THE IMPACT OF MATHANXIETY IN THE PRIMARY GRADES

by

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THE IMPACT OF MATH ANXIETY IN THE PRIMARY GRADES

Amanda R. Anderson-Mix

Math anxiety is an increasingly common occurrence among individuals when working with mathematical concepts. While researching math anxiety the author came across common gender stereotypes implying: women do not perform as well as men in the field of mathematics, women experience a much higher level of math anxiety than men, and most women do not appreciate performing mathematical tasks. Although the concept of math anxiety is an interesting topic to the author, it's important to look deeper than simply the question, “What is math anxiety?” Seeing these stereotypical assumptions that women have higher math anxiety levels, it made this author wonder, when does this math anxiety start? What impact does math anxiety have in the primary grades? Are there trends among girls and boys? What evidence is there?

Using this main question and sub-questions as lenses to analyze a variety of case studies, it is important to verify that researched articles are not just those of opinion, but conclusions based on data and documented proof when comparing math anxiety levels between males and females in the primary grades. The author also made a point to examine contradicting resources to keep an open mind when comparing credible resources while creating a high quality research report.

Approved by

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Chapter 1: Introduction

According to Ogilvy PR, which supports the "Change the Equation" }cause, a survey was conducted to understand the common American viewpoints toward the perception of mathematics. This survey reports 30% of Americans would clean the bathroom instead of solving a mathematics problem (2014, para. 1}). Out of 100 students and 50 colleagues at a local elementary school, when asked whether or not they like mathematics in June of 2011, only two students and one colleague answered affirmatively. All three positive respondents were male. A large percentage of the female participants said they experience math anxiety when working with mathematical concepts. This interesting outcome makes the author wonder about the impact of math anxiety among the genders in the primary grades What trends exist among children that might continue into adulthood?

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This research paper focuses on answering these questions and looks at a variety of case studies that provide data and evidence comparing math anxiety among genders and age groups. Some of the case studies report statistically significant data linking higher levels of mathematical anxiety to females than males (Frenzel et al., 2007)). When data did suggest females experience higher levels of anxiety, authors mention the possibility that women are more willing to admit their anxieties and believe gender stereotypes (Ashcraft & Ridley, 2005). These stereotypes include the assumption that mathematics is a male dominated field, and that males are better performers of mathematics.

These stereotypes concern the author being that she is female, loves mathematics, and is an educator in an elementary school. The author wants children to feel confident in mathematics, regardless of their gender. It was the realization of the existence of these stereotypes, that caused the author to wonder what impact math anxiety has on children in the primary grades. It is crucial, as an educator, to understand how to nurture future generations in mathematics}. It is the responsibility of educators to

motivate, not hinder, the next generation and help these future members of society to embrace mathematical situations in their environments.

Background

When researching the concept of math anxiety in the primary grades the author, first, came across several studies that examined students in middle school, high school, and college. Else-Quest, Hyde, & Linn (2010) used data from the 2003 Trends in International Mathematics and Science Study and the Program for International Student Assessment in order to recognize statistically significant differences between genders in mathematics achievement attitudes, and affect. These two forms of research involved analyzing 493-495 students approximately 14-16 years old from 69 different countries. The researchers found there were similarities in mathematics achievement among the two genders, but concluded boys stated more positive attitudes regarding mathematics}. National effect sizes ranged from d = −0.61 to 0.89.

This article shows differences from previous tests because the areas that focused on gender equity, in terms of the number of women in research jobs, school enrollment, and women's representation in parliament heavily predicted national variability in mathematics regarding gender gaps. Else-Quest et al. (2010), concluded there is, nationally, a larger increase in female participation on society gender equity. This study contains quantitative and qualitative data that show although the mathematics achievement among genders is not statistically significance in terms of differences, boys did have a more optimistic viewpoint of mathematics. Hyde and Linn (2010) discovered a similar conclusion,“Girls outperformed boys on computation in elementary school and middle school. There was no gender difference in high school. There was not a gender difference in deeper understanding of mathematical concepts at any age. For complex problem solving, a skill that is highly relevant for

science, technology, engineering, and mathematics careers, there was no gender difference in elementary or middle school" (p.599).

Devine, Fawcett, Szucs, & Dowker (2012), analyzed 433 (165 girls and 268 boys) British school children in 7th, 8th and 10th grade. The students completed math anxiety and test anxiety questionnaires and mental mathematics tests. The study showed both males and females experience math anxiety but girls showed math anxiety at a higher level. Having high levels of math anxiety was seen to lower math performance which could contribute to lower levels of mathematical performance in online learning environments. It was emphasized that math anxiety needs to be monitored in the math classroom for it seems to develop during the early school years (elementary school). Although there was no difference in mathematical performance among the genders, even though there were girls with higher levels of math anxiety, the study suggests girls may be able to perform at a higher mathematical level than boys if their levels of math anxiety were diminished. The study did state that longitudinal research was needed in order to understand further the development of math anxiety and how it contributes to overall math performance. "This hypothesis, known as the sex-role socialization hypothesis, argues that because mathematics is traditionally viewed as a male domain, females may be socialized to think of themselves as mathematically incompetent and therefore females may avoid mathematics and when females do participate in mathematical activities they may experience more anxiety than males"(Devine, et al., 2012, p. 6).

It was this trend found in Devine, et al.'s, (2012) study that made the author question whether or not it was a common trend for females to be impacted by math anxiety more than males. According to this Study, "gender differences in MA (math anxiety) and TA (test anxiety) is that females may be more willing to admit to feelings of anxiety than males because the expression of emotion by females may be

accepted whereas the expression of anxiety in males may be viewed as less acceptable" (Devine, et. al., 2012, p. 6).

