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UNIVERSITY OF NORTHERN COLORADO

Greeley, Colorado

The Graduate School

DEMOGRAPHIC PREDICTORS OF MATH ANXIETY IN
ELEMENTARY SCHOOL CHILDREN

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Arts

Melissa Reann Flowerdew

College of Education and Behavioral Sciences
School of Psychological Sciences
Educational Psychology

August 2021

This Thesis by: Melissa Reann Flowerdew

Entitled: *Demographic Predictors of Math Anxiety in Elementary School Children*
has been approved as meeting the requirements for the Degree of Master of Arts in the College
of Education and Behavioral Sciences in the School of Psychological Sciences, Program of
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ABSTRACT

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Due to the increasing interest of math anxiety in elementary level children, the present study explored math anxiety contextual factors through Bandura's (1999) Social Cognitive perspective. Using the *Children's Anxiety in Math Scale*, researchers gathered data from 40 primary-level children to explore four demographic predictors--grade-level, special needs identification, gender identity, and socioeconomic status-- of mathematics anxiety through a hierarchical regression model. Findings indicated demographic variables accounted for over one-third of the variance in math anxiety scores at 38.2% (grade level: 12.3%, SNI: 8.4%, gender identity: 13.2%, SES: 4.1%). With the exception of socioeconomic status, all predictors were significant. These findings provide implications and recommendations for educators, parents, and future researchers.

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CHAPTER I

INTRODUCTION

Understanding Mathematics Anxiety

Experiencing non-pathological anxiety is common in humans, as it originates from our innate fear response, which instinctually serves as a means of survival in response to an undesired stimulus (Jansen et al., 1995). Homo sapiens of the prehistoric age faced daily life-threatening encounters (e.g., ferocious animals); these experiences activated the autonomic nervous system to better equip the body with resources to flee or face the situation, including increased heart rate and strength of heartbeat, redistribution of blood to vital areas (i.e., blood and energy is sent to muscles instead of the digestive system), and increase in oxygen intake (McCarty, 2016). Humans have mitigated fearful encounters throughout evolution, but still experience these physiological responses when perceiving danger. Even when danger is absent, the body experiences anxiety--mirroring the same physiological response as fear (Milosevic & McCabe, 2015). Stimuli that is not life-threatening can still be perceived as a threat. In an academic setting, many students find mathematics threatening; thus, mathematics anxiety is a common type of academic performance anxiety (Finlayson, 2014; Luttenberger et al., 2018).

Math anxiety is fear, tension, or avoidance that affects manipulating numbers or solving mathematic problems in both academic and ordinary life circumstances (Ashcraft, 2002; Hopko et al., 2003). Tasks are viewed as threatening or challenging through personal judgment of an individual's own abilities (Şakar et al., 2015). Those who lack in resources (e.g., self-efficacy, motivation, intelligence, knowledge, social support) view the task at hand as threatening—eliciting physiological responses of fear (Ashcraft & Faust, 1994; Faust, 1996; Shi & Liu, 2016;

Sorvo et al., 2017). When an individual deems themselves as having the ability to meet the demand, they view the task as a challenge and avoid the physiological changes (Blascovich & Mendes, 2010; Lyons & Beilock, 2012). Triggering stimuli is relative to the individual and can range from plausible (i.e., high-pressure testing situations; Maloney & Beilock, 2012) to unconventional circumstances (i.e., budgeting or calculating a tip at a restaurant; Harari et al., 2013).

Occupational or academic settings can elicit math anxiety, but it can also be found in non-academic daily life (e.g., refiguring a restaurant bill or counting change at the grocery store; Jansen et al., 2016). In educational settings, subtraction and division (problems requiring carrying operations) are most frequently recognized as anxiety inducing (Ashcraft, 2002); even so, demands of basic numerical skills and processing of any kind can elicit an anxious response (Maloney et al., 2010; Richardson & Suinn, 1972; Rubenstein & Thompson, 2012; Suinn et al., 1988; Wu et al., 2012). Various tasks like reading math problems, completing homework, or teachers assigning time restrictions can invoke tension and distress among students (Ashcraft & Moore, 2009; Maloney & Beilock, 2012; Onwuegbuzie & Wilson, 2003; Sorvo et al., 2017). Occupations, especially those in the STEM field, present opportunities for employees to experience math anxiety; for instance, a math anxious nurse may experience distress while counting pills or configuring medication dosages (Beilock & Maloney, 2015; McMullan et al., 2012). Maladaptive negative cognitions and concerns develop from forecasted performance and outcome-based settings—making numerical anxiety a subtype of performance-based anxiety (Ashcraft, 2002; Ashcraft et al., 2007; Harari et al., 2013; Hopko et al., 2001).

Albeit currently missing diagnostic criteria in the DSM-V, the negative response indicates an affinity with social phobia and general anxiety (Ashcraft & Moore, 2009; Egger &

Angold, 2006). Performance-based anxiety stems from the potential for undesirable evaluation or judgement that a student may experience when an instructor is selecting a learner at random to solve a problem on the whiteboard or asking a math problem to be read aloud. Completing assessments, answering questions in front of classmates, and the anticipation of high-pressure aptitude tests like the GRE or SAT also present the potential for unwanted evaluation (Ashcraft & Moore, 2009; Hembree, 1990; Hopko et al., 2001; Jameson, 2013; Klados et al., 2017; Ramirez & Beilock, 2011; Sorvo et al., 2017; Vukovic et al., 2013; Wu et al., 2014). Math anxiety shares similar characteristics with test anxiety, but empirical research has found they need not be concurrent, and the common variance is only 37% (Sorvo et al., 2017).

For math anxious individuals, prospective thoughts alone are enough to invoke negative reactions and disrupt performance (e.g., low test scores or incorrect solving strategies) but do not solely indicate an individual has math deficits or poor numerical ability (Aiken, 1976; Ashcraft, 2002; Ashcraft & Moore, 2009; Ashcraft & Ridley, 2005; Beilock & Maloney, 2015; Beilock & Willingham, 2014; Suinn & Edwards, 1982). Researchers recognize math anxiety as a multifaceted construct that has several contextual factors affecting the expression and impact among demographically diverse populations.

Despite missing criteria in the DSM and the lack of emphasis in most educational settings, math anxiety is not an atypical experience among any populace—adults, adolescents, or children (Ashcraft & Moore, 2009; Dowker, 2005; Dowker et al., 2016; Stevenson et al., 2000).

Purpose

The current study explored the relationship between personal and environmental contextual factors and CAMS mathematics anxiety scores. Intrigued by the existing research of

contextual factors and children, the research team sought to broaden the understanding of the predictive role contextual factors play in math anxiety levels.

Research Question

A demographically diverse sample was targeted to address the following posed research question:

- Q1 How do demographic variables contribute to students' math anxiety scores based on the *Children's Anxiety in Math Scale*?

CHAPTER II

REVIEW OF LITERATURE

Math Anxiety and Age

Adults and Adolescents

Most research conducted on math anxiety over the last 60 years has been on adults and adolescents. International investigations have estimated 17% of the world's adult population suffer from a significantly high degree of math anxiety (Ashcraft & Moore, 2009) and 33% of 15-year-olds report experiencing mathematics anxiety (The Organization for Economic Co-Operation and Development, Program of International Student Assessment, 2013). Research has consistently provided evidence that math anxiety is an increasingly prevalent issue among these populations (Baloglu & Koçak, 2006; Betz, 1978; Jain & Dowson, 2009; Jameson & Fusco, 2014; Ma & Xu, 2004; Richardson & Suinn, 1972; Rodarte-Luna & Sherry, 2008).

Individuals with minimal academic exposure experience fewer formal opportunities to trigger their math anxiety, thus the majority of research in this population has been conducted on college-level students. Near the beginning of college-level research, Richardson and Suinn (1972) estimated 11% of undergraduate students showed levels of math anxiety high enough to be in need of formal advising, tutoring, or counseling. Betz (1978) later found that approximately 68% of United States undergraduate students enrolled in math classes experienced high mathematics anxiety. In the last 10 years, research has found 25% of four- year university students and 80% of community college students report experiencing moderate-to-high levels of

math anxiety. This is potentially influenced by students having low self-efficacy or poor math-concept (Beilock & Willingham, 2014; Chang & Beilock, 2016).

Feelings of nervousness, fear, and loathing were reported by 75% of adults in regard to mathematics (Furner & Duffy, 2002). Neural research found math-anxious adults experience slower reaction times and heightened activity in frontal brain regions (Klados et al., 2017; Núñez-Peña et al., 2015; Núñez-Peña & Suárez-Pellicioni, 2014), and fMRI scans have indicated that math anxious adults may experience phobia-related neural patterns—resembling those of a physical pain response—when doing math-related tasks (Lyons & Beilock, 2012). Math-related cues can inhibit activation in brain regions needed for mathematical reasoning in both adults and children, fostering disengagement and avoidance behaviors (Hembree, 1990; Klados et al., 2017; Pizzie & Kraemer, 2017; Ramirez & Beilock, 2011; Wu et al., 2014). Johnston-Wilder et al. (2014) found 48% of STEM apprentices experience numerical anxiety—18% experiencing moderate and 30% experiencing high levels (Beilock & Maloney, 2015; Johnston-Wilder et al., 2014). Reports from those who study or work in a math-driven field continue to encourage research on the contextual factors of mathematics anxiety. Taking into consideration that 93% of adults in the US report negative numerical experiences during their K-12 education, investigating arithmetic experiences in elementary-level children became crucial for understanding the origin of math anxiety (Furner & Duffy, 2002).

Children

After decades of investigating the influence of math anxiety on adolescents and adults, researchers sought to understand development with hopes to cultivate prevention plans and treatment (Harari et al., 2013; Jameson, 2013). Initial research of elementary students concluded that children could hold negative attitudes towards math, but further research was needed to

confirm if those feelings were equivalent to experiencing math anxiety (Gierl & Bisanz, 1995). Through cognitive interviews and pilot testing, children demonstrated the ability to comprehend and report feelings related to mathematics anxiety such as nervousness, anxiety, or tension levels (Ganley & McGraw, 2016; Ramirez et al., 2013; Vukovic et al., 2013). After concluding children were capable of experiencing math anxiety, research focused on time of onset. Data collection indicated that students began encountering math anxiety as early as kindergarten (Chang & Beilock, 2016; Frost et al., 1990; Sorvo et al., 2017).

Subsequently, researchers saw a number of parallels with adolescents/adults and children experiencing math anxiety; this led to investigating similarities among neural patterns and correlates. Young et al. (2012) evaluated regional activation in 7-to-9-year-old children during math related scenarios. Researchers found similar activity in regions associated with pain and areas connected to numeracy, emotions, and problem solving (i.e., amygdala, posterior parietal and dorsolateral prefrontal cortex, right caudate and left hippocampus). To properly grasp math anxiety beyond cerebral functioning and basic self-reports, understanding causal factors involved in its development during childhood is essential to deter and mitigate effects of numerical anxiety. Contributions to development and achievement are examined through environmental, personal, and behavioral contextual factors. This triad of mutually interacting factors is known as triadic reciprocal causation--the basic foundation of Social Cognitive Theory (Bandura, 1989).

