction. Student Sigma felt unmotivated to work on his extracurricular math because it was more challenging than Math 7/8/Algebra. Students Epsilon and Beta, from both Math 7+ and Math 7/8/Algebra classes, felt at a disadvantage for not taking extracurricular math courses, but related the disadvantage more to speed rather than mastery of content. Only one student, Nu, shared a liking for her extracurricular math class.

Students used the writing exercise to make self-reflections. Omega from Math 7/8/Algebra stated, "I feel a bit confident that I can successfully learn new math concepts," and Kappa from the same class said she was proud of her progress. Omicron from Math 7+ shared a similar sentiment, "I am sure the class won't have anything difficult, which makes it easier for me to relax and participate." However, not all students felt efficacious. Alpha said she loved math at a young age but finds it increasingly difficult to be "good at math." Gamma's writing attested to 7th grade Algebra was harder than math in 6th grade. Iota from Math 7/8/Algebra said, "…it seems like no matter how hard I work I just can't seem to get the grade/test score that I want, which is highly frustrating; it hurts."

Students reflected on their self-regulation strategies and cognitive resources. Student Eta, from Math 7+, desired to manage her stress because stress limits her "brain power" while student

Pi, from Math 7/8/Algebra recognized the math class may not be difficult because she has a "large memory capacity." Psi, also in Math 7/8/Algebra, said she tries to get a good night's rest the day before a test and wears "comfy clothes" on test days. "Keep your head in the game," says Zeta, in the same math class, a mantra she repeats to herself to help reduce anxious thoughts from overwhelming her. In Math 7+ is Phi, who mentioned the calming music of a breathing exercise display the teacher casts to the projector on the whiteboard is relaxing and reminded him of an aquarium. The same breathing exercise display was found "annoying" by Math 7/8/Algebra student, Chi, who said the breathing exercise "barely helps." Students' reflections showed an understanding of their cognitive abilities in their math course as it relates to their own capabilities, to other students, and to extracurricular and previous math courses. They also show an understanding of stress management tools including self-soothing tools such as listening to relaxing music, repeating affirmations, and wearing comfortable clothing.

Parenting Styles

Parents' expectations were expressed in three students' writing submissions. Alpha, previously mentioned, that her parents do not pressure her to academically perform. This was also true for student Upsilon in the Math 7+ class, stating, "I am beyond lucky to have parents that only care if I understand the topics and help me if I don't." On the other hand, recall Eta from Math 7+ who said she felt her peers outperformed her but still felt confident and wanted to decrease her stress to maximize her brain power, felt pressure from her mom to perform.

Parents shared diverse parenting orientations and practices. Three parents with children in Math 7+ shared their thoughts. Sun Tzu, concerned about her child's stress level, simply said, "Happiness first, then you can do whatever you want" while parent Descartes established, "…whether you like it or not, you have to play along. It is probably not as healthy. You have to look at what is good in this stressful environment and try to gain as much as possible from it." Parent Khayyam put it in this perspective.

> We are going to be thrilled if you get an A but if you get a B and you're trying your hardest, we're going to recognize your effort. They're still so young, you have so many years of schooling, you're gonna get better at it as it goes on. When you get into college and you're picking your classes, I don't want them to have that negative feeling of 'I don't like those classes, so I'm not going to do it.

Aryabhata and Bhaskara, parents of a Math 7/8/Algebra student, say they aren't stressed about their child's math performance perhaps because their student is confident in math and maintains interest in the subject. They support him with his math homework and accept that he makes mistakes. Aryabhata and Bhaskara interact with other parents through a community group chat. According to their experiences with the parent community, parents put too much pressure on kids who need space to be able to relax. They think parents should be more accepting of children's errors on math tests and discourage the practice of arguing with the teacher over small point deductions to help raise the child's grade. They suggest instead that parents encourage students to focus on understanding mistakes and communicating with the parent and teacher for support. All parents desired to see their students succeed but placed an emphasis on different elements such as prioritizing mental well-being or effort or understanding how to take advantage of the system.

Conclusions

The present study set out to understand students' experiences with math anxiety and parents' perspectives in their child's math learning. Expressive writing was explored as a possible intervention on students' levels of math anxiety. All 69 student participants were part of the intended population of study, except for eight students whose parents overrode the placement recommendation. In general, the students' survey results showed they were responsive to the intervention. However, expressive writing as a mindfulness exercise did not yield statistically significant results on reducing math anxiety.