Azar (2010) stated that, after reviewing decades of research on gender differences,"Cornell University psychologists Steven Cecci, PhD, and Wendy Williams, PhD, conclude that while there is probably some genetic basis for small differences between the sexes in mathematical and spatial ability, culture plays by far the bigger role in men and boys' higher interest and achievement" (Azar, 2010, p. 40). Azar stated that females (when in the primary grades) actually perform quite well in mathematical problem solving but male children tend to be more confident. "This lack of confidence among females is what can lead to math anxiety which is shared by the cultural stereotype that males are better at math" (Azar, 2010, p. 40). However, Azar (stated) that Janet Hyde (another researcher of genders in the field of mathematics education) is trying to rebut this skewed assumption caused by society. She says "a key component among female math anxiety stems from the math anxiety among the female instructors that children have in elementary school" (Azar, 2010, p.40).

This curiosity of how teachers can impact student beliefs about their mathematical success, and how it can contribute to math anxiety, lead to the creation of this report. When looking at a problem it is logical to look at the beginning. The author decided that focusing on students in the primary grades (K-6) would shed some light on the impact of math anxiety.

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Statement of the Problem

There are societal, emotional, self, and gender contributors influencing math anxiety. If math anxiety is gender specific among primary age children, then one gender could be at higher risk of avoiding mathematical situations. It would mean an entire gender's needs are not being met in the school

environment or in their everyday lives. Math anxiety is a common enough problem, but the research behind this study will determine if society is affecting half of humanity in its views toward the field of mathematics.

Research Questions

1. What is math anxiety?
2. What is the impact of math anxiety in the primary and intermediate grades?
3. Is there a trend of math anxiety affecting one gender more than the other?
4. If linked to a specific gender what are some of the causes behind that gender's math anxiety?
5. How can we minimize math anxiety in the primary classroom? *(addressed through the research provided in the conclusion)*

Significance of the Research Problem and Study

There is a stereotypical assumption that mathematics is a male dominated field. This assumption could negatively impact children in their societal views and future goals regarding mathematics. If this assumption is impacting a specific gender, causing math anxiety, or affecting mathematical performance, then primary children will be less willing to further their careers and more willing to avoid areas or opportunities involving mathematics. If this stereotype that mathematics is a male dominated field proves to be false and math anxiety is not gender specific, then this will help aid teachers in providing evidence refuting this statement. If females are linked to math anxiety, then this will provide ways to help teachers understand possible causes behind their math anxiety. If math anxiety is found to be starting in the primary and intermediate grades and progressing through into adulthood, then teachers as well as students need to be shown anxiety-based coping strategies to help decrease the negative viewpoints, currently, geared towards mathematics.

Limitations and Assumptions

The author is limiting research to students who are already reading proficient. The author is not including students seen as "at risk" in the areas of language and reading. The author is also limiting international case studies involving math anxiety to studies found only in the United States of America. The author will use examples from different parts of the world to demonstrate math anxiety is not strictly found in the United States. The focus on math anxiety will be through the societal lens of gender only. The author is not including research that emphasizes variability in math anxiety through race, ethnicity, socioeconomic status, or religion.

In this research, the author is making the assumption that all students can learn. The author is also assuming that all individuals have experience in mathematics classes and contain the basic mathematical knowledge learned in the elementary school environment. In studies where quantitative data are formulated, the author is assuming that all mathematical scenarios are solved accurately.

Definition of Terms

Competence Beliefs: When an individual feels they can or cannot do something based on their level of comprehension about a particular concept or idea (Wigfield & Eccles, 1994).

Gender Differences: the typical differences between men and women that is often specific to a particular culture where domains as careers, communication, health, social awareness and orientation to the environment are seen. When societal roles emphasize that one gender is superior to the other, or the roles expected of a particular gender (www.psychologydictionary.org, 2011).

Gender Equity: to eliminate inequalities between women and men, discrimination, and to ensure equal opportunities. Gender equity leads to equality (Concise Oxford Dictionary 7th ed., 1982).

Math Anxiety: a feeling of tension, apprehension, or fear that interferes with math performance (Ashcraft, 2002).

Mathematical Intervention: "Students not making adequate [mathematical] progress in the regular classroom (...) are provided with increasingly intensive instruction matched to their needs on the basis of levels of performance and rates of progress. Intensity varies across group size, frequency and duration of intervention, (...) These services and interventions are provided in small-group settings in addition to instruction in the general [mathematical] curriculum" (http://www.rtinetwork.org/learn/what/whatisrti, 2014).

State anxiety: Momentary math anxiety (Goetz et. al., 2013).

Trait anxiety: Habitual math anxiety (Goetz, Hall, Ludtke, Pekrun & Bieg, 2013).

Working Memory: A limited resource cognitive system responsible fore the temporary storage and processing of information in immediate awareness (Vukovic, Kieffer, Bailey, & Harari, 2012).).

Summary Statement

This research report focuses on answering the following questions:

1. What is math anxiety?
2. What is the impact of math anxiety in the primary and intermediate grades?
3. Is there a trend of math anxiety affecting one gender more than the other?
4. If linked to a specific gender what are some of the causes behind that gender's math anxiety?

By researching answers to the questions listed above, the research will also help answer this report concluding question of, how can we minimize math anxiety in the primary classroom? If math-anxiety is gender specific, then an entire gender could be at risk of avoiding mathematical situations. When trivial amounts of data did suggest females experienced higher levels of anxiety, it is because of societal, emotional, self, and gender contributors. If stereotypical societal assumptions are proven false

and math anxiety is not gender specific, then this will help aid teachers in providing evidence refuting this false assumption. If females are linked to math anxiety, then this will provide ways to help teachers understand possible causes behind math anxiety in females. Either way, the awareness of math anxiety, and its impacts, will help teachers realize that a need to ease this influencing factor is exists.