Social Cognitive Perspective of Math Anxiety

The groundwork for Social Cognitive Theory (Bandura, 1989) emphasizes humans' ability to manage their own life course by making agentic choices. A combination of physiological systems (i.e., sensory, motor, and cerebral), brain mechanisms, and environmental influences aid in future direction and goal achievement (Bandura, 1999; Harre & Gillett, 1994).

Human agency focuses on individuals' control over their own thoughts, opinions, and actions through a mind that pairs its reactive tendencies with self-reflection, assessment, and creation (Bandura, 1999). As previously mentioned, contextual factors are not unidirectional; triadic reciprocal causation declares that environmental elements, personal factors (cognitive, affective, and biological), and behavioral patterns interact simultaneously (Bandura, 1986, 1997). This causation model is a valuable tool in helping researchers establish implications for future areas of research, populations of interest, and treatment.

Environmental Factors

Culture influences students via societal ideals or beliefs and through their individual appraisals of their relationship with mathematics (Bieg et al., 2015). Previous empirical research implies that cultural practices likely mediate the relationship between negative reactions, performance or achievement, and maladaptive views on failure (Dowker et al., 2016; Stevenson et al., 2000). Culture develops through “joint experience of a group of people who share vital or labor activities” (Gorgorió & Planas, 2000, p. 1). Cultural beliefs responsible for shaping student appraisals are fostered through the national climate regarding values, race, and gender (Geary, 1994).

Cultural differences on the approach of mathematical performance or presence of math anxiety can impact student's expectation, beliefs, and motivations (Brown et al., 2020; Eccius-Wellmann et al., 2017). For example, Columbian students are educated about low performance levels in mathematics; this knowledge may impact self-efficacy or self-concept levels (Brown et al., 2020) as training for educators in Columbia has not targeted problem resolution (García-Santillán et al., 2016). Reports of math anxiety values and practices suggest variables like pedagogical techniques or curriculum impact cultural groups individually, likely because each

culture differs in organization, values, and policies in the education system (Andrews & Brown, 2015; Brown et al., 2020; García-Santillán et al., 2016).

Race has also been identified as a cultural influencer for mathematics attitudes and performance (Gross, 1988; Matthews et al., 1984). Studies found students in the Asian American community outperformed Caucasian students; performance patterns also found that Asian American and Caucasian students outperformed Hispanic students. Students in the African American community were found to be the lowest performers. In second grade, Hispanic and African American students begin to fall behind a grade level in their math performance, while Asian American and Caucasian students begin advancing (Gross, 1988). Students who fall behind or advance a grade-level are more likely to continue to do so, widening the gap. Reported levels of enjoyment regarding math mirrored these patterns—Asian Americans and Caucasians reported higher enjoyment of math, while Hispanic and African American students enjoyed math less (Gross, 1988; Hall et al., 1999).

Gender is a societal factor that is sustained through stereotype threat; Stereotype threat is fear an individual will uphold a stereotype based on their racial, ethnic, gender, or cultural group (Spencer et al., 1999, 2016). Limited research has been done on this topic outside of the gender binary, thus the following data exclusively reflects male and female identities. Geary (1994) discusses the US culture as a potential contributor to threat preservation:

...US culture abounds with attitudes that foster math anxiety. Math is taught to be inherently difficult (as Barbie dolls used to say, “math class is hard”), aptitude is considered far more important than effort, and being good at math is considered relatively unimportant, or even optional. (p.7)

Until recent reforms of gender, Barbie has been classified as an exclusively feminine toy-- implying the most exposed population to Barbie's perspective of mathematics was gender identifying females. Students who found themselves similar to Barbie used her perceived math-concept, perceived ability and beliefs create personal schemas about skill capability, to judge their own abilities through vicarious experience, resulting in stereotype threat (e.g., Barbie is a female who thinks math is difficult; it's likely that female-identifying children assume they will inherently struggle and find math hard; Bieg et al., 2015; Geary, 1994; Nash & Grossi, 2007; Steele & Aronson, 1995). Parental attitudes, family SES, and educator practices are also culturally influenced environmental factors.

Home Environment Factors

Parents are considered the main influencers of vicarious experience and verbal persuasion in their children. Parents and their chosen parenting styles play a primary role in socializing their children (Chang & Beilock, 2016; Jameson, 2014; Maloney et al., 2015). Data has diligently shown that mathematics anxiety is not fostered solely in schools, inferring parenting practices shape their children's attitudes (Chang & Beilock, 2016; Jameson, 2013, 2014; Maloney et al., 2015; McLeod et al., 2007; Ramirez et al., 2018; Wood et al., 2003). Positive parenting aids in math-concept by developing better attitudes and beliefs about their academic capabilities through encouragement, positive feedback, and modeling appropriate behaviors (Daches Cohen & Rubinsten, 2017; Harper & Daane, 1998;). These parenting practices not only increase efficacy but have been shown to correlate with lower levels of numerical anxiety (Bong, 2008; Campbell & Verna, 2007; Fan & Williams, 2010; Koutsoulis & Campbell, 2001; Scarpello, 2007; Turner et al., 2004). Parents with a controlling style that monitor homework or demand continuous high achievement, negatively impact math-concept and self-efficacy (Bleeker & Jacobs, 2004) and

likely causing a reduction in interest and motivation (Bong, 2008; Campbell & Verna, 2007; Ginsburg & Bronstein, 1993).

Parental beliefs and personal experiences about math can also be modeled or communicated to their children (Maloney et al., 2015; Vukovic et al., 2013). Parents who do not report having math anxiety and who have positive attitudes towards math can help lessen anxiety and increase problem-solving performance levels; however, those with higher levels of anxiety can cause children to experience confusion from suggesting alternative problem-solving methods or a decreased achievement (Quach et al., 2015). Parents that express negative attitudes towards math may encourage children to conclude that math is something to be feared or infer they have poor arithmetic ability due to receiving uninvited help (Maloney et al., 2015; Pomerantz & Ruble, 1998).

Similarly, parents' gender stereotypes in math can transmit to their children and affect attitudes and achievement (Eccles et al., 1990; Gunderson et al., 2012; Jacobs & Eccles, 1992; Midgley et al., 1989; Yee & Eccles, 1988). Parent reports indicate beliefs of higher math ability and natural talent in their male children even if their male and female children show no differences in math achievement (Jacobs, 1991; Parsons et al., 1982; Yee & Eccles, 1988). For example, studies of 3rd and 4th grade children found parents of male students reported higher math ability than those of female students (Tiedemann, 2000); parents of kindergarten children also believed males to be better at math, while females were thought to be better at reading (Lummis & Stevenson, 1990). This longitudinal study confirmed parent gender-stereotypes affected students by 5th grade with males reporting higher expectations for success in math than females (Lummis & Stevenson, 1990).

Educational Factors

Elementary students in the US spend on average, a minimum of 26 instructional hours (not including lunch, recess, or certain specials) in school per week--an 880-hour average school year (Education Commission of the States [ECS], 2020). Consequently, a large amount of math ability, attitudes, and efficacy are also developed in the elementary classroom. Exposure to educator beliefs has the potential to shape student abilities, perceptions, and gender-stereotypes (Gunderson et al., 2012). For instance, similar to parent effects, teachers who endorse gender-stereotyped math views can also lead students to endorse like ideals, expectancies, and later achievement (Fiske & Neuberg, 1989; Keller, 2001; Tiedemann, 2000, 2002).

In-service and preservice educators in the U.S. have reported moderate-to-high levels of numerical anxiety (Battista, 1986; Bryant, 2009; Hembree, 1990). After reviewing U.S. standardized test scores and observing little change from year-to-year, data indicated a lack of mastery in fraction and division operations (National Mathematics Advisory Panel [NMAP], 2008). Qualitative researchers investigated this deficit by assessing conceptual ideas and foundational underpinnings in educators. Elementary and middle school teachers (1st-8th grade) displayed minimal understanding when asked to generate an explanation for the operational use of “invert-and-multiply” (e.g., $abcd=adbc$; Ma, 1999; Moseley et al., 2007; Seigel, 2012). Data suggest that educators in Japan and China not only understood conceptual ideas but were able to generate multiple explanations for inverse operations. These outcomes are a potential of multiple contextual factors including teacher anxiety and low self-efficacy (Allen, 2009; Chavez & Widmer, 1982; Markovits, 2011; Ramirez et al., 2018). Teachers who are numerically anxious claim the link began inside elementary classrooms; the pedagogical practices encouraged development of anxiety due to poor or hostile responses from teachers when in need of support

with math (Allen, 2009; Bryant, 2009; Bulmahn & Young, 1982; Furner & Berman, 2005; Jackson & Leffingwell, 1999; Ramirez et al., 2018).

In addition to responding negatively to students, low self-efficacy and anxiety tend to encourage textbook-based teaching approaches instead of engaging strategies, making numeracy inherently a negative stimulus for students who may later become educators. This cyclical influence continues to affect future educators, parents, and cultural practices (Ahmed et al., 2012; Bursal & Paznokas, 2006; Gresham, 2008; Jain & Dowson, 2009; Swars et al., 2006). Thus, environmental influence on the development of numerical anxiety continues in co-occurrence with personal factors.

Personal Factors

Attributes

Demographically diverse children that develop math anxiety are influenced individually by their personal characteristics--namely foundational knowledge, grade level, gender, and special needs identification.

Research shows math anxiety development may, in part, stem from foundational knowledge and numerical building block deficits (Bieg et al., 2015; Gunderson et al., 2018; Maloney et al., 2015). At the base of conceptual understanding are basic numerical processing skills such as counting (Maloney et al., 2010), comparing quantities of single-digit numbers (Dietrich et al., 2015; Pantoja et al., 2020), and 3D rotation visualization (Ferguson et al., 2015; Maloney et al., 2010). Findings also indicate a negative association with spatial processing skills and the development of the mental number line—an innate ability rather than developed skill (Harari et al., 2013). A weak math number line may cause negative experiences with math, likely effecting performance and leading to math anxiety (Ferguson et al., 2015; Pantoja et al., 2020).

Existing research indicates that math anxiety can manifest as early as kindergarten; most research shows that math anxiety increases over time, until dropping off in late high school or early college years (Cargnelutti et al., 2017; Hembree, 1990; Ma, 1999; Vukovic et al., 2013). Researchers suggest this progression occurs when math curriculum increases in difficulty (Tankersley, 1993; Yeo, 2005) or students experience the bidirectional relationship between math anxiety levels and performance (Cargnelutti et al., 2017; Gunderson et al., 2018; Luo et al., 2014; Park et al., 2014). Evidence is limited and inconsistent for children in 1st-3rd grade, but most indicates grade level and anxiety are either positively correlated (Jameson, 2013, 2014; Krinzing et al., 2009; Passolunghi et al., 2014) or reflect no correlation (Finlayson, 2014; Gunderson et al., 2018; Namkung et al., 2019; Ramirez et al., 2013). Some research also finds negative correlations between grade level and math anxiety (Maloney et al., 2015; Ramirez et al., 2016), suggesting that math anxiety decreases as children move throughout elementary school, perhaps due to increased efficacy, prior knowledge, or social comparisons (Eccles, 1984; Gunderson et al., 2018; Jordan et al., 2007).