Both parents and students shared their experiences with math. Parents provided insight to math schooling in other countries, which shaped their views on U.S. schooling and their children's math learning experiences. Students acknowledged the associations of achievement with Asian culture and their writings were cognizant of their parents' expectations. Most students shared their thoughts about the school environment including peer relations and peer perceptions as it relates to their math identity. Perceptions of the math teacher and her instructional practices appeared to be polarizing from students' writing submissions. A range of parent approaches was also represented, from an emphasis on mental well-being, to an acceptance of the competitive environment, to a commentary of the unnecessary pressure parents place on their children in the local school community.

Discussion

Though the sample size of the student participants was sufficient to use inferential statistics as determined by Yamane's formula on sample size in finite populations (Sutanapong & Louangrath, 2015), there was no statistically significant differences found in expressive writing and math anxiety levels before and after the intervention. Since the study was conducted within the last 8 weeks of the school year, disruptions in scheduling and typical end-of-school-year events may have contaminated the outcomes. Since seventh grade is the first year students have an opportunity to take advanced math, an iterative examination of math anxiety and expressive writing may be more fruitful if conducted in the fall of the school year, when students are beginning their transition into advanced math class. Students have adapted to their math class by the end of the school year and have likely enacted different coping strategies when faced with math anxiety. Therefore, conducting the study at the beginning of the school year can also capture potentially more nuanced and novel aspects of math anxiety.

Cultural identity and math identity were a topic of discussion for both parents and students. Wu and Battey (2021) found Chinese and Taiwanese American immigrant parents felt it was important for the students to experience more challenging math than what was taught in schools. Consistent with Wu and Battey's study, the parents of the present study also utilized extra teaching at home with challenge problems as well as enrolling their child in extracurricular math classes. Certain extracts from students' expressive writing results deeply resonated with the students' sentiments reflected in Wu and Battey's study relating math identity to cultural identity including the association of Asian identity with being "good at math." As discussed in Chapter 1, the model minority myth is a double-edged sword where Asian American students are positively stereotyped for being naturally smart and hardworking but are also responsible for upholding the model. The evidence of students' writing indicates the math classroom impacts their math self-beliefs through not only cultural identity but through peer relations whether competitive, hurtful, or helpful. Thus, the math classroom environment, as a result, becomes a social conduit for children to showcase both their cultural and math identity.

Personal experiences appeared to strongly influence parenting decisions but not consistently across parent interviews. The findings of the present study are consistent with Choi et al.'s (2013) study on parenting styles which found a mixture of authoritarian and authoritative parenting practices in Korean parents. For example, parents who came from strict educational contexts felt either it was a necessary experience for their child to also experience a strict environment for success while for other parents, rigid and stressful educational experiences led them to underemphasize performance. Interestingly, parents from both approaches acknowledged the role of children's mental wellbeing but with different viewpoints.

Parent participants may not be representative of the wider parent community. Potential selection bias (Shadish et al., 2002) and social desirability bias (Ranjan & George, 2014) may be at play, which compromises the findings of the study. Selection bias occurs frequently in social research when random sampling is not employed, and some members of the intended population are not represented in the research. Parents who engage in strict, authoritarian parenting styles may not want to consent to be interviewed for concern they would be criticized and appear to be a bad parent. Therefore, the parents interviewed in the study may fit an atypical profile of students' parents. Social desirability bias occurs when individuals respond in ways that are favorable to themselves, reducing negative components and highlighting positive, socially desired, components. Similarly, parents who did consent to be interviewed may be more prudent in sharing their negative approaches to downplay negative perceptions of bad parenting.

Students' writing overwhelming included peers and teachers. Students interact with peers and teachers daily and are the most prominent relationships held outside of the home environment, comprising a significant component of the student's microsystem (Neal & Neal, 2013). Their conceptions of middle school math education were more related to the classroom environment, their math teacher's instructional practices, and comparisons to other math classes. These findings are consistent with Watabe and Hibbard's (2014) study on Japanese students that school factors were more strongly associated with students' academic motivation than parenting styles.