Chapter 2: Review of the Literature

Math anxiety is the anxiety or stress associated with unsuccessful problem solving or negative scenarios involving the use of mathematics (Ashcraft, 2002). Beilock and Willingham (2014) include that math anxiety starting in elementary school can develop on a deeper level depending on their social environment (2014). Common causes of math anxiety are: a previously negative mathematics class experience, a bad grade on a mathematics assignment that led to disappointment or a consequence, or a person's feeling of low-efficacy in mathematics (Ashcraft, 2002).

Other causes for math anxiety among primary and intermediate children are: a long absence from school, a poor self-image, an emphasis on the correct answer, a placement in the wrong course, and the nature of mathematics where it is knowing more than simply memorizing basic mathematical facts (Bluman, 2011). Bluman (2011) and Berch and Mazzocco (2007), all state poor mathematics teachers can be a factor for increased math anxiety. A student's mathematical environment can also cause math anxiety if it deals with time limits or deadlines (Phillips, 2014).

Some physical symptoms (pounding of the heart) and mental symptoms (a feeling of helplessness) can cause an individual, especially a young child, to feel stupid (Bluman, 2011). This feeling of stupidity can lead the individual involved to avoid mathematical situations, environments, or scenarios (Berch & Mozzocco, 2007). Not being confident when it comes to mathematical concepts can cause math anxiety levels to rise in an individual" (Stuart, 2000).

Math anxiety based scenarios that occur in the primary grades can lead to heightened math anxiety in adulthood (Devine, Fawcett, Szucs, & Dowker, 2012). With math anxiety occurring at young ages, it is suggested teachers intervene to stop the negative viewpoint of mathematics from becoming permanent

(Vukovic, et al, 2012). When math anxiety goes unnoticed or is not treated properly it can cause children with a higher working memory to deter away from mathematical situations in the future (Ramirez, Gunderson, Levine, & Beilock, 2013). Students with a low working memory still had math anxiety. “These students struggled with multi-step mathematical problems and could develop a social phobia towards mathematics” (Berch & Mazzocco, 2007, p. 342-343). Similar findings from a survey taken by students ranging from nine to twelve years old (22 females, 25 males) discovered students who thought they were not very good at mathematics also thought they performed the worst (Stuart, 2000).

When Ramirez et al. (2013) studied 154 first and second grade children (69 boys, 85 girls), they discovered a negative relation when comparing math anxiety and mathematical achievement. The negative relation existed more prominently in children who were higher in working memory. This raised the concern that these students may eventually avoid future mathematical related careers (Ramirez et al., 2013). Vukovic, et al. (2012), conducted a study which consisted of 113 second and third grade students (54 females, 59 males). These students demonstrated mathematicay individuality when it came to mathematical calculation but geometric reasoning was not impacted by anxiety-related traits or anxiety based behaviors (Vukovic, et al., 2012).

Hall, Davis, Bolen, & Chai (1999) used data from the California Achievement Test (CTB/McGraw-Hill, 1986) given to fifth and eighth grade students in the United States. This test analyzed mathematical performance based on gender and race. These quantitative data found there were no significant score differences based on gender but it did show differences based on race. African-American students scored significantly lower than Caucasian students in mathematical concepts. Through a qualitative parent questionnaire, this study revealed relationships and trends between the

child and his/her parents suggesting that a child's mathematical performance can vary greatly depending on race, environment, and parental beliefs (Hall, et al., 1999). Math anxiety is not caused by mathematics, but from the viewpoints of others and how it is presented (Geist, 2002).

Pekrun's (2000, 2006) Control Value Theory of Achievement Emotions theory in order to determine if there were gender differences in math anxiety due to the students' value beliefs. In a study consisting of 1,036 males and 1,017 females (fifth graders) by qualitative self-reported measures, and quantitative academic grades, it was discovered that the mathematical grades of the boys and girls in this study were quite similar. Yet, the girls reported having significantly higher levels of math anxiety than the boys (Frenzel, Pekrun, &Goetz, 2007). In 2013, a study that examined 584 students in fifth through tenth grades (45% female, 55% male). Trait (habitual) math anxiety versus state (momentary) math anxiety were affected because of those students' beliefs. The findings suggest the female students involved do not have more math anxiety than the male students when it involves testing scenarios or math instruction, but their self-confidence was lower than the males (Goetz, Hall, Ludtke, Pekrun, & Bieg, 2013).

Steele (2003) conducted two experiments with elementary school children supporting this theory. In the first study, 38 girls placed advanced mathematics pictures with males more often than basic math pictures (eight first grade students, 11 second second grade students, 11 third grade students, and eight fourth grade students). In addition, girls rated men as liking mathematics more and being better at mathematics than women, but viewed boys and girls as being equal on these variables. In the second study, comprising of 58 children (32 girls, and 26 boys ranging from ages 6-10) girls were more likely to draw a man when told a story about an adult mathematician, but were more likely to draw a girl when told of a child mathematician. Steel (2003) suggested there needs to be an increase in positive

female role models in mathematics and science in order to break the negative societal stereotypes involving females and mathematical performance (Steele, 2003).

In 2010, a study on adolescents used meta-analysis data from 242 studies published from 1900-2007 which includes the testing of a total 1,286,350 participants. This study used quantitative data that indicated no gender differences, and almost equal female and male variances. It compared: the National Education Longitudinal Study of 1988, the National Assessment of Educational Progress (1992-2004), the National Longitudinal Surveys of Youth (1997-2002)), and the Longitudinal Study of American Youth (1987-1992). The study concluded females and males perform quite similarly in the area of mathematics (Lindberg, Hyde, Peterson, & Linn, 2010).