Gender research has consistently been of interest due to the prominence of stereotype threat--especially in its relation to math anxiety (Halpern et al., 2007). As previously discussed, identifying as a woman increases subjection to the negative stereotypes indicating men are superior at mathematics (Costa et al., 2001; Egloff & Schmukle, 2004; Spencer et al., 1999). While some researchers (e.g., Benbow & Stanley, 1980, 1983) viewed gender as indicative of math performance, other researchers (e.g., Eccles, 1987; Fennema & Sherman, 1978; Levine & Ornstein, 1983; Meece et al., 1982) argue socialization differences of women are a larger contributor than innate biological differences. Little differences in performance have been found among gender; female participants indicated a slight advantage in computation skills and male

participants had an advantage in problem-solving ability (Hyde et al., 1990). These differences do not typically emerge until adolescence, and even then, the difference in performance was not significant (Hyde et al., 1990; Spencer et al., 1999). Alternatively, gender differences are significantly apparent in math attitudes and anxiety levels (Hembree, 1990; Hyde et al., 1990; Meece et al., 1990; Spencer et al., 1999). A meta-analytic review (Halpern et al., 2007) concluded that women report experiencing more math anxiety than men who score lower on trait anxiety self-report scales. Possible influential factors are gender society norms or men feeling reserved when publicly revealing personal attitudes (Costa et al., 2001; Egloff & Schmukle, 2004). While female elementary school students report higher levels of academic self-esteem compared to their male counterparts, female students tend to report lower levels of math-specific self-efficacy and higher levels of math anxiety than their peers (Bentz & Hackett, 1983; Costa et al., 2001; Halpern et al., 2007; Hembree, 1990; Hyde et al., 1990).

Special needs identification (SNI) may also mediate the relationship with math anxiety. SNI includes gifted and talented students as well as any student in need of an individualized education plan or 504c. It is estimated 6%-14% of students have learning disabilities in math (Barbarese et al., 2005); these students tend to struggle with low math achievement due to difficulties selecting problem solving strategies appropriate for achieving a goal (Duncan & McKeachie, 2005; Jain & Dowson, 2009; Kramarski & Michalsky, 2010; Ramirez et al., 2018). Gifted children and those with learning deficits equally struggle with self-efficacy and are commonly alienated from other children. Students of all special need designations develop aversions to math, resulting in an underdevelopment of skill and potential (Byrne & Shavelson, 1996; Fennema & Sherman, 1978; Robinson & Noble, 1991). SNI children share in developing learned helplessness (Covington & Beery, 1976; Dweck & Reppucci, 1973), avoid mastering

concepts deemed as un-useful (Rubinsten & Tannock, 2010), and persistence –all indicators of low math achievement and performance (Eccles, 1984; Fennema & Sherman, 1976; Fennema et al., 1990; Steele et al., 2002)

Behavioral Factors

Math Anxiety and Performance

Highly math anxious individuals are typically low performers; this is, in part, due to working memory as well as social cognitive factors like self-efficacy, motivation, and stereotypes.

Working Memory. Findings indicate working memory plays a role in mathematics performance that goes far beyond ability (Barrett et al., 2004; Conway, 2005; Engle, 2002; Smith & Jonides, 1999). Working memory, a short-term memory mechanism responsible for integrating, storing, and manipulating information relevant to a given task, is a vital performance indicator (Baddeley, 2002; Baddeley & Hitch, 1974; Chang & Beilock, 2016; Engle, 2002; Miyake & Shah, 1999). Capacity of working memory (5-7 pieces of information at a time; Eysenck & Calvo, 1992) is compromised when presented with threatening stimuli (i.e., numeracy challenges or worries founded in concerns for consequence of failure; Liebert & Morris, 1967). Worries become intrusive thoughts that occupy valuable attentional resources (Chang & Beilock, 2016; Engle, 2002), limiting the ability for one interact with details needed for problem solving requiring holding and manipulating information synchronously (Ashcraft & Kirk, 2001; Baddeley & Hitch, 1974; Beilock et al., 2010; Beilock & Maloney, 2015; Hopko et al., 1998; Peng & Terng, 2016). Students experiencing working memory disruptions frequently use strategies like pause, look back, and read aloud to help themselves maintain information accuracy (Ashcraft & Faust, 1994; Walczyk & Griffith-Ross, 2007). While effective, strategies

may sacrifice efficiency and problem-solving speeds in children—an increasingly important aspect of education productivity demands (Lopez, 2007; Valli & Buese, 2007). Students without time constraints show higher achievement and less errors on basic math problems. In total, working memory accounts for 30% of performance variance, rather than domain competence issues, within math anxious students (Ashcraft & Kirk, 2001; Ashcraft & Moore, 2009; Ashcraft & Ridley, 2005; Geary et al., 2009; Jordan et al., 2007).

Self-Efficacy. Self-efficacy expresses an individual's confidence in their ability to perform, persevere, and respond when faced with a task (e.g., performing mathematics; Ashcraft & Rudig, 2012; Bandura, 1997; Bandura & Locke, 2003). Self-efficacy levels form through past experiences (e.g., vicarious experience or verbal persuasion), perception of task difficulty, and performance (Bandura, 1997; Lopez & Lent, 1992; Özyürek, 2005; Shell et al., 1989; Stajkovic & Luthans, 1998). Vicarious experiences occur when a child compares themselves to another individual whom they feel similar to and judges their abilities based on the abilities of that figure (e.g., Barbie, as previously discussed, or a female student with a female teacher). A child with a higher self-efficacy level may compare themselves to a successful person when having a vicarious experience; while low efficacious students will compare themselves with someone less successful (Bandura, 1989, 1993; Jameson, 2013). Verbal persuasion increases or decreases levels of efficacy through praise, encouragement, or criticism given by others--especially from a significant figure like a parent or educator (Jameson, 2013; Pajares, 1997; Schunk, 1982).

Verbal persuasion influenced narratives become part of the student's identity or thought process--affecting decisions, behavior, and performance in the future. (Jameson, 2013, 2014; Pajares, 1997). Feedback, reinforcements, and evaluations remain the most impactful when forming beliefs and confidence (Bandura & Locke, 2003; Byrne & Shavelson, 1996). Belief not

only eases the use of everyday mathematics but can impact academic outcomes and performance. While belief does not provide knowledge or ability, it assists with navigating the application of skills they already possess (Bandura, 1989). If personal ability is surpassed, efficacious beliefs no longer predict behavior or performance (Chen, 2002; Jain & Dowson, 2009; Walczyk & Griffith-Ross, 2007). However, high efficacy can potentially encourage expectations of easy success and cause effort to be withheld. These actions will negatively affect performance, attitudes, and motivation levels (Chen, 2002; Pajares, 1997; Pajares & Graham, 1999; Valentine et al., 2004; Zimmerman, 2000).

Motivation. Motivation is the level of intent to act in regard to personal goals and beliefs (Ames, 1992; Gottfried, 1985, 1990). Findings indicate intrinsic and extrinsic motivation are mitigators of the math anxiety and performance relationship (Daches Cohen & Rubinsten, 2017; Harper & Daane, 1998). Math anxious individuals typically report low levels of intrinsic and extrinsic motivation (Daches Cohen & Rubinsten, 2017). Extrinsic motivation is driven through rewards; children are influenced through grades and praise via verbal persuasion (Timmerman et al., 2017). Intrinsic motivation is an act for the sake of one's own learning (Daches Cohen & Rubinsten, 2017; Murayama et al., 2013). Students with high intrinsic motivation levels report lower math anxiety levels and better predict future achievement; for example, intrinsic motivation levels at age nine were predictive of levels at sixteen--inadvertently forecasting performance (Gottfried, 1990; Murayama et al., 2013). Children with low motivation allow negative thoughts to disrupt working memory processing (Wang et al., 2015); thus, affecting time and effort spent mastering numerosity (Hembree, 1990; Maloney et al., 2015).

Stereotypes. Gender-based stereotypes impact future performance and avoidance levels, even with minimal differences found in skill or content understanding (Eccles, 1987; Halpern et

al., 2007; Hyde et al., 1990). Female achievement may suffer when exam difficulty is discussed, expression that males outperform their peers, and superiority in STEM fields is conveyed (Costa et al., 2001; Spencer et al., 1999). As outlined earlier, low achievement may stem from parental or educator gender-stereotyping or beliefs that impact self-perceptions of ability (Bleeker & Jacobs, 2004; Jacobs & Eccles, 1992; Miller et al., 2006). Low achievement may impact willingness to approach math material, choose STEM-related college majors or careers, or taking elective classes relating to numeracy (Hembree, 1990; Ma, 1999; Meece et al., 1990).

Avoidance and Performance

Aversion to math may surface from complex problem-solving, lack of conceptual understanding, past performance, or negative emotional response (Hiebert & Grouws, 2007). Fear of failure may influence students to avoid negative stimuli by rushing through assessments or withdrawing from elective math courses (Ashcraft, 2002; LeFevre et al., 2010; Morsanyi et al., 2018; Ramani et al., 2015; Skwarchuk et al., 2014; Thompson et al., 2017). Students may also avoid math-related professions or college majors that limit career opportunities or earning potential (Beilock & Maloney, 2015; Chipman et al., 1992; Hembree, 1990) and limit use of mathematics in everyday life (e.g., reading grocery receipts, configuring discounts, or paying with cash; Ashcraft, 2002; LeFevre et al., 2010; Primi et al., 2014; Ramani et al., 2015; Skwarchuk et al., 2014).

Chronic avoidance behavior can put students at risk of creating a vicious cycle (Beilock & Maloney, 2015; Jameson, 2014); aversion of numerical encounters due to anxiety limits learning opportunities to strengthen skills and abilities. When students limit their achievement potential, they tend to fall behind in conceptual understanding, induce more numerical anxiety and negative responses, and perform poorly (Daches Cohen & Rubinsten, 2017; Hembree, 1990;

Jameson, 2014). These maladaptive reactions tend to cause further disappointments and re-solidify negative efficacious beliefs—creating a progressive cycle of worsening math anxiety (Ashcraft, 2002; Beilock & Maloney, 2015; Dowker et al., 2016; Hembree, 1990; Jameson, 2014; Krinzinger et al., 2009).

Researching Math Anxiety

Assessments

Mathematics anxiety research has used several measurements that assess affective levels across diverse populations. Richardson and Suinn (1972) developed the *Mathematics Anxiety Rating Scale* [MARS], for adult and adolescent populations; the MARS contained 98-items and was used as the primary measure for 30 years (Jameson, 2013). The length of the MARS encouraged the creation of a shortened measure [sMARS], eliminating 73-items (Ashcraft & Kirk, 2001). Following the sMARS, the *Abbreviated Math Anxiety Scale* [AMAS] was created (Hopko et al., 2003) --a nine-item measure. These were effective scales assessing anxiety in education and daily-life (Ashcraft, 2002; Suinn & Winston, 2003), but were not developmentally appropriate for children (Jameson, 2013). Existing research for children used modified versions of adult measures or a composed measure specifically tailored to the study.