Teacher behaviors and practices were prominent constructs in students' writing. This study is unique in that the researcher is also the students' math teacher and the expressive writing exercise asked students to make comments on their math learning experiences. As a result, some students wrote their response directly to their math teacher, knowing she would be the one to analyze the results. Others wrote about the math teacher, with the same knowledge. To that end, the researcher has implemented measures to maintain as much objectivity as feasible in reporting the findings and analyzing the results. Though statements of positionality are increasingly popular in social science research to contextualize the epistemological lens of the research, a statement of researcher reflexivity is intentionally omitted to safeguard the integrity of the research, as intended by rigorous scientific methods (Savolainen et al., 2023).

In conjunction with the socioemotional learning curriculum implemented at the school site, the math teacher incorporated mindfulness exercises in the classroom. On test days, the teacher would cast a breathing exercise animation from the Calm.com website for students to utilize if they were feeling anxious during the test. The Calm app has been proven to effective in delivering mindfulness meditation to assist individuals in reducing stress (Clarke & Draper, 2019; Huberty, 2009). The animation is accompanied by relaxing audio which was broadcasted at a low volume. This mindfulness exercise was found "annoying" to one student who said that she tries the breathing exercise and finds no difference in her anxiousness. To another student the visual was calming and the music reminded him of an aquarium which he found relaxing. Clearly students are in search of coping mechanisms to help alleviate their math anxiety. Considerations for expressive writing and other potential directions for assisting students with their math anxiety are discussed.

Limitations

The expressive writing activity did not yield statistically significant results. The empirical research on expressive writing shows a single bout of writing can be effective in reducing anxiety (Park et al., 2014). The intervention took place in the last 7 weeks of the school year. Several factors potentially impact students' behavior and performance during this period of the academic calendar. On the first day of implementation, April 14, 2023, several students participated in a school-sponsored field trip to Disneyland Theme Parks. Three additional field trips were scheduled before the end of the school year, impacting students in relevant classes and clubs, and missing school as a result. Immediately following the Disneyland field trip was Spring Break recess for all staff and students. Upon return from Spring Break was the commencement of state testing where the school site staff implements a reduction of homework assignments and assessments to assist students' workload from an intensive testing schedule. Five additional days had noteworthy schedules including a staff learning day, national holiday, 2 days with shortened periods from the traditional 52-minute class to a 47-minute class to accommodate for a socioemotional learning curriculum, and 1 minimum days with 28-minute classes. Students' mentality is also affected. One student shared in her writing, "Plus, next year's math placement is already guaranteed so it's not like it means that much other than boosting my grade a bit, so why should I stress myself out about it?"

Students answered the mAMAS after their math test, when there can be a rush to finish, check work, and pack up materials to leave for class. These factors can impact the mAMAS results. Response bias occurs when individuals answer surveys inaccurate. In the case of the mAMAS, students may answer inaccurately if they are bound by time constraints to finish a test and perform end-of-class procedures, causing them to answer impulsively rather than evaluating their response carefully. Since students answered the same mAMAS survey after each exposure, response bias may impact results since students have already seen the questions and indicate the same responses even if their answer had changed.

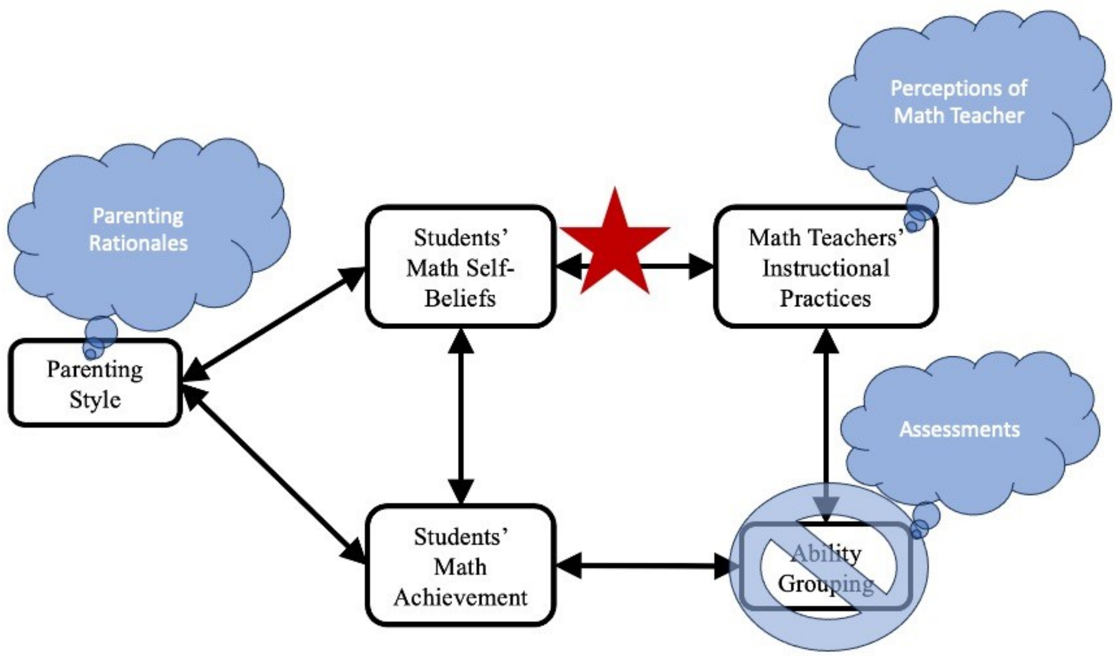
The decision to forego the online discussion, despite seemingly adequate results from the participant responsiveness survey item and content from the expressive writing results, is another limitation. There is no way to confirm that the online discussion would yield similar results since it did not occur. Therefore, reporting positive participant responsiveness is speculative without the online discussion.