Using the Mathematics Anxiety Rating Scale, the responses were on a Likert scale one to five where one meant low anxiety and five meant high anxiety, 12 first-grade teachers (female) and five second-grade teachers (female) from five public elementary schools in a large mid-western school district. The students of the teachers (117 classroom students: 65 girls and 52 boys), were read the gender neutral stories (one where a student is good in mathematics, and another where the student in good in reading) and were told to draw a picture of a boy or a girl from each story (a boy drawing received a score of one, a girl drawing received a score of zero) then the responses were applied to the formula (mathematics drawing − reading drawing). The higher the score the more children believed that girls excel in reading and boys excel in mathematics. The study showed when female teachers show math anxiety, this anxiety affects the mathematical achievement of their female students at the end of the school year (Beilock, Gunderson, Ramirez, & Levine, 2010). However, a comparison was not made on the differences of male teachers affecting the female students' math anxiety levels, or the impact female teachers had on male students and their anxiety levels.

Bowd (2003), analyzed the relationship between math anxiety and gender among preservice student teachers (357 teacher education college seniors). Using the Mathematics Anxiety Rating Scale }and a questionnaire to assess elementary and secondary school mathematics experiences, attitudes, and beliefs towards mathematics, there was not statistically significant evidence regarding mathematics achievement among male and female participants in informal mathematics. The association of math anxiety and both perceptions of school experience and beliefs about mathematics were at a higher level in women due to negative experiences with mathematics in high school (Bowd, 2003). Environmental factors, not necessarily the mathematics itself, is a cause for math anxiety among females and not among males (Rubinsten, Bialik, Solar, 2012). Ashcraft and Ridley (2005) suggest females were associated with a higher level of math anxiety because they (females) are more willing, than males, to admit they are experiencing math anxiety.

When female teachers show math anxiety, this anxiety affects the math achievement of their female students at the end of the school year. The female students who accepted the stereotype “boys are good at math, and girls are good at reading” had a lower mathematics achievement. Math anxiety was discovered to not only affect achievement but was more prevalent with females due to the carry over in anxiety from the elementary teachers of those female students (Beilock, et al., 2010, pp.1880-1883).

Geist (2008) discovered girls had higher math anxiety caused by a memory than boys due to a 1990 societal theory girls need to work hard to ahieve good grades in mathematics, whereas boys are naturally good at mathematics. This belief may be the reason why teachers, parents, and many students still are affected socially and why girls lack confidence and show doubt in the field of mathematics (Geist, 2008). Contrary to the viewpoints of the students in Geist's (2008) study, girls do have the

ability to out perform boys in national mathematical assessments. In 2010, the NAEP reported that 4th and 8th grade girls scored higher than boys in every category of mathematics, proving that girls have the capability to achieve high scores in the field of mathematics. Society, however, can impact girls' viewpoints of their own mathematical awareness and demonstration (Hyde & Linn, 2006).

Chapter 3: Analysis of the Literature Review

What is math anxiety?

Vukovic et al. (2012) defined math anxiety as “a feeling of tension, apprehension, or fear that interferes with math performance”(pp. 1). This term can be used in association with academic or non-academic environments. Math anxiety is the anxiety or stress associated with unsuccessful problem solving or negative scenarios involving the use of mathematics (Ashcraft, 2002).

But what causes it to occur? According to Beilock and Willingham (2014), “factors related to both students' math abilities at the start of elementary school and students' social environment (in the classroom, at home, and in society generally) likely play a role in the development of math anxiety” (p. 30). Common causes of math anxiety are: a previously negative mathematics class experience, a bad grade on a mathematics assignment that led to disappointment or a consequence, or a person's feeling of low-efficacy in mathematics (Ashcraft, 2002). Other causes for math anxiety among primary and intermediate children are: poor mathematics teachers, a long absence from school, a poor self-image, an emphasis on the correct answer, a placement in the wrong course, and the nature of mathematics where it is knowing more than simply memorizing basic mathematical facts (Bluman, 2011). Similarly, to Bluman's philosophy, Berch and Mazzocco (2007) stated “students who encounter teachers (...) with a high demand for correctness and little or no cognitive or motivational support during class are particularly at risk, especially those who are more vulnerable to performance-based anxiety (e.g., those with lower self-esteem)” (p. 342). Which is why there is a connection between timed tests and deadlines that can cause mathematical anxiety (Phillips, 2014).

Some physical symptoms of math anxiety are: nervousness, pounding heart, rapid breathing, sweating, nauseousness, upset stomach, and tension. Aside from physical symptoms, several mental symptoms

are commonly associated with math anxiety. These mental symptoms can include: a feeling of panic or fear, cloudy or fuzzy thinking, a lack of concentration, a mental block in thinking, and a feeling of helplessness that can lead to the feeling of stupidity, guilt, or shame (Bluman, 2011). It is this feeling of guilt, shame, or stupidity that can lead to the "deliberate avoidance of math, certainly of math curriculum(...)and also of career paths that rely on math achievement and skill (Berch and Mozzocco, 2007, p. 343). Vanessa Stuart (2000) approached from the angle that negative feelings and lack of confidence in mathematical concepts causes math anxiety to arise when an individual is "working with mathematical situations" (p. 331).

What is the impact of math anxiety in the primary grades?

When math anxiety begins in the primary grades it can lower their confidence when experiencing mathematical situation in adulthood. "MA [math anxiety] can develop in the early school years [five to seven years old] and becomes increasingly common with age [eight to nine years old]. It is thought to affect a notable proportion of school age population and adults in post-secondary education" (Devine et al., 2012, p. 2). With math anxiety occurring at young ages, it is suggested that interventions with math anxiety occur before the constant worry and feelings of fear toward mathematics become permanent. "Mathematics anxiety may detrimentally affect not only how young children perform mathematically, but also how much mathematics some children learn. (...) the importance of understanding sources of children's mathematics anxiety in order to intervene before children experience the negative consequences associated with consistent and repeated feeling of tension and worry towards mathematics" (Vukovic, et al, 2012, p. 9).