Jameson (2013) recognized this deficit and developed a psychometrically sound measure for assessing math anxiety levels in primary students--the *Children's Anxiety in Math Scale* [CAMS]. The CAMS was developed based on academic curriculum standards for elementary mathematics. Items were reviewed by experts that independently deemed the original 20 items appropriate. After a pilot study to assess the function of items, four were removed to create the current 16-item scale (Jameson, 2013). The CAMS has assessed math anxiety in children in the US and Turkey [T-CAMS]; each version showed evidence of an appropriate and

psychometrically sound scale (Jameson, 2013, 2014; Kandemir et al., 2016). Jameson (2014) then used the CAMS to investigate predictors of childhood math anxiety through hierarchical regression to identify the factors with the strongest influence on numerical anxiety. This study found a number of factors with average-to-strong correlations such as math self-efficacy, reading self-concept, and math self-concept (Jameson, 2014). Jameson's work was primarily conducted with white students in the Midwest US, but her work did encourage further research of contextual variables in math anxiety in children. Current researchers were interested in investigating environmental and personal contextual factors within a more demographically diverse sample to explore other potential predictors of math anxiety levels.

CHAPTER III

METHODOLOGY

The purpose of this study was to identify various demographic predictors and the role they play in math anxiety levels among elementary school students according to the *Children's Anxiety in Math Scale* (Jameson, 2013).

Participants

Complete responses were collected from 40 primary-level children, 38 of whom resided in the United States (U.S.) and two resided in New Zealand [NZ], age 6 to 12 years ($M = 8.47$, $Mdn = 9$). This sample was composed of 22 cisgender females, 17 cisgender males, and 1 genderfluid individual. 90% ($n = 36$) of students identify as White or European Origin (e.g., German, Irish, English, Italian, Polish, French); 17.5% ($n = 7$) Hispanic, Latino/Latina, Latinx, or Spanish Origin (e.g., Mexican American, Puerto Rican, Cuban, Salvadoran, Dominican, Colombian); 7.5% ($n = 3$) American Indian or Alaska Native (e.g., Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Nome Eskimo Community); 2.5% ($n = 1$) Black or African American (e.g., Jamaican, Haitian, Nigerian, Ethiopian, Somalian); and 2.5% ($n = 1$) multiracial. All children spoke English as their primary language at home. 90% ($n = 36$) of children were monolingual and 10% were bilingual ($n = 4$). Two children were fluent in English and Spanish, one in English and American Sign Language, and one in English and Hebrew (see Table 1).

Table 1*Demographic Data of Sample*

Demographic Characteristic	<i>n</i>	%
Race/Ethnicity ^a	-	-
American Indian or Alaska Native	3	7.5
Black or African American	1	2.5
Hispanic, Latino/a, Latinx, Spanish Origin	7	17.5
White	36	90.0
Biracial ^b	1	2.5
Language ^c	-	-
English	40	100.0
Bilingual	4	10.0
American Sign Language	1	2.5
Spanish	2	5.0
Hebrew	1	2.5

Note. *N* = 40

^aSee Appendix C for detailed examples of race/ethnicity

^bBiracial or Mixed Race: Student reported being of Black/African American decent and White.

^cAll participants spoke English as their primary language at home; children who were bilingual spoke English and American Sign Language, Spanish, or Hebrew.

Students were enrolled in 1st - 6th grade ($M = 3.05$, $SD = 1.72$) and attended various school types: home ($n = 3$), public charter ($n = 4$), public classical ($n = 1$), religious ($n = 2$), and public neighborhood ($n = 30$). Participants all lived in community environments with populations at or under 1,000,000; 25% ($n = 10$) resided in a city, 7.5% ($n = 3$) in an exurban/commuter town, 40% ($n = 16$) in rural areas, and 27.5% ($n = 11$) in suburban areas (see Table 2).

Table 2*Key Demographics of Sample*

<i>Variables</i>	<i>N</i>	<i>%</i>	<i>M</i>	<i>SD</i>	<i>Range</i>	
					<i>Possible</i>	<i>Actual</i>
Grade Level ^a	-	-	3.05	1.74	1-6	1-6
1 st Grade	12	30.0	-	-	-	-
2 nd Grade	5	12.5	-	-	-	-
3 rd Grade	6	15.0	-	-	-	-
4 th Grade	9	22.5	-	-	-	-
5 th Grade	3	7.5	-	-	-	-
6 th Grade	5	12.5	-	-	-	-
Special Needs	-	-	1.43	.5	1-2	1-2
ADHD	6	15.0	-	-	-	-
Communication Disorder	2	5.0	-	-	-	-
Dyslexia	1	2.5	-	-	-	-
Emotional Disorder	1	2.5	-	-	-	-
Hearing Impairment	1	2.5	-	-	-	-
Academic G/T	4	10.0	-	-	-	-
Math G/T	3	7.5	-	-	-	-
Nonverbal G/T	2	5.0	-	-	-	-
Verbal G/T	4	10.0	-	-	-	-
IEP	7	17.5	-	-	-	-
ALP	2	5.0	-	-	-	-
504c	4	10.0	-	-	-	-
Gender Identity	-	-	1.6	.55	1-7	1-3
Male	17	42.5	-	-	-	-
Female	22	55.0	-	-	-	-
Genderfluid	1	2.5	-	-	-	-
SES	40	-	16.6	4.4	1-27	1-25
P1 Ed	40	-	5.3	1.33	1-8	1-6
P2 Ed	40	-	4.54	1.57	1-8	1-7
Income	40	-	5.25	2.09	1-9	1-9
F/R Lunch	40	-	1.65	.48	1-2	1-2

Note. N = 40. G/T = Gifted and Talented; F/R = Free or Reduced

^a school child currently attends or will attend for the upcoming academic year if on a break.

Sampling Procedure

Participants were part of a random sample with broad inclusion criteria. Children completing the CAMS were required to be in elementary school (i.e., 1st - 6th grade) and within the age range of 6 - 12 years to participate. The participants ($N = 40$) were a self-selected sample recruited via Facebook. The CAMS was distributed on parenting and education group pages with no payments or agreements conditional for completion. Intended sample size was estimated in the hundreds, but the resultant final sample size ($N = 40$) was due to low willingness of group administrators to share the scale and member inclination to complete. With the broad inclusion criteria and online distribution, data collection locations are largely unknown, though approximate coordinates provided by Qualtrics indicated participants were in New Zealand and fifteen US states (primarily Colorado). All participation in this study was voluntary and University of Northern Colorado Institutional Review Board (IRB) approval was granted April 2019 before data collection began. This study complied with human research participant ethical guidelines of both the American Psychological Association and University of Northern Colorado.

Measures and Materials

Demographic Questionnaire

Researchers crafted an eighteen-item demographic questionnaire (see Appendix, C) to assess potential predictor variables of mathematics anxiety levels. This selected response measure was used to help researchers understand the sample diversity. Parents/guardians of children were asked to complete the questionnaire in efforts to collect accurate data about the sample; questions regarding socioeconomic status or parental education may otherwise be unknown. Items inquiring about guardian relationship to the child, ethnicity/race, gender

identity, and special needs identification were selected response items that allowed participants to select multiple answers or provide a text entry. Primary language spoken at home and date of birth were exclusively text entries; the remaining items were multiple choice allowing selection of one answer.

Children's Anxiety in Math Scale

The CAMS (Jameson, 2013) is composed of 16 Likert-type items developed from elementary-level mathematics tasks and asks participants to respond by selecting one of five facial images (*very anxious* [5], *anxious* [4], *not anxious or excited/neutral* [3], *excited* [2], and *very excited/not at all anxious* [1]) that most reflect their feelings for each item. Facial expression images assist children in accurately expressing their feelings (Ganley & McGraw, 2016; Jameson, 2013; Ramirez et al., 2013; Vukovic et al., 2013). Sample items include “When I solve math problems, I feel:”, “When I know that I’m going to have a math test, I feel:”, or “When I make a mistake in math, I feel:” (Jameson, 2013). The CAMS measures three factors of math anxiety: general math anxiety, math performance anxiety, and math error anxiety. CAMS scores range from 16 to 80; lower scores indicate low levels of math anxiety, and higher scores reflect high levels of math anxiety. The CAMS has excellent levels of internal consistency ($\alpha = .86$), and scores on the CAMS are negatively correlated with math performance (Jameson, 2013, 2014).

Typically, the CAMS is administered in a small group academic setting (e.g., classrooms) using paper-and-pencil responses. In an attempt to reach a more diverse sample, the CAMS was placed online and administered via Qualtrics. No changes were made to response options, but the online CAMS was administered individually and presumably with a parent nearby.

Design and Procedure

The present study lacked the element of variable manipulation following a single-group, non-experimental research design. The CAMS questionnaire was completed online and distributed among parent and education Facebook groups. Researchers shared the Qualtrics link and purpose of the study with admin via Facebook Messenger. Consenting admins were instructed to post on the main group newsfeed with a caption composed at an eighth-grade literacy level--the US national average (Nienkemper & Grotlüschen, 2019).

Willing group members selected the link and were redirected to the first page of the survey (see Appendix, B). Parents were explained the study and gave their informed consent by progressing to the next page; consent to participate in the study was ensured to be completely voluntary and susceptible to their termination at any point without penalty (see Appendix, A for IRB approval). Parents were instructed to answer the demographic questionnaire for their child accurately to ensure accurate information. After completing the demographic questionnaire, parents were instructed to read aloud all subsequent items to their child but to allow the child to select the face that represent their feelings. Several practice items unrelated to math were administered to the participants to become familiar with the response options. The 16-items of the CAMS (see Appendix, D) were then presented on one page, followed by a confirmation of submission page. Data collection lasted between 5-24 minutes ($\bar{x} = 8$ mins and 20 seconds) and occurred between April and October 2019. After removing five participants with incomplete and missing data, the original sample of 45 was reduced to a final sample size of 40 which included complete responses used in all subsequent analyses.

CHAPTER IV

ANALYSIS

Data Analysis

Data Configuration

Missing Data

Original data collection consisted of 73 responses; 38% ($n = 28$) were deemed incomplete for missing one or more responses to the 16-item CAMS measure. 62% ($n = 45$) of responses were complete; five additional data points were eliminated due to data missing completely at random (MCAR) from the demographic questionnaire. The finalized sample size ($N = 40$) consisted of 55% of the original data and is used for all subsequent analyses.

Data Programming

Demographics. Demographic data (see table 1) was examined and used for understanding sample characteristics. To analyze the contextual factors' impact on math anxiety levels, researchers used four variables: grade level, special needs identification, gender identity, and socioeconomic status (SES). Variable coding required researchers to condense data points to reduce chances of an overfit regression model. The researchers classified students reporting characteristics required special education (i.e., disability status, gifted/talented identification, and/or any educational accommodation plan) as having a special needs identification. SES scores were the sum of parent one and parent two education level, household annual income, and qualification for free/reduced lunch; scores ranged from 4 - 27 ($M = 16.6$, $SD = 4.4$). Higher scores indicated they were had a combination of higher household income and more educated parents.

Children's Anxiety in Math Scale. Using the continuous variable of CAMS, items were combined via Qualtrics; totals ranged from 20 - 68 out of a possible 16 - 80 ($M = 49.6$, $SD = 14.2$).