Revisiting the Conceptual Framework

The original conceptual framework (see Figure 2) proposed in Chapter 1 was configured based on the factors presented in the existing literature around math achievement in high-achieving, Asian American, affluent demographics. After collecting empirical data from teachers, parents, and students and conducting two literature reviews on the problem of practice and intervention programs, changes to the conceptual framework for future directions is warranted. Though Baumrind's (1972) seminal study on parenting styles is widely used to discuss parents' roles in adolescents, the scope of parents' influence goes beyond their style of parenting. Evident in the parent interviews of intervention study are parents' rationales for their parenting decisions, which appeared related to their personal experience with their own parents, schooling, and cultural identity. Askew (2019) categorized math teacher orientations with three approaches. Mentions of teachers' instructional practices in students' writing were vague and sparse. Instead, students wrote about their math teacher's personality and their feelings about math class. Therefore, further investigation into the same or similar populations may benefit from examining perceptions of the math teacher rather than the math teachers' instructional practices. Though ability grouping appeared to be a potential underlying factor in two students' writing, their focus was again on feelings about their math ability, including peer perceptions of their math ability. In studying the participants iteratively, ability grouping should not be a focus when examining math achievement. Instead, assessments would serve as a viable replacement since several students mentioned their negative feelings about the upcoming test, which they indicated was specific to test-taking and not present during non-test-taking class periods. Finally, in accordance with the Organization for Economic Co-operation and Development (2003), math self-beliefs appeared to be a significant factor in students' writing as they wrote about their math anxiety and physiological symptoms related to math anxiety. Their use of the term, "math anxiety" also indicates a need to explore this specific math self-belief in this context. A final augmented version of these changes to the conceptual framework can be found in Figure 12.

Figure 12

Augmented Conceptual Framework



Future Directions

The current body of work has examined math anxiety in high achieving students in an affluent, predominantly Asian and Asian American suburb of Silicon Valley, California.

Comprising a learner's microsystem (Neal & Neal, 2013), teachers, parents, and students were studied to provide empirical evidence of factors impacting students and their math learning environment. Understanding the contextual factors around math anxiety is essential but not a solution. Considerations for next steps from the perspective of the teacher practitioner and scholar are discussed.

Self-regulatory tools such as breathing exercises and expressive writing are relatively simple and can be used to address math anxiety in the classroom. Students, teachers, and parents alike expressed interest in the topic of math anxiety while the intervention study was being conducted. Therefore, raising awareness around math anxiety and self-regulatory tools has high application potential. Considering the widespread nature of math anxiety in school-aged adolescents, future research to find additional self-regulatory tools to address math anxiety would be helpful to both students and educators.

Coping with math anxiety does not eliminate math anxiety. Discussed in Chapter 1, antecedent factors to math anxiety include math anxiety in teachers and parents, which may transfer onto children. Parents in the intervention study indicated a desire to understand math anxiety and engage in discourse with other parents about their children's experiences with math learning. Facilitating a parent workshop or discussion could benefit the school community as parents share and learn about different perspectives on the academic goals they have for their children. Social norms and cultural identity as discussed and found in the intervention study also play a role in how students view their relationships with math. Though antecedent factors of math anxiety are complex and sociologically embedded, research into eliminating math anxiety at the root is necessary and most beneficial to math learners.