Vukovic et al. (2012) also concluded that math anxiety starts in the primary grades. Vukovic et al.

(2012), discovered that 113 second and third grade students (54 female, 59 male) demonstrated math anxiety individually and their results showed differences in mathematical application and skills regarding calculation. Interestingly enough, geometric reasoning was not seen to be impacted by anxiety based behaviors. Students who demonstrated a working memory at a higher level were more greatly impacted and did not show much gain in mathematical application. Other findings suggest that children may use their working memory resources differently depending on how greatly their math anxiety impacted their reasoning skills (Vukovic, et al., 2012).

When math anxiety is left untreated, the anxiety found in young children could cause students with the highest potential [the students with a high working memory that requires intensive problem solving strategies, which are more likely to be disrupted] to "avoid math courses and math-related career choices" (Ramirez, et al., 2013, p. 187). Berch and Mazzocco (2007) found students with a low working memory still experience math anxiety just like the students found to have a high working memory. These students [students with a low working memory] tend to have difficulty solving multi-step mathematical problems and may increase a negative viewpoint and feelings toward mathematical situations. "Alternatively these skill deficits might increase the likelihood of experiencing a negative conditioning event and, thus, the onset of math anxiety or a more generalized social phobia" (Berch & Mazzocco, 2007, p. 342). Similar findings from a survey taken by students ranging from nine to twelve years old (22 female, 25 male) found "students of both sexes who disliked mathematics also believed that they were not good at it and that they performed worse than their classmates. These same students also said that they worried when asked to do mathematical tasks" (Stuart, 2000, p. 331). Students also at risk of developing math anxiety are those who experience a classroom teacher who does not provide motivational or cognitive support and demand correctness consistently (Berch & Mazzocco, 2007).

When Ramirez et al, (2013) studied 154 first and second grade children (69 boys, 85 girls), they discovered a negative relation when comparing math anxiety and mathematical achievement. The negative relation existed more prominently in children who were higher in working memory (WM) than children whose working memory were at a lower level. Ramirez et al., (2013), concluded it was necessary to find a treatment for math anxiety in the primary grades based on the conclusion that students who are seen to have high levels of working memory (the highest potential), may eventually avoid mathematical related careers and courses in the future. "The finding that children who are higher in WM way be most susceptible to the deleterious effects of math anxiety is particularly worrisome because these students arguably have the greatest potential for high achievement in math. Investigating the development of math anxiety from the earliest grades will not only increase our understanding of the relation between math anxiety and math performance across the school years but is also a critical first step in developing interventions designed to ameliorate these anxieties and increase math achievement" (Ramirez et al., 2013, p. 199). Although Ramirez et al., (2013) focused on students with a higher working memory, and Berch and Mazzacco (2007) focused on students with a lower working memory, both studies concluded their group of students experienced math anxiety. The combination of these two studies make it apparent that math anxiety affects a large group of students ranging in mathematical ability from the academically struggling to the mathematically advanced.

Is there a trend of math anxiety affecting one gender more than the other?

Determining if math anxiety affects one gender more than the other is not a new topic. Yet, it is still the topic of mathematics education research today. In 1999, Hall, et al. used data from the California Achievement Test (CTB/McGraw-Hill, 1986) that was given to fifth and eighth grade students in the United States. This test was used to analyze mathematical performance based on gender and race. Hall,

et al. (1999) analyzed these quantitative data and found no significant score differences based on gender. The study did show, however, there were differences in race because the African-American students scored significantly lower than Caucasian students when it came to mathematical concepts. Through a qualitative parent questionnaire, this study found relationships between how well the child performed in mathematics and the parents' own math anxiety, education level, and highest completed mathematics course. The study suggests that a child's mathematical performance can vary greatly depending on race, environment, and parental beliefs. Hall et. al, (1999) used both qualitative and quantitative data to discover these findings. “Responses to a parent questionnaire showed significant relationships between parents' self-reported math anxiety, parents' most advanced mathematics course, and parents' education level in relation to the child's mathematics performance. Differences in these relationships suggest that, although parents' beliefs and attitudes about mathematics influence their child's mathematical performance, the relationship is complex and may vary with race” (p. 677).

According to Geist (2008, p. 29), “Math anxiety does not come from the mathematics itself but rather from the way math is presented in school and may have been presented to teachers as children.” Through the perceptions of teachers, authority figures, parents, and peers the personal opinion of mathematical concepts can change in the child affected. Frenzel, et al., (2007), used Pekrun's (2000, 2006) Control Value Theory of Achievement Emotions theory in order to determine if there were gender differences in mathematics anxiety due to the students' value beliefs. This study was conducted with the assumption that math anxiety emotions and value beliefs were invariant between boys and girls. Frenzel, et al. (2007) assessed 1,036 males and 1,017 females (fifth graders) by qualitative self-report measures, and quantitative academic grades that analyzed their prior mathematics successes. The researchers found the math grades between the girls and boys were similar, the same findings discovered by Hall et al. (1999). However, Frenzel, et al. (2007) documented that the girls reportedly

had significantly more math anxiety than the boys, and less enjoyment and pride. It was concluded that the emotional patterns expressed by the females was due to low competence beliefs in mathematics. "Girls reported (…) more anxiety, hopelessness, and shame" (p. 497).