Results

First, to determine which demographic characteristics would most likely provide adequate predictive value in math anxiety in children, correlational patterns between CAMS scores and all measured demographic variables were examined (see table 3). Based on correlations, grade level and special needs identification were selected as predictor variables. Based on review of the literature, gender identity and socioeconomic status were also selected as predictor variables, though they showed a weak correlation within the present study.

Table 3

Intercorrelations of Contextual Factors and Math Anxiety

<i>Variable</i>	1	2	3	4	5
1. CAMS	1.00	-.382**	-.321*	-.172	-.044
2. Grade level		1.00	.004	-.222	.152
3. Special needs			1.00	-.301*	.335*
4. Gender identity				1.00	.059
5. SES					1.00

* $p < .05$. ** $p < .01$. *** $p < .001$.

Next, a hierarchical regression analysis was completed. CAMS scores served as the outcome variable; the predictors variables were entered into the regression analysis in four steps (see Table 4). From previous research (Bandura, 1989; Chang & Beilock, 2016; Jameson, 2014; Luttenberger et al., 2018), independent variables are thought to interact and potentially be related, increasing the issue of multicollinearity. Through evaluation of the variance inflation factors (VIF), all variable values measured between 1.0 and 1.33 (see Table 3); these values indicate multicollinearity is not of concern.

The first step of the regression, grade-level, showed a significant predictive relationship with math anxiety levels, $R^2 = .146$, $\Delta R^2 = .123$, $F(1,38) = 6.484$, $p = .015$, and accounted for approximately 13% of the variance. The second step, $R^2 = .247$ $\Delta R^2 = .207$, $F(2, 37) = 6.084$, $p = .005$ indicated a significant relationship with math anxiety levels; this step indicated that special needs identification accounted for 8.4% unique variance in math anxiety and 20.7% when combined with grade level. In this model, grade level ($p = .011$) and special needs identification ($p = .031$) were found individually significant predictors. The third step was responsible for combined 34.1% of variance in the sample, $R^2 = .391$ $\Delta R^2 = .341$, $F(3, 36) = 7.714$, $p < 0.001$; gender identity uniquely contributes 13.4% of the variance in math anxiety scores. The final step including socioeconomic status, $R^2 = .445$ $\Delta R^2 = .382$, $F(4, 35) = 7.019$ $p < 0.001$, accounted for 38.2% of variance. Socioeconomic status individually accounted for 4.1% of variance, making SES the weakest predictor of the four variables. All regression statistics are available in Table 4.

Table 4

Hierarchical Regression Analysis with Children's Anxiety in Math Scale Scores as the Dependent Variable

<i>Variables</i>	<i>B</i>	<i>95% CI</i>	β	<i>t</i> (39)	α	<i>VIF</i>
Step 1						
Grade level	-3.114	[-5.59, -.638]	-.382	-2.546	.015	1.000
Step 2						
Grade level	-3.103	[-5.46, -.746]	-.380	-2.667	.011	1.000
Special needs identification	-9.034	[-17.22, -.849]	-.319	-2.236	.031	1.000
Step 3						
Grade level	-3.837	[-6.048, -1.626]	-.470	-3.520	.001	1.056
Special needs identification	-12.502	[-20.352, -4.652]	-.441	-3.230	.003	1.104
Gender identity	-10.627	[-18.017, -3.237]	-.409	-2.916	.006	1.161
Step 4						
Grade level	-4.262	[-6.456, -2.069]	-.523	-3.945	.000	1.107
Special needs identification	-15.605	[-23.947, -7.264]	-.551	-3.798	.001	1.327
Gender identity	-12.182	[-19.547, -4.817]	-.468	-3.358	.002	1.228
Socioeconomic status	.825	[-.084, 1.735]	.259	1.843	.074	1.242

Note. VIF= variance inflation factor. Significance level = 0.05

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Discussion

This study aimed to identify the predictive relationship of demographic factors on math anxiety levels in elementary school students. To avoid an overfit regression model due to small sample size and large number of predictors, demographic variables were correlated with math anxiety scores. The four variables most strongly correlated with CAMS scores were selected as predictor variables. Each predictor variable was added hierarchically to a regression model with math anxiety scores as the outcome variable. Gender identity accounted for the largest amount of variance among CAMS scores at 13.4%. All variables significantly contributed to the model, with the full model (grade level, special needs identification, gender identity, and socioeconomic status) accounting for 35% of the variance in CAMS scores. In this sample, demographic variables accounted for over one-third of the variance in math anxiety scores. While the remaining variance is likely accounted for by personal (Bandura, 1986, 1997, 1999; Bieg et al., 2015; Gunderson et al., 2018) and environmental (Bandura, 1999; Dowker et al., 2016; Stevenson et al., 2000) factors, this is a large amount of variance explained by demographic factors.

Grade Level

In the current research, we found a weak but statistically significant negative correlation between math anxiety and grade level; math anxiety levels decreased as children got older. Grade level accounted for 12.3% unique variance in CAMS scores. Findings support these latter interpretations of the relationship between grade and math anxiety.

Pre- and in-service elementary educators report the most elevated levels of math anxiety in comparison to the general population (25%-30% worldwide report moderate-to-high math anxiety levels) and other college majors or in-service secondary educators (Becker, 1986; Beilock & Willingham, 2014; Ganley et al., 2019; Hembree, 1990; Kelly & Tomhave, 1985). Anxious educators develop maladaptive thought processes, detrimental feelings, and aversive behaviors, but are expected to instruct students with an enthusiastic perspective (Mihalko, 1978; Pantoja et al., 2020; Wood, 1988). Not only do these educators lack efficacy in their teaching ability (Bursal & Paznokas, 2006), their low engagement and poor performance levels can compromise both their pedagogical techniques and children's math learning (Duncan et al., 2007; Foley et al., 2017; Gershenson, 2016; Wilkins, 1976). Students have attributed the onset of math anxiety to educator attitudes and expectations for student success (Gershenson, 2016; Malinsky et al., 2006; Sloan, 2010; Uusimaki & Nason, 2004; Wilkins, 1976), as teachers are the primary source for math-related knowledge in early elementary school (Cannon & Ginsburg, 2008). Supportive findings indicate teachers with high levels of anxiety are associated with lower math knowledge levels at the end of the school year in students—even after considering math ability of the educator and the knowledge level of the students at the beginning of the school year (Pantoja et al., 2020).

Consequently, teachers that do not enjoy math tend to spend 50% less time on mathematics in comparison to educators comfortable in this area (Schmidt & Buchmann, 1983) and often spend time teaching students basic skills (i.e., counting) they've already learned (Engel, 2013; Gunderson et al., 2018). Findings indicate that this pedagogy is likely to foster anxious feelings within students (Greenwood, 1984). Students in early elementary (pre-kindergarten – 1st grade) were originally thought to be “overly optimistic” regarding their

academic performance compared to their peers (Eccles, 1984; Eccles et al., 1990; Wigfield et al., 1997), but recent findings indicate that assessment of math achievement indeed affects negative emotions and beliefs in young students (Gunderson et al., 2018; Park et al., 2014; Ramirez et al., 2016; Stipek & Gralinski, 1996; Vukovic et al., 2013). It is possible the negative correlation of grade level is due to younger students feeling less comfortable with math due to lack of practice and conceptual understanding in earlier grade levels (Boaler, 2014; Engel, 2013; Gunderson et al., 2018).

Standardized tests and basic assessments in the United States are commonly timed as a regular part of instruction, inducing stress they otherwise may not experience when solving problems without time restrictions (Engle, 2002; Ramirez et al., 2013). As previously discussed, negative emotions (like stress) occupy space in the working memory; this prevents students from retrieving information and causes them to question their abilities (Boaler, 2014). Students are also exposed to the myth that quick math performance is good math performance—causing students who are deep thinkers to turn away from mathematics (Boaler, 2014). Educators are instructed to spend an ample amount of time preparing students for assessments by using rote learning techniques rather than developing conceptual understanding or presenting alternative solving methods (Gray & Tall, 1994; Gunderson et al., 2018; Harris et al., 2001). Standardized state math testing, developed in accordance with the No Child Left Behind Act of 2001, commonly begins second semester of 3rd grade (Greisen et al., 2018). Because of the importance of performing well on these assessments, preparation screening begins in kindergarten or first grade to identify reading difficulties and areas of improvement (Jordan et al., 2007). Math screening at this age is still in its infancy, increasing the likelihood children will be underserved prior to receiving their individualized state testing proficiency reports in fourth grade (Greisen et

al., 2018; Jordan et al., 2007)—another potential explanation for higher math anxiety levels in earlier elementary.

Outside of the classroom, students may seek help from parents with homework, particularly those in early elementary. Findings have indicated that homework assistance is sometimes negatively linked to math achievement, particularly in students who have parents with mathematics anxiety (Maloney et al., 2015; Patall et al., 2008). Anxious parents might lack the proper skills or introduce solving operations that differ from those presented within the classroom, causing confusion (Maloney et al., 2015). Parents who are frequently involved also have increased opportunities to expose their child to the negative attitudes they experience towards math, resulting in their child learning less throughout the school year (Beilock & Maloney, 2015; Maloney et al., 2015). As math difficulty increases over time, the need for parent assistance declines. Correspondingly, learning impacts from parents decrease as grade levels increase, with the potential to reduce math anxiety levels (Beilock & Maloney, 2015; Maloney et al., 2015; Rubinsten et al., 2015).

Special Needs Identification

Our current research suggests the relationship between SNI and math anxiety is a significant but weak negative correlation. Overall SNI accounted for an additional 8.4% of the variance among math anxiety scores. This study indicates that students without a SNI students have higher math anxiety levels. We propose this relationship due to several educational and societal expectations relevant to this subpopulation. Because this demographic includes various difficulties and abilities, the existing empirical evidence does not assess this group as a single entity. However, the succeeding evidence is used to deduce logical reasoning in support of this

prediction. Our proposed mediating factors are individual attitudes, educator training and accountability, and parenting techniques.

Research has reported SNI students commonly experience a lack of specialized curriculum and instruction sufficiently meeting their learning needs (Archambault et al., 1993; Eddles-Hirsch et al., 2010; Kahveci & Akgül, 2014). Differentiation is limited with minimal adjustments, potentially due to educator training deficits. In fact, 50%-60% of state and private educators indicated they were not taught instruction modification for these students (Archambault et al., 1993; Kahveci & Akgül, 2014). Proper pedagogy can elevate talents, interests, and potential, but inadequate instruction can contribute to underachievement and a decrease in motivation (Reis, 2002; Reis & McCoach, 2002; Reis & Renzulli, 2010). SNI students report experiencing boredom, overwhelm, pressure, or embarrassment in the classroom and a sense of estrangement within the education system (Gallagher et al., 1997; Heilbronner et al., 2009; Reis, 2002). Negative attitudes and feelings of failure may encourage apathy towards academics and potentially explain lower math anxiety levels in SNI students. Conversely, it is possible math anxiety levels decline if SNI students have a special education teacher to assist in anxiety inducing tasks and provide a sense of security.