The current body of work studied middle school students in advanced math levels. Advanced math students may feel pressure to perform and to succeed due to expectations from peers, parents, and teachers. Still, all students, regardless of math level, want to feel successful in math. Contextual factors examining the students in grade level and intervention populations may overlap with those in advanced math classes. However, further investigation into the experiences of diverse student groups would be beneficial since all math learners develop math self-beliefs.

Does math anxiety affect females and males the same? Though the research did not focus on gender as a factor, females had higher math anxiety levels than males. Social norms also impact females' math self-beliefs. If females do indeed have lower math self-beliefs than males, supporting females in the math classroom would be necessary. If there was not a difference in genders' math self-beliefs, studies could add to the body of research examining gender disparities in math education with potential solutions.

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Appendix A

Logic Model

<table>
<tr><td colspan="5">Background: This intervention aims to bring awareness of the negative effects of math anxiety on math performance to math teachers and students. The intervention will provide a tool for students to use to mitigate math anxiety before a math exam.</td></tr>
<tr>
<td rowspan="3">Context:
- High-achieving student population
- High socioeconomic status
- Public K-8 school district
- Silicon Valley, California
- Demographic majority Asian

Needs Assessment Overview:
Teachers report students:
- Are fearful in taking risks or getting an answer incorrect.
- Have difficulty seeking help.
- Dislike math.
- Experience pressure to take advanced math courses from parents

Literature Support:
- Math avoidance, feelings of pressure, and low-performance are bidirectionally associated with math anxiety. Self-regulation strategies are effective in reducing students' math anxiety.
- Teacher, parent, and student play a roll in developing and supporting the student's socioemotional adjustment.</td>
<td rowspan="2">Inputs
- Adult proctor
- Support from teachers in the math department, counselors, school psychologist, and administration.
- YouTube
- Projector or presentation device
- Classroom to conduct intervention
- Paper or digital log of implementation notes.
- Electronic devices to collect data</td>
<td colspan="2">Outputs</td>
<td rowspan="2">Student Outcomes
Proximal outcomes (day of intervention):
- Decrease in negative physiological symptoms associated with math anxiety
- Decrease in math anxiety
- Working memory resources freed up to focus on the math assessment.
- Improved reaction time on math problems
- Less math errors

Distal outcomes:
- Improved math performance
- Decrease in math avoidance
- Improved self-efficacy in math
- An additional tool for self-regulated learning</td>
</tr>
<tr>
<td>Activities
- Proctor presents video, "Do you have math anxiety?" (GCFLearnFree.org)
- Proctor reads instructions of expressive writing to class.
- Using a device, students are given seven minutes for expressive writing before a math assessment.</td>
<td>Participants
- Proctor to conduct intervention Teacher, counselor, administrator, or researcher
- Researcher or other adult logging intervention procedures for fidelity purposes.
- Approximately 60 7th-grade students enrolled in an accelerated pathway with similar context characteristics, to perform expressive writing intervention.</td>
</tr>
<tr>
<td colspan="2">Assumptions
- Students experience varying levels of math anxiety before math assessments.
- Efforts to mitigate math anxiety not already present in classrooms.
- Students are able to participate, understand instructions, and use technology (e.g., navigate a web-browser, type using a keyboard)</td>
<td colspan="2">External Factors
- Community influence – teachers, parents, and/or peers may express negative perceptions of intervention, impacting student receptivity towards implementation.
- Unplanned changes to implementation by proctor or students.</td>
</tr>
</table>

Appendix B

Recruitment Letter

Approved March 23, 2023 Protocol Number: HIRB00016855

Dear Parents,

My name is Kimberly Lam, and I am your child's current math teacher at [redacted] I am also a doctoral candidate for Johns Hopkins University School of Education, where I study the connection between the mind, brain, and teaching. As part of fulfillment for my dissertation, I am conducting a study on math anxiety in high-achieving students at our school.

Partnering with the parent community continues to be a strength [redacted] is proud to foster. We at [redacted] understand the important role that parents play in developing the whole child. We are deeply appreciative of parents' involvement and support towards that endeavor.