In contrast with the 2007 Frenzel et al. study, Goetz et al. (2013) conducted a study that examined a total of 584 students in fifth through tenth grade (45% female, 55% male) that found "trait [habitual] versus state [momentary] math anxiety were partly accounted for by students' beliefs about their competence in mathematics, with female students reporting lower perceived competence than male students having the same average grades in math" (Goetz, et al., 2013, p. 1). Goetz, et al. (2013), in contrast of Frenzel's (2007) study, findings suggest the female students involved do not actually have more math anxiety than the male students when it involves testing scenarios or mathematics instruction. Similar to Frenzel's (2007) study, however, Goetz et al. (2013, p. 6) "girls' competence beliefs, which were lower than those of boys despite girls' and boys' similar achievement outcomes, may be partly responsible for girls' higher levels of reported habitual mathematics anxiety." Thus, how girls view themselves can affect their anxiety levels and achievement outcomes.

Hall et al. (1999), Frenzel et al. (2007) and Goetz et al. (2013) all came to the similar conclusion that there were not significant differences among the genders when it came to mathematical performance. Hall et al. (1999) concluded there were key differences among mathematical performance and race but not gender. This may be due to the fact that Control Value Theory of Achievement Emotions theory used in the study Frenzel et al. (2007) conducted was not created until 2000. Frenzel et al. (2007) reported girls expressed having more math anxiety than boys, but Geotz et al. (2013) reported math anxiety among females is situational (not during testing or math instruction). Both Frenzel et al. (2007) and Goetz et al (2013), however, stressed that low competency beliefs in females can be a contributing

factor on math anxiety levels being at a higher level than males. These low competency beliefs among females may be due to social stereotypes that imply women are good at reading and men are good at mathematics. According to Steel (2003), Lindberg et al. (2010), Beilock et. Al (2010), and Bowd (2003) the environment surrounding students in the primary grades as well as their teachers can negatively impact how students view themselves when working on mathematics.

Steele (2003) explains that when it came to how women performed in mathematics outside of a testing environment, they performed as well or better than men. Women under perform on standardized mathematics tests compared to men. However, girls perform as well if not better than boys in mathematics. It is proposed that this discrepancy may be explained in part by a process of stereotype stratification, in which targets of a negative in-group stereotype view themselves as a member of a subgroup to which the stereotype does not apply. “It was proposed that girls develop a gender stereotype about mathematics that is specific to women (i.e., “Men are better than women at math.”), not girls (“girls and boys are equally good at math”)” (Steele, 2003, p. 2602). Steele (2003) conducted two experiments with elementary school children supporting this theory. In study one, 38 girls placed advanced mathematics pictures with males more often than basic mathematics pictures (eight first grade students, 11 second grade students, 11 third grade students, eight fourth grade students). In addition, girls rated men as liking and as being better at mathematics than women, but viewed boys and girls as being equal on these variables. In study two, comprising 58 children (32 girls, and 26 boys ranging from ages 6-10) girls were more likely to draw a man when told a story about an adult mathematician, but were more likely to draw a girl when told of a child mathematician. As girls grow into women, if girls have a negative stereotype about women and mathematics, it may hinder the female desire to work in a mathematical field as they become older. Steel (2003) suggested there needs to be an increase in positive female role models in mathematics and science, in order for children to, as

the study suggests, “challenge their current gender stereotypes about women in these domains” (Steele, 2013, p. 2603). The results of this study will show that environmental factors, not biological, are the reason why women may have a higher level of anxiety in mathematics than men (Steele, 2003).

Similar to Steele's (2003) results, Lindberg et al., (2010) used a very large population (N = 1,286,350) to discover there were not significant data differences among genders. But the difference is the focus of the population was on adolescents instead of primary levels. Lindberg et al. (2010) used meta-analysis data from 242 studies published from 1900-2007, which includes the testing of a total 1,286,350 participants. This study used quantitative data that indicated no gender differences and almost equal female and male variances. The researchers then analyzed the 242 studies to look for patterns based on probability sampling with adolescents in the last 20 years in the United States. The researchers compared: the National Education Longitudinal Study of 1988, the National Assessment of Educational Progress (1992-2004), the National Longitudinal Surveys of Youth (1992-2002), and the Longitudinal Study of American Youth (1987-1992). The researchers concluded that females and males perform quite similarly in the area of mathematics. “Overall, it is clear that, in the U.S. and some other nations, girls have reached a parity with boys in mathematics performance. It is crucial that this information be made widely known to counteract stereotypes about female math inferiority held by gatekeepers such as parents and teachers, and by students themselves (..) there are no gender differences in performance at any grade level through grade 11” (Lindberg et al., 2010, p. 15).

These gatekeepers Lindberg et al., (2010), referred to are where Beilock et al. (2010) focused. Beilock et al. (2010), used 12 first-grade teachers and five second-grade teachers from five public elementary schools in a large mid-western school district. All of the teachers were female who had an average of 13 years teaching experience. Using the Mathematics Anxiety Rating Scale, the responses were on a

Likert scale one to five where one meant low anxiety and five meant high anxiety. The teachers were also assessed using the Elementary Number Concepts and Operations sub-test of the Content Knowledge for Teaching Mathematics (Beilock et al., 2010, p. 1862), measure to determine mathematical knowledge used in classroom teaching and the raw scores (number correct out of 26 questions were collected. 117 classroom students (65 girls and 52 boys). They were read the gender neutral stories (one where a student is good in mathematics, and another where the student in good in reading). The higher the gender ability belief score, the more popular the belief that mathematics is the subject area where boys are strong, and reading is a strength found in females. The theory that teachers can influence the performance of their students, stressed by Lindberg et al., (2010) is exactly what Beilock et al. (2010) discovered. Especially present in the teachers' female students, Beilock et al. (2010, p. 1862) stressed, “Teachers with high math anxiety seem to be specifically affecting girls’ math achievement and doing so by influencing girls' gender-related beliefs about who is good at math.”