Widespread deficits in educating early elementary teachers on SNI students indicate this curriculum lacks importance in most undergraduate programs (Sak et al., 2015; Tomlinson, 1995, 1997; Vaughn & Schumm, 1995). Apart from a certified special education teacher, students lack a support system that understands and adapts their approaches based on needs (Callahan & Hertberg-Davis, 2012; Purcell & Eckert, 2006; Reis & Renzulli, 2010; Robbins et al., 2011). Instructional adaptations require separate curriculum and modifying materials (i.e., assessments, grading criteria, presentation styles, etc.) to enhance student environment (Friend &

Bursuck, 1999; Scott et al., 1998; Scruggs & Mastropieri, 2000; Shukla-Mehta & Albin, 2003). Research findings indicate large-group instruction with minimal management techniques are favored by most elementary educators, particularly those with limited teaching resources (Avramidis et al., 2000; Avramidis & Kalyva, 2007; Kuyini & Desai, 2007, 2008; Vaughn & Schumm, 1995). Even with the existing empirical evidence, SNI students are disadvantaged in the United States education system as there are no federal mandates, laws, regulations, or guidelines apart from the Americans with Disabilities Act of 1990 that ensure adequate instruction (Gallagher, 2002; Plucker & Callahan, 2014; Stephens et al., 2008). Without training and holding teachers accountable for inclusive education practices, these environmental factors may continue to impact SNI student attitudes and their reported math anxiety levels (Ajuwon et al., 2012).

Parenting a child with needs requires specialized approaches that are often more time-consuming than class peers. Many SNI children function significantly below or above their age level and may require 1:1 attention to monitor learning or behavior (Kauffman & Badar, 2013). Parents commonly report frustration with educational interventions, especially for those who consider their parenting effective (Mowder, 2005). For successful parenting, adapting to their unique needs is essential for proper social and emotional development (Kauffman & Badar, 2013; Mowder, 2005; Mowder et al., 1995). Findings suggest parenting styles dictate the parent-child and family dynamic; they are also responsible for parental components (e.g., bonding, discipline, education) that fluctuate levels of importance based on individual need (Mowder et al., 1995). Parenting methods predict approximately 30% of the variance (Yaffe, 2015) in educational functioning; findings specified authoritative style as the most effective form of parenting regarding achievement and overall academic efficiency (Durbin et al., 1993; Dyches et

al., 2012; Eisenberg et al., 2005; Wigfield, 1994). Researchers also found a mediated relationship between parenting style and mathematics achievement, but further investigation is required to understand the direction of correlation (Ishak et al., 2012; Sessa et al., 2001; Spera, 2005; Yaffe, 2015); the challenges of parent interactions—whether that is being under or over involved—may explain the decrease in math anxiety scores in SNI students in comparison to their peers.

Gender Identity

Our results found adding gender identity to the model explained an additional 13.4% of the variance in math anxiety scores but did not indicate a significant correlation. The link between anxiety levels and gender may be explained by a small spread of interrelated mediators.

Previous findings have indicated general anxiety is a likely mediator when it comes to gender and reported math anxiety levels (Hill et al., 2016; Szczygiel, 2020). General anxiety is an inclination for one to chronically worry about a large variety of happenings (events, behaviors, competencies) unique to that individual (Spence, 1997). Females have indicated a higher level of general anxiety than males (Hill et al., 2016; Núñez-Peña et al., 2016; Zalta & Chambless, 2012). Research of elementary-level students shows that math anxiety exists before the start of formal school despite their lack of experience with math (Carey et al., 2017; Cargnelutti et al., 2017; Ganley & McGraw, 2016; Gierl & Bisanz, 1995; Harari et al., 2013; Hill et al., 2016; Krinzinger et al., 2009; Ramirez et al., 2013, 2016; Szczygiel, 2020; Vukovic et al., 2013; Wu et al., 2012; Young et al., 2012). This determination has been thought to be explained by the individual inclination to general anxiety (Baloglu & Koçak, 2006; Carey et al., 2017; Dew & Galassi, 1983; Hembree, 1990). The gender gap in general anxiety levels indicate females experience more anxiety than males (Ganley & McGraw, 2016), a possible justification for previous research indicating a gender gap. Similarly, high levels of test anxiety have been

consistently found in elementary-level females; a combination of test anxiety and general anxiety is thought to be responsible for mediating math anxiety levels (Cargnelutti et al., 2017; Ganley & McGraw, 2016; Hill et al., 2016; Van Mier et al., 2019). Therefore, the nonexistent gender correlation may indicate low levels of predisposed general anxiety and/or test anxiety among the sample.

Stereotypes and expectations that effect self-efficacy levels may also mediate the gender gap relationship (Brown et al., 2020; Devine et al., 2012; Szczygiel, 2020). While the present results do not indicate a significant correlation, these mediators may clarify why previous findings have shown a gender gap. Female students experience stereotype threat and self-efficacy levels of higher impact than male students (Eysenck & Calvo, 1992; Eysenck et al., 2007; Ramirez et al., 2013). The societal expectations about males and their math anxiety or performance can boost self-efficacy levels; this may originate from the pressure and demands put on males to perform better. Males stereotypically are expected to have greater math potential than their female peers—causing anxiety levels of female students to increase (Casad et al., 2015; Niederle & Vesterlund, 2011; Schmader et al., 2004; Thoman et al., 2008). Females have reported feeling more comfortable than their male counterparts when admitting feelings of mathematics anxiety (Ashcraft & Ridley, 2005)—stories regarding math anxiety in males are recognized as socially deviant or shameful (Devine et al., 2012). The gender gap may be mediated by high male self-efficacy levels from societal beliefs about potential or the denial of anxious feelings (Szczygiel, 2020). It is also possible that because females feel more comfortable reporting math anxiety levels and with discussing their struggles with math anxiety. Females may also use their comfort levels on discussing math anxiety to alleviate some worries or potentially decrease reported levels (Brown et al., 2020; Devine et al., 2012; Niederle &

Vesterlund, 2011; Szczygiel, 2020). Females alleviating anxiety levels and high self-efficacy levels in males could explain the present absence of a gender gap.

Other potentially significant mediators of math anxiety and gender are pedagogical methods and gender identity of their educators (Ashcraft, 2002; Cates & Rhymer, 2003; Finlayson, 2014; Jackson & Leffingwell, 1999; Pantoja et al., 2020; Popham, 2009; Stuart, 2000; Tsui & Mazzocco, 2007). As formerly discussed, math anxiety is largely prevalent among elementary level educators (Foley et al., 2017; Ganley et al., 2019; Hembree, 1990) and most attribute their anxiety levels to their early elementary teachers (Cannon & Ginsburg, 2008). Through a combination of stereotypes and teacher gender identity, students are impacted through vicarious learning experiences (Bandura, 1989) and choice of instruction (Pantoja et al., 2020). Because approximately 85% of pre-k – 8th grade educators are predicted to be female (Cvencek et al., 2011), research indicated that female educators could affect learning (in both male and female students), achievement, and math anxiety development in their female students (Beilock et al., 2010). In conjunction with gender identity, teacher behavior has been deemed a prime factor causing math anxiety (Finlayson, 2014). Math anxiety evolves from the way math has been introduced to the students—especially if presented as a “right or wrong” subject that discourages experimentation, risks, or alternative solution methods (Stuart, 2000). Teachers often assume that introduction methods, preferred learning style, and solving times do not differ among students (Boaler, 2002; Finlayson, 2014). Ignoring the looming stereotype or attitude differences that may affect males and female learning, educators can create negative attitudes towards mathematics and mathematics anxiety—potentially explaining gender gap findings (Ashcraft, 2002; Finlayson, 2014; Popham, 2009; Stuart, 2000; Tsui & Mazzocco, 2007). Findings not reflecting a gender gap may indicate a development in elementary teaching

techniques that focus on problem-solving and understanding concepts instead of rote memorization or speed (Finlayson, 2014; Popham, 2009; Scarpello, 2007).

Socioeconomic Status

ES added to the model explained an additional 4.1% of variance among math anxiety scores. Our findings did not indicate a significant correlation between SES and mathematics anxiety. SES is comprised from (e.g., parent education, familial income, free/reduced lunch qualification) individually mediate their relationship with mathematics anxiety. As previously discussed, research on the link between these concepts and math anxiety levels is limited; the existing empirical evidence has been used to hypothesize the absent correlation (Bradley, 2001; Singh et al., 1995; Tsui, 2005).

Parent education has been thought to influence behavior, attitudes, and decisions in children (Chevalier, 2004). Parent education background may not only mediate success and motivation in children; SES and education level have also shown to be sufficient indicators of academic support available to the child (Joshi, 1995). Additionally, parents with higher levels of education are more likely to be knowledgeable about emotional regulation. Regulation technique knowledge may have a positive impact on coping skill development that is later used to lessen math anxiety (Geyik, 2015). Other empirical evidence has deemed parent educational background as less important in development and achievement than general parent attitudes and values regarding education (Dini et al., 2019; Hall et al., 1999). The lack of correlation found in the present study may mirror these findings—indicating parent education level is less influential on children than the attitudes, resources, values, and support of parents (Campbell et al., 1992).

A larger body of contradictive research exists regarding family income. Previous investigations have shown income is commonly related to children's cognition, achievement, a

higher likelihood of poor performance on standardized testing, and an increased high school dropout rate (Bradley, 2001; Brooks-Gunn et al., 1997; Duncan et al., 1994; McLanahan & Sandefur, 1994; Yeung et al., 2002). Intrigued researchers investigated income levels and math knowledge of children entering early elementary school. Evidence suggests children coming from low-income families are less advantaged in math knowledge development (Duncan et al., 2007; Jordan et al., 2009; Watts et al., 2014); this causes children to not only enter school with deficits but continue their elementary education with weaker knowledge than their peers (Jordan et al., 2009). Some researchers found the relationship between income and performance to be caused by a lack of resources (events, services, etc.), while others argue that there is an indirect effect of low-income. For example, Henretta et al., (2002) concluded that financial hardship can cause parent distress resulting in less involved, attentive, and interested parent-child interactions. Other research notes low-income families may have differing parental beliefs regarding their role in the education of their child, resulting in less involvement (Catsambis & Garland, 1997; Chavkin & Williams, 1993; Connell, 1994; Hoover-Dempsey et al., 1987; Muller & Kerbow, 2018; Rittle-Johnson et al., 2017; Stevenson & Baker, 1987). Because families with limited financial resources may experience parental sacrifice, the sacrificial willingness depends on family size and their outlook on potential for financial return of the educational investment (Becker & Tomes, 1986; Rosenzweig & Schultz, 1982). Due to perceived impact of income levels, researchers chose to examine math anxiety levels. These studies indicate families with low income are more likely to have children with high levels of math anxiety (Geyik, 2015; Richland et al., 2020). However, other exploration into income levels showed no effect on anxiety levels and found parental expectations, attention, and effort impact math anxiety

(Morsanyi et al., 2018; Richland et al., 2020); these findings can provide potential justification for the null correlation we found between SES and math anxiety levels.

Conclusions and Limitations

Findings of the current study indicated a correlation existed between two of four variables, grade level and SNI; these variables had a weak, negative correlation. The other two variables, gender identity and SES, had no correlation. Grade level, SNI, and gender identity were found to be significant predictors of CAMS math anxiety scores, leaving SES as the only variable lacking significance. Variance of the full model was analyzed at 38.2% (grade level: 12.3%, SNI: 8.4%, gender identity: 13.2%, and SES: 4.1%).