A study examining students' experiences with math at our school would be remiss without the voice of parents and their valuable insight into students' math learning. I am recruiting parents of eligible students to participate in my study to share their perspectives on math anxiety and their child's math learning. Should you consent to participate, your participation includes a virtual interview conducted on the conferencing platform, Zoom. The interview may take up to 30 minutes of your time and will be audio-recorded. Any identifying information, including your name, will be kept confidential and will not appear anywhere in the study or its report by redaction or anonymizing methods. The report will capture broad themes found in the data and will not include specific results.

I am eager to hear parents' perspectives. I plan on sharing the findings of my study with the broader community of educators and parents to advocate for our students. My study will also contribute to the existing scholarly research on math anxiety. All parents of students eligible to participate will receive a consent form via Google Form from my advisor and principal investigator, Dr. Elizabeth Todd Brown. If you have any questions about the study, please contact Dr. Todd Brown at [redacted]

Your participation is entirely voluntary. There is no cost to participate, and no payment will given to those who participate. There are no foreseen risks or anticipated discomfort involved by participating. If you agree to be interviewed for the study, you can change your mind and stop anytime. Before you say yes or no, please ensure I have answered all your questions. You can contact me, the researcher, at [redacted] or Dr. Todd Brown at [redacted] by email at [redacted].

If you want to be in this study, please sign your name and write today's date. You will get a copy of this form to keep. I ask that you return this consent form by (third business day).

With appreciation,
Kimberly Lam

____

Signature of Parent (Print Name) Date/Time

Appendix C

Modified Abbreviated Math Anxiety Scale

Modified Abbreviated Math Anxiety Scale (mAMAS; Carey et al., 2017)

Instructions: Please give each sentence a score in terms of how anxious you would feel during each situation. Use the scale at the right side and circle the number which you think best describes how you feel.

	 Low anxiety	Some anxiety	Moderate anxiety	Quite a bit of anxiety	 High anxiety
1. Having to complete a worksheet by yourself	[]	[]	[]	[]	[]
2. Thinking about a math test the day before you take it.	[]	[]	[]	[]	[]
3. Watching the teacher work out a math problem on the board.	[]	[]	[]	[]	[]
4. Taking a math test	[]	[]	[]	[]	[]
5. Being given math homework with lots of difficult questions that you have to hand in the next day.	[]	[]	[]	[]	[]
6. Listening to the teacher talk for a long time in math class	[]	[]	[]	[]	[]
7. Listening to another child in your class explain a math problem	[]	[]	[]	[]	[]
8. Finding out that you are going to have a surprise math quiz when you start your math class	[]	[]	[]	[]	[]
9. Starting a new topic in math class	[]	[]	[]	[]	[]

Appendix D

Intervention Prompts

Intervention Prompts (Brewster & Miller, 2022)

Expressive Writing Prompt

Please take the next 7 minutes to write as openly as possible about your thoughts and feelings regarding the mathematics test that you are about to have. In your writing, I want you to really let yourself go and explore your emotions and thoughts as you are getting ready to start the mathematics class. You might relate your current thoughts to the way that you felt during other similar situations at school or in other situations in your life. Please be as open as possible as you write about your thoughts at this time. You may write about the same general issues or experiences on all days of writing or about different topics each day. All of your writing will be completely confidential. Don't worry about spelling, grammar, or sentence structure. The only rule is that once you begin writing, you continue until the time is up.

Control/Neutral Prompt

Please take the next 7 minutes to write as factually as possible about the activities and events that occurred in your life yesterday. Please describe in a non-emotional manner what you did yesterday, such as activities or tasks that you performed. For example, you might start when your alarm went off and you got out of bed. You could include the things you ate, where you went, which buildings or objects you passed by as you walked from place to place. I am not interested in your emotions or opinions, rather I want you to try to be completely objective. Feel free to be as detailed as possible. However, the most important thing is for you to describe what you did as accurately and as objectively as possible.

Appendix E

Expressive Writing Intervention Student Online Discussion Questions

Adapted from Hudson and Day's (2012) study on expressive writing in athletes

General Topics

Experience of using expressive writing

Writing about the stressor

Changes in perceptions of themselves

Anticipated changes to their approach to future math exams

Experiences of the writing process and its potential use as an applied strategy

Themes and Questions

Self-development

1. Did the expressive writing exercise help you develop as a person such as focus, confidence, relation to others, renewed motivation, or clearer goals?