What Beilock et al. (2010) discovered about female teachers affecting the viewpoints of their female students in terms of mathematics, strongly supports the evidence Bowd discovered in 2003. Bowd (2003), concluded that math anxiety follows pre-service teachers into the education profession even before they start teaching. This study analyzed the relationship between math anxiety and gender among pre-service student teachers (357 teacher education college seniors). They were assessed using the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972) and a questionnaire to assess elementary and secondary school mathematics experiences and the attitudes and beliefs about the pre-service teachers' views towards the subject of mathematics. Mathematics achievement was not statistically significant among male and female participants in informal mathematics. It was the perceptions of school mathematics experience that differed among the genders. Although both genders expressed an increased enjoyment of mathematics in elementary school than high school, women had

less interest overall when viewing the concept of mathematics. The association of math anxiety and both perceptions of school experience and beliefs about mathematics were at a higher level in women due to negative experiences with mathematics in high school. There was an implication that educational programs meant to prepare teachers should be reviewed due to the influence of peers' and teachers' behaviors in association with mathematics in high school (Bowd, 2003).

If linked to a specific gender, what are some of the causes behind that gender's math anxiety?

Steele (2003, p. 2603) suggested "as girls grow into women, if girls have a negative stereotype about women and mathematics, it may be hindering the female desire to work in a mathematical field as they become older." Steele (2003) stressed there needs to be more females in math and science professions that can be a positive role model for students and that it is due to environmental factors, not biological, are the reason why women may have a higher level of anxiety in mathematics than men.

Rubinsten et al., (2012) had a similar philosophy to Steele (2003). Rubinsten et al., (2012) stressed that environmental factors, not necessarily the mathematics itself, is a cause for math anxiety among females and not among males. One possibility on why a higher math anxiety is linked to females accordingly is that females are more willing than males to admit they are experiencing math anxiety. Other evidence points to the possibility that women simply chose not to further their career in a mathematics or science-based profession (Ashcraft & Ridley, 2005).

When female teachers show math anxiety, this anxiety affects the mathematical achievement of their female students at the end of the school year. The female students who accepted the stereotype "boys are good at math, and girls are good at reading" had lower achievement in mathematics. Math anxiety

was discovered to not only affect achievement but was more prevalent with females due to the carry over in anxiety from the elementary teachers of those female students (Beilock, et al., 2010).

In Bowd's (2003) study, although both genders expressed an increased enjoyment of mathematics in elementary school than high school, women had less interest overall when viewing the concept of mathematics. The association of math anxiety and both perceptions of school experience and beliefs about mathematics were at a higher level in women due to negative experiences with mathematics in high school. “The present results suggest that the development of math anxiety should be examined in the context of socialization experience in the middle school or high school as well as the elementary school (…) the fact that most elementary teachers are women (...) means that many girls are exposed to women as mathematics role models before puberty” (Bowd, 2003, p. 34).

Although Bowd's (2003) claim was stated over ten years ago, there is recent evidence that supports this claim. According Goldring, Gray, & Bitterman (2013, p. 3), “In public schools, a larger percentage of teachers were female in primary schools (89 percent) than in high schools (58 percent). In private schools, 86 percent of elementary school teachers were female and 56 percent of secondary school teachers were female.” A key difference between current statistics and Bowd's (2003) statement is Bowd suggested that math teachers in the secondary grades were mainly men and so there were not many mathematics based mentors for young females. Goldring, Gray, & Bitterman (2013) disproved Bowd's (2003) statement, by showing that, now the larger percent of secondary teachers in public schools (58%) and private schools (56%) are female. There are more female mentors now than when Bowd (2003) conducted his study.

Geist (2008) discovered girls had higher math anxiety caused by a memory than boys. Geist (2008,

p.26) stressed that as of 1990 it was discovered many teachers believed "that girls achieve in mathematics due to their hard work while boy's achievement is attributed to talent (...) these differering expectations by teachers and parents may lead to boys often receiving preferential treatment when it comes to mathematics." Children may take these socially engrained viewpoints and believe these skewed beliefs because it resonates in what their guardians and teachers believe. It may be the cause as to why girls lack confidence and show doubt in the answers they give on tests (Geist, 2008). Hyde and Linn (2006, p.600) also agreed with society having an impact on girls viewpoints of their own mathematical awareness and demonstration. "Emphasis on gender differences in the popular literature reinforces sterotypes that girls lack mathematical and scientific aptitude."

Chapter 4: Conclusion

Math anxiety is "a feeling of tension, apprehension, or fear that interferes with math performance" (Vukovic et al., 2012, p. 1). Math anxiety impacts students in the primary grades that can damage future experiences regarding mathematical situations, careers, and environment (Ramirez et al., 2013). Math anxiety is most consistently caused by: a poor grade on a class assignment, an unmotivated classroom teacher who stresses correct answers, an embarrassing mathematical situation, and low self-esteem (Ashcraft, 2002). Math anxiety can cause physical and mental symptoms that can lead to students feeling guilty, stupid, and shamed (Bluman, 2011). This negative cycle of math anxiety starting in the primary grades and staying present throughout adulthood affecting future primary students needs to end. This leads to the final question of how can math anxiety be reduced in the primary classroom?

In the author's classroom, anecdotal evidence suggests boys and girls suffer equally from math anxiety. This contradicts both Frenzel et al. (2007) and Steele (2003). This anecdotal evidence may have occurred because the author does not stress correct answers (encouraged by Ashcraft), does not use literature that supports gender stereotypes (supported by Linn), and is a female mathematician (suggested by Bowd) that does not exhibit math anxiety traits (stressed by Rubinsten). Based on the research, the author suggests ways to reduce math anxiety within the classroom as a whole versus reducing math anxiety for a specific gender.