Mediators were identified for each independent variable using existing research. Three mediation themes existed across the variables: parental influences (e.g., homework help, attitudes, effort), educator influences (e.g., gender, pedagogy, training), and attitudes (e.g., existing anxiety, self-efficacy, stereotype threat). These findings solidify the lack of continuity between evidence, indicating future research is necessary; mediators can be used for succeeding studies to form hypotheses or as factors to control for.

Limitations

Current research found a significant portion of math anxiety in elementary students is accounted for by the combination of gender identity, special needs identification, grade level, and socioeconomic status. Even so, limitations to this research could be improved for future projects.

Sample

A concern in this study is the adequacy of the achieved sample; sample size, generalizability, and selection bias point towards limitations that could threaten overall validity.

The sample size ($N = 40$) was smaller than anticipated and lacked proper representation of the target population. Small samples can create difficulty accurately interpreting findings and overestimating correlations (Hackshaw, 2008). These samples can threaten the statistical power of a study which affects the ability to identify effect sizes and avoid Type II error (i.e., confirming the hypothesis when an alternative hypothesis is true; Field, 2013; Hackshaw, 2008). External validity may also be jeopardized with small accessible samples, as they are not typically reflective of the target population and thus restrict generalizability. Obtaining a larger sample through alternate recruitment methods may mitigate diversity deficits and increase external validity. The sample size also effected the number of independent variables used in the regression analysis. Researchers planned to use seven predictor variables in the hierarchical regression; to avoid an overfit model, variables were reduced to four predictors. Guidelines suggest a minimum of 10 datasets per predictor variable, but 15 or more are desirable for a regression (Field, 2013; Hackshaw, 2008); thus, obtaining a sample size ≥ 60 is advised for study replication. Researchers replicating this study should also be cognizant of the subsequent limitations of methodology.

Methodology

This investigation was the first attempt to administer CAMS through an online platform. Although online distribution has potential to reach a wide range of individuals from a variety of locations, selection bias proposes a threat. While internet access is a common amenity, approximately 8% of the US population does not have access to home broadband internet services or a smartphone with data (Pew Research Center, 2021). With the CAMS only available online, students without internet access did not have equal opportunity to participate. Selection

bias was also threatened by distribution via social media groups, limiting the potential sample to those who use particular platforms (e.g., Facebook).

Online administration of the CAMS could not allow researchers to control for extraneous variables that might influence participant responses (e.g., setting, distractions, scale administrator characteristics). While parents/guardians were provided instructions including this information, there were no controls in place to minimize these potential confounding variables. Traditional face-to-face administration is more standardized, including training scale administrators for research purposes.

Implications and Recommendations

These present findings provide meaningful contributions to the field and insights for mitigating math anxiety among elementary-level students in educational and home environments. Study findings continue to support the relevancy of math anxiety awareness, training, and research in elementary level students. Correlational patterns suggest a need for math anxiety assessment and treatment in all grade levels, regardless of special need designation. Findings support higher math anxiety levels occurring in early elementary than in later—suggesting focused intervention on defining and combatting math anxiety should begin immediately in elementary school. Interventions should not only be a normalized practice but widespread—instead of limiting those needing learning accommodations. For example, Response to Intervention (RtI), combining pedagogical practice and strategy, provides early elementary intervention for struggling students based on their individual needs (Fuchs & Fuchs, 2005, 2006).

This multi-teared intervention is designed for student-specific instruction to improve learning outcomes (Brown-Chidsey et al., 2009). This intervention includes alternate

pedagogical techniques and supports change in learning environments in accordance to needs of students that would promote individual success (Johnson et al., 2009). Unlike special education or gifted and talented programs, RtI tiers 1 and 2 target all general education students' learning needs (Carlson et al., 2010). Tier 1 focuses on classroom strategies for all, while Tier 2 aims to provide additional support (e.g., tutoring) for struggling students. Tier 3 is more intensive, existing for those students with academic and behavior needs through specialized instructional practices or special education programs (Bender & Shores, 2007; Carlson et al., 2010; Howard & Potts, 2009; Johnson et al., 2009; Wright, 2007). Ideally through RtI and training, educators and families work together in and outside of the classroom to mitigate math anxiety levels and develop coping mechanisms to keep performance impacts minimal.

Supplemental Recommendations

Math anxiety levels can be easily transmitted through words and body language during homework help or everyday math-oriented scenarios (i.e., figuring out a sale discount). Comments like "I'm not a math person" or "math is not for everyone" can add to math anxiety development, even if the intent is to sympathize or console them. Thus, a need exists for family training regarding the importance of math self-concept. It is recommended training discusses gender or cognitive differences in math ability, how to make math fun and enjoyable through playing games or applying math to relevant life (e.g., counting money to buy a toy), and how communicating their students' strengths increases self-efficacy. Research on parent involvement indicates support and expectations are main influencers in creating or minimizing negative attitudes and math performance deficits (Suárez-Pellicioni et al., 2016; Vukovic et al., 2013).

Potentially of greater importance is proper training for educators to mitigate math anxiety effects; empirical evidence indicates origins of math anxiety are classroom experiences (Beilock

& Willingham, 2014; Bekdemir, 2010; Geist, 2010). Students who experience embarrassment, hostility, or messages endorsing stereotype threat are likely to develop math anxiety. Teachers are one of the largest influences on young children (Beilock & Willingham, 2014) and should be provided with training for creating a space where questions are encouraged, mistakes are normalized, and math is viewed as a valuable skill (Ashcraft et al., 2007). Teachers should also be advised on how to approach their own existing math anxiety levels and take actions to prevent transmitting them to their students—especially female educators (Beilock et al., 2010). Training should extend to assessing math anxiety levels multiple times throughout the year and adapt classroom instruction accordingly (e.g., rid timed tests, emphasize positive attitudes, etc.) as math has been linked to avoidance behaviors and performance deficits (Hembree, 1990; LeFevre et al., 2010). Observing the vulnerability of teachers making errors, receiving positive feedback, and adopting attitudes of hard work is the key to mathematic success can all assist in anxiety levels and mitigating math anxiety effects (Suárez-Pellicioni et al., 2016).

Future Research

Math anxiety, especially in children, is an important and timely topic. The CAMS has shown to reliably measure math anxiety ($\alpha = .939$), and the current research continues to support its use assessing math anxiety levels in elementary school children. As such, this field should continue to be researched using the CAMS. Future researchers should consider investigating the following areas:

1. Investigate a larger sample size with a more diverse population to determine possible correlates of math anxiety levels and demographic factors (i.e., familial income, government school funding, parent education, investigating gender as a spectrum, etc.).

2. Explore further validation of the CAMS scale by measuring invariance to ensure the scale accurately measures math anxiety levels among all demographics.
3. Conduct CAMS research by controlling or measuring extraneous variables (e.g., general anxiety, parent anxiety levels, etc.).

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER



Institutional Review Board

DATE: April 17, 2019

TO: Melissa Flowerdew, Psychology, BA
FROM: University of Northern Colorado (UNCO) IRB

PROJECT TITLE: [1315749-3] Invariance of the Children's Anxiety of Math Scale
(CAMS) SUBMISSION TYPE: Amendment/Modification

ACTION: APPROVE

D APPROVAL DATE: April 17, 2019

EXPIRATION DATE: November 16, 2019

REVIEW TYPE: Expedited Review

Thank you for your submission of Amendment/Modification materials for this project. The University of Northern Colorado (UNCO) IRB has APPROVED your submission. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on applicable federal regulations.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of November 16, 2019.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Nicole Morse at 970-351-1910 or nicole.morse@unco.edu. Please include your project title and reference number in all correspondence with this committee.

Thank you for providing clear and thorough amendments/modifications. These revised protocols and materials are approved and you may proceed with your participant recruitment and data collection accordingly.

Best wishes with your research.

Sincerely,

Dr. Megan Stellino, UNC IRB Co-Chair

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Northern Colorado (UNCO) IRB's records.

APPENDIX B
INFORMED CONSENT

PARENTS/GUARDIANS:

The purpose of this survey is to determine if math attitudes can be measured well in children from all different backgrounds and personal characteristics. There are two parts to the survey: the first part you fill out about your child, and the second part you read to your child and they record their responses.

The following questions ask about your child's background and personal characteristics. Please answer all questions accurately, as they help us make sure that different backgrounds are represented. These questions should take less than 10 minutes to complete. The questions that your child will answer should take approximately 15 minutes to complete.

By continuing to the next page you are granting your consent to participate in this study. Your responses are completely confidential and voluntary. Any data from this study will be presented as large group data, with no chance of your child being identified. You may stop at any time without penalty.

If you have any questions regarding this research, please contact Master's student Melissa Flowerdew, at flow5532@bears.unco.edu or her faculty sponsor, Dr. Molly Jameson, at molly.jameson@unco.edu

This study has been approved by the University of Northern Colorado Institutional Review Board. If you have any concerns about your selection or treatment as a research participant, please contact the Office of Research, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910

APPENDIX C
DEMOGRAPHIC QUESTIONNAIRE

Who is answering these questions about your child? Please check all that apply.

- Child's Biological/Adopted Father
- Child's Biological/Adopted Mother
- Child's Biological/Adopted Grandparent
- Child's Caretaker
- Child's Foster Parent
- Child's Second Father
- Child's Second Mother
- Child's Stepfather
- Child's Stepmother
- My role is not listed. (Please describe your role here.)

In what country does your child live?

- United States
- Country other than United States (Please type country here.)

If your child lives in the United States, in what region does your child live?

- New England (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, & Vermont)
- Mid-Atlantic (New Jersey, New York, & Pennsylvania)
- East North Central (Illinois, Indiana, Michigan, Ohio, & Wisconsin)
- West North Central (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, & South Dakota)
- South Atlantic (Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, District of Columbia, & West Virginia)
- East South Central (Alabama, Kentucky, Mississippi, & Tennessee)
- West South Central (Arkansas, Louisiana, Oklahoma, & Texas)
- Mountain (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, & Wyoming)
- Pacific (Alaska, California, Hawaii, Oregon, & Washington)

How old is your child?

- 5 10
 6 11
 7 12
 8 13
 9

What is your child's birth date? Please enter as MM-DD-YYYY (For example, April 12, 2010 would be entered as 04-12-2010).

What is your child's gender identity? (check all that apply)

- Genderfluid
 Female
 Non-binary gender
 Male
 My child's gender identity is not listed. (Please describe your child's identity here.)

 Transgender
 I prefer not to say.

Which categories describe your child? Select all that apply to your child:

- American Indian or Alaska Native--For example, Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Native Village of Barrow Inupiat Traditional Government, Nome Eskimo Community
 Asian--For example, Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese
 Black or African American--For example, Jamaican, Haitian, Nigerian, Ethiopian, Somalian
 Hispanic, Latino, Latina, Latinx, or Spanish Origin--For example, Mexican or Mexican American, Puerto Rican, Cuban, Salvadoran, Dominican, Colombian
 Middle Eastern or North African--For example, Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian
 My child's race, ethnicity, or origin is not listed. My child's race/ethnicity is:

 Native Hawaiian or Other Pacific Islander--For example, Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, Marshallese
 White--For example, German, Irish, English, Italian, Polish, French
 I prefer not to answer.