Emotion management

2. Did the expressive writing exercise help you deal with emotions which had been unresolved from the past? Were there any emotions you expressed in writing that you feel would be difficult expressing verbally?

Negative effects during writing

3. Did you feel any negative emotions whilst writing? How did they affect your mood, emotions, or feelings?

Transitions during writing

4. Did you feel your emotional state and writing content changed over time?

Difficulties and concerns

5. Did you have any initial fears or concerns about writing?

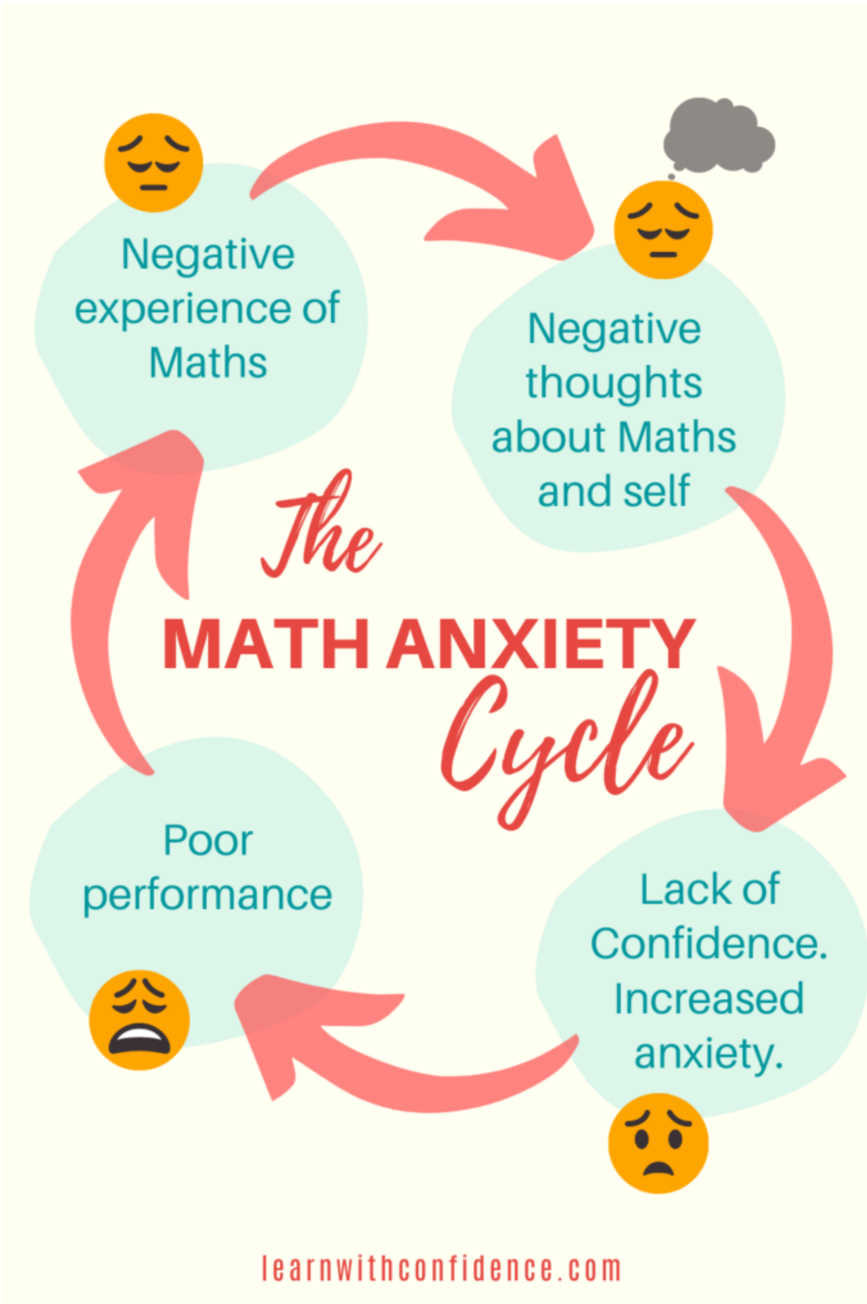
Writing as an intervention

6. Would you use writing as a strategy for preparing for future stressors such as a math test?

Appendix F

Math Anxiety Image

Math anxiety image displayed on screen during parent interview, next to interview questions



Appendix G

Semi-Structured Interview With Parents

Adapted from Jay et al.'s (2018) study on parental involvement in their child's math learning.