What is your child's primary language spoken at home?

Does your child speak another language? If so, what language?

- No
- Yes

Has your child been identified as having special needs by the school? If so, select all that apply.

- My child has not been identified as having special needs.
- Attention/Hyperactive Disorders
- Autism Spectrum Disorder
- Behavioral Disorder
- Communication Disorder
- Dyscalculia
- Dysgraphia
- Dyslexia
- Emotional Disorder
- Hearing Impairment
- Intellectual Disability
- Visual Impairment
- Academically Gifted/Talented
- Mathematically Gifted/Talented
- Nonverbally Gifted/Talented
- Verbally Gifted/Talented

Does your child have an Individualized Education Program (IEP), an Advanced Learning Program (ALP), or a 504c?

- My child does not have an IEP, ALP, or 504c.
- Individualized Education Program (IEP)
- Advanced Learning Program (ALP)
- 504c
- My child has both an IEP and an ALP.

Please describe the highest level of education attained by the child's first parent/guardian.

- Less than 12th grade and No GED
- GED
- High school diploma
- Some college
- Associate's degree--For example, AA, AS, AAA, AAS
- Bachelor's degree--For example, BA, BS, BFA
- Master's degree--For example, MA, MS, MBA, MFA
- Doctoral degree/Professional degree--For example, PhD, PsyD, EdD, JD

Please describe the highest level of education attained by the child's second parent/guardian (if applicable).

- Less than 12th grade and No GED
- GED
- High school diploma
- Some college
- Associate's degree-For example, A.A., A.S., A.A.A., A.A.S.
- Bachelors degree--For example, B.A., B.S., B.FA
- Master's degree--For example, M.A., M.S., M.B.A., M.F.A
- Doctoral degree/Professional degree--For example, Ph.D., Psy.D., Ed.D., J.D.

How would you describe your family's household income? Total family income is:

- Under \$15,000
- \$15,000-\$24,999
- \$25,000-\$34,999
- \$35,000-\$49,999
- \$50,000-\$74,999
- \$75,000-\$99,999
- \$100,00-\$149,999
- \$150,000-\$199,999
- \$200,000 or more

Does your child qualify for free/reduced lunch at school?

- Yes
- No

APPENDIX D
CHILDREN'S ANXIETY IN MATH SCALE

PARENTS/GUARDIANS:

The next page of questions are for your child. Please read the information and each item to your child. You will read them a total of 16 questions, and for each one your child will select the face that is most like how they feel about that math activity.

We are trying to know how different kinds of kids feel about math. If you would like to help us, you will be read some things about math, and you will need to pick a face that is most like how you feel about that math thing. If you decide that you do not want to answer questions anymore, you can stop at any time.

Don't worry, there are no right or wrong answers and this is not a test.

First we are going to just look at the faces and what they mean.

This face with the big frown feels **really upset**:



This face with the little frown feels a **little upset**:



This face with the flat mouth **does not feel upset or excited:**



This face with the little smile feels **excited:**

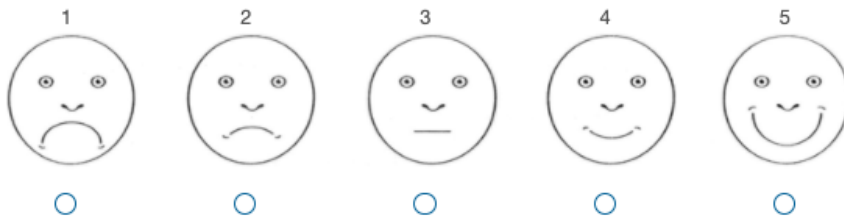


This face with the big smile feels **really excited:**

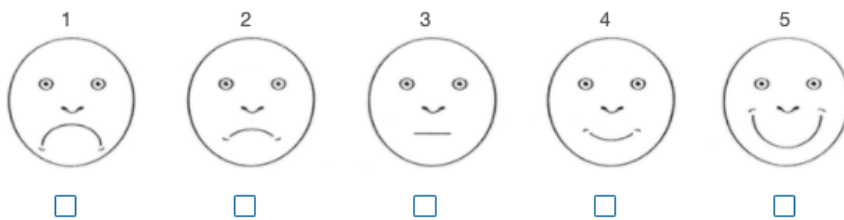


Now we are going to answer questions about how math makes you feel.

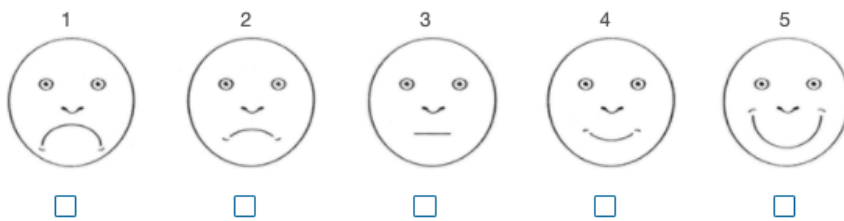
When I solve math problems, I feel:



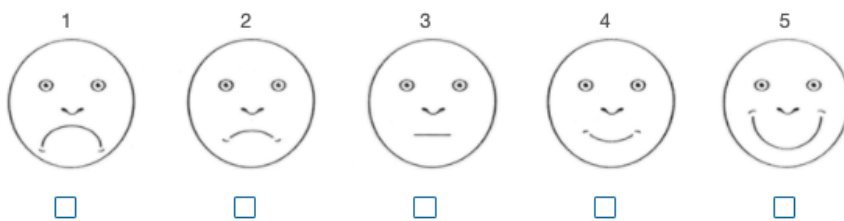
When I think about doing math, I feel:








When I am working on math problems that are difficult and make me think hard, I feel:








Compared to other school subjects, math makes me feel:








When I solve math puzzles, I feel:

1	2	3	4	5
				
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

When I have a hard math question, I feel:

1	2	3	4	5
				
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

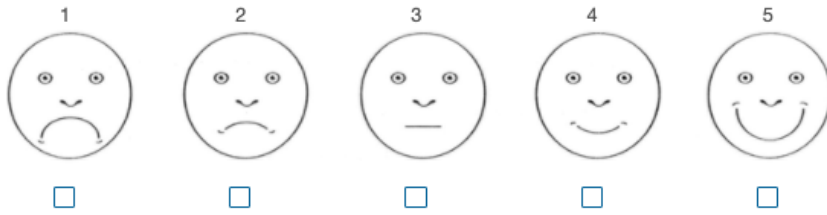
When the teacher calls on me to answer a math problem, I feel:

1	2	3	4	5
				
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

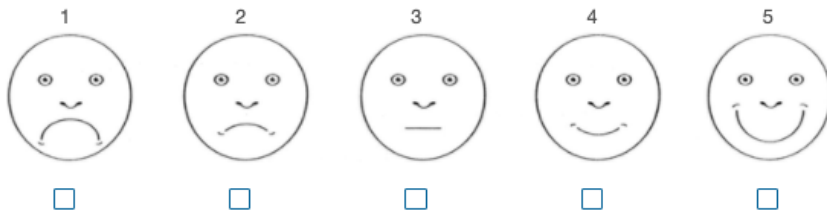
When the teacher is showing the class how to solve a math problem, I feel:

1	2	3	4	5
				
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

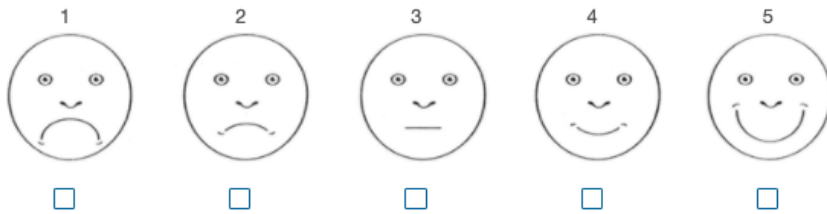
If I have to add up numbers on the whiteboard or Smartboard in front of the class, I feel:



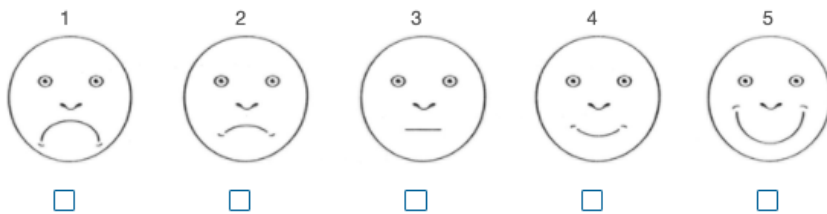
When I make mistakes in math, I feel:



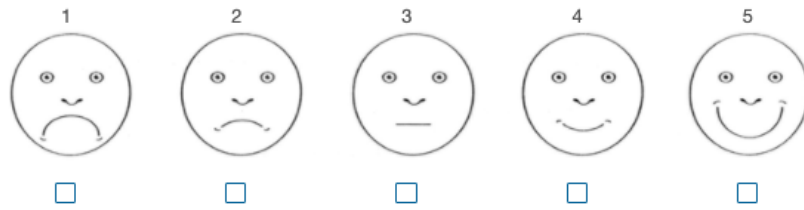
Thinking about working on math in class makes me feel:



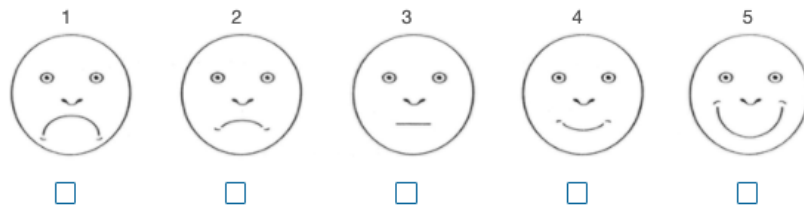
Working on math at home makes me feel:



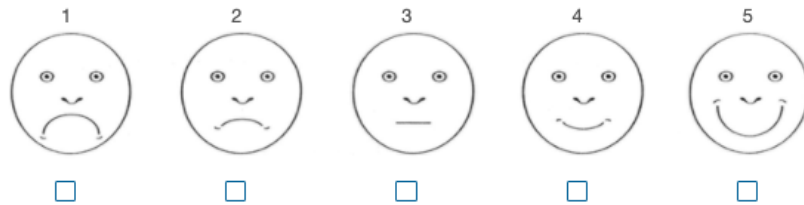
When the teacher gives the class a math problem I don't understand, I feel:



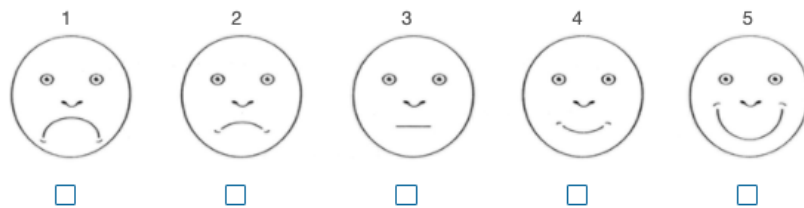
When my teacher says that he or she is going to give me a math problem on the whiteboard or Smartboard, I feel:



When I know that my class will be working on math at school, I feel:



When I know that I am going to have a math test, I feel:



Thank you for helping us understand how different kids feel about math. We are very thankful for your help!