Themes and Questions

Parents' experience of mathematics with their child(ren)

1. Do your children talk about math?
2. What kind of things do they say?
3. How do you think they feel about math?

Parents' own experience of mathematics when they were at school

4. What did you think of math when you were at school?
5. Can you remember the kinds of things you did?
6. How different do you think this is to what you see your child doing?

Parents' interactions with their child(ren)'s school about learning

7. How much do you talk with the school about what your child is doing?
8. How much does the school ask you about what you do with your child?

Interactions with school about mathematic learning in particular

9. What do you think about the math your child does at school?
10. What do you think about what/how the school teaches in math?

Parents' experience of mathematics with their child(ren)

11. What kinds of things do you do to help your child at math?
12. How do you feel about helping your child at math?

Parents used mathematics in their everyday lives

13. What kinds of ways do you use math now in everyday life?

14. How important is math to you?

Appendix H

Parent Letter

Approved March 23, 2023   Protocol Number: HIRB00016855

Dear Parents,

My name is Kimberly Lam, and I am your child's current math teacher at [redacted]. I am also a doctoral candidate for Johns Hopkins University School of Education, where I study the connection between the mind, brain, and teaching. As part of fulfillment for my dissertation, I am conducting a study on adolescent math students.

At [redacted] we take pride in developing the whole child through rigorous instruction, abundant elective opportunities, and a robust athletic department. We also prioritize our students' socioemotional health and work closely with them to ensure they are supported.

Students will have an opportunity to participate in my study. Their participation includes answering an online survey and performing a brief writing exercise. Students will be asked to report their levels of anxiety related to math topics on the survey. The survey will take approximately five to ten minutes and be administered up to five times. The writing exercise, Expressive Writing, is a self-regulation mindfulness strategy, shown to offload negative emotions and feelings that may arise in stressful moments. Students will write about their concerns, worries, or other anxious thoughts for seven minutes before taking a math assessment and will do this exercise up to three times. Finally, the study will end with a survey asking students to provide feedback about the writing exercise and their overall experience. Your child's name will be kept confidential and will not appear anywhere in the study or report. Any identifying information will be redacted or anonymized. The report will capture broad themes found in the data and will not include specific students or specific results.

I am excited to conduct my study to capture students' perspectives in our community. I plan on sharing my findings and their implications with the broader community of staff and parents to advocate for our students. My study will also contribute to the existing scholarly research on math anxiety. All parents of students eligible to participate will receive a consent form via Google Form from my advisor and principal investigator, Dr. Elizabeth Todd Brown. The form will provide more detailed information about the study I am conducting. If you have any questions about the study, please contact Dr. Todd Brown at [redacted] or by email at [redacted]u. We will only collect data from students enrolled in the class who have obtained and submitted parent consent. Your child does not have to participate in the study.

I ask that you fill out the consent form by (fifth business day). I will hold a virtual information session on (fourth business day) to briefly present the study and answer any questions. You can find information about the virtual informational session below. I hope to see you there.

With appreciation,
Kimberly Lam [redacted]

Virtual Information Session
What: Brief overview of study and Q&A
When:
Where [redacted]
Who: Parents (students welcome)

Appendix I

Non-Participant Survey

Adapted from NSSE's (2013) study on student engagement

Instructions: The following questions ask you to report the frequency of school-related activities. Answer each question the best you can. Your responses will be anonymous and will not be included in the study's data analysis.

	Never				Alway s
1. I receive hot lunch from the cafeteria.	[]	[]	[]	[]	[]
2. I check out books from the school library.	[]	[]	[]	[]	[]
3. I use an electronic device at home to work on school assignments.	[]	[]	[]	[]	[]
4. I am on campus after school for events such as sports, club meetings, contests, performances, dances, and/or homework club.	[]	[]	[]	[]	[]
5. I participate in the school spirit week events by dressing up or participating in competitions.	[]	[]	[]	[]	[]
6. I forget to bring what I need for school.	[]	[]	[]	[]	[]
7. I email my teachers with questions.	[]	[]	[]	[]	[]