In order to reduce math anxiety, mathematics needs to be viewed positively. According to Phillips, "[a] person's state of mind has a great influence on his/her success" (n.d.). Phillips stressed the point that the subject of mathematics needs to be viewed in a positive manner in order to reduce math anxiety in the classroom. Through a positive attitude (not talking negatively about mathematics) students can develop

strong skills in mathematics because there will not be a fear to fail or make mistakes (Beilock et al, 2010). “All teachers need to model positive attitudes and beliefs about mathematical concepts and skill” (Bowd, 2003, p. 34). If math anxiety can be stopped at a young age, it will allow more children to consider the possibility of working in mathematics related fields and take mathematics courses as they grow into adults (Ramirez et al., 2013).

Aside from maintaining and expressing a positive attitude towards mathematics, it is suggested that students should use manipulatives, cooperative learning, and symbols whenever it would be helpful. “By using manipulatives, pictures, and symbols to model or represent abstract ideas, the stage is set for young learners to understand the abstractions they represent. They are more inclined to explore with manipulatives. Cooperative groups provide students a chance to exchange ideas, to ask questions freely, to explain ways and to express feelings about their learning” (Phillips, 2014, n.d.). Bluman suggests that whenever mathematical concepts can be related to real life, mathematics will become more relatable and significant to the individuals involved (Bluman, 2013). By accommodating students and their learning styles, mathematical concepts are being introduced and tried on a more personal level (Woodard, 2004).

Azar (2010), supports this theory by talking about how boys are motivated by competition and are more willing to use memory for problem solving mathematical sums. Girls, on the other hand, tend to use manipulatives more to reassure themselves they also know a correct answer retrieved from memory. “Three-fourths of the students thought that using manipulatives when learning a new mathematical concept was helpful. Most of the comments indicated that using manipulatives first helped students see the origin of the numbers in the formulas (…) overall, most students appreciated the opportunity to work in cooperative groups. Students' comments pointed out that sometimes peers

could explain things better than the teacher. Others said that they enjoyed helping one another over working alone" (Stuart, 2000, pp. 332-333).

A third way to reduce math anxiety is less emphasis on mathematical speed and accuracy (Geist, 2010). "Math anxiety depresses math performance because it occupies working memory. Timed tests can cause math anxiety. Not doing a timed test reduces worries about not finishing on time, to giving students the time and space to work through their answers (Beilock and Willingham, 2014, p. 31). If teachers place less stress on students always having the correct answer, it will decrease student fears of being put in embarrassing situations of saying the wrong answer (Ashcraft, 2002). Providing motivation and support while students problem solve mathematical concepts allows the students to use more strategies and feel successful. "Think carefully about what to say when students struggle. Giving concrete strategies for changing up study habits or for approaching a particular problem differently in the future helps the students understand that, with added hard work and effort, he or she has the potential for success" (Beilock, and Willingham, 2014, p. 32).

To reduce math anxiety in the classroom, it is crucial to "dispel harmful but popular misconceptions" (Woodard, 2004, p. 3). This starts with the student's guardian, administrator, or mentor becoming a positive involvement. This list of gatekeepers, as Lindberg et al. (2010) refers to, will impact a child's viewpoint negatively is seen negatively by important role models in their lives. "Knowledge that a teacher's math anxiety can affect her students' math achievement suggests that we also need to ensure that teachers feel fully confident in their preparation to teach math" (Beilock and Willingham, 2014, p. 31). Teachers need to "neutralize traditional stereotypes about girls' lack of ability and interest in mathematics and science, we need to increase awareness of gender similarities. Such awareness will help mentors and advisors avoid discouraging girls from entering these fields (science and

mathematics)" (Hyde and Linn, 2006, p. 600).

Steele (2003) stressed that when it comes to the educational environment, teachers need to make sure to teach both young males and females that women can do highly complex mathematical problems. "As girls become women, holding a negative stereotype about women and mathematics may be hindering girls' desire to pursue this field in adolescence and beyond. By providing young scholars with more positive female role models in mathematics and sciences, children may be in a better position to challenge their current gender stereotypes about women in these domains" (Steele, 2003, p. 2603). Similarly, Goetz et al, (2013, pp.7) concluded that, "Educators could help girls improve their well-being and engagement in mathematics-related domains by explicitly informing them their achievement and anxiety in actual mathematics classes do not significantly differ from those of the boys despite persistent beliefs to the contrary."

A final thought on ways to reduce math anxiety in the classroom is to recognize student anxiety early, before it is too late. It is stressed interventions that ease math anxiety designed to address the needs of students in grades as early as first grade. "[M]aking students aware of alternative problem-solving techniques that can withstand the impact of math anxiety on WM (working memory) may be one such way to lessen the math anxiety-math performance relationship" (Ramirez et al., 2013, p. 199). One quick intervention is letting students write down any anxieties they have regarding mathematical concepts before a test or mathematically involved situation. "Giving students the opportunity to write freely about their emotions for about 10 minutes with respect to a specific situation can help boost test performance" (Beilock, and Willingham, 2014, p. 32). It is important for educators to support students in their struggles with math anxiety "while developing their skills in solving mathematical applications" (Devine et al., 2012, p. 7).

Conclusions

Math anxiety is presently occurring in the primary grades. Newly developed mathematics curriculum options need to be available that incorporate interventions geared towards reducing and alleviating math anxiety in the classroom. It is the job of educators, and updated curriculum, to combat math anxiety at developmentally appropriate levels. Such research in finding a curriculum that helps reduce math anxiety is currently lacking. Present research has found some causes of math anxiety, but not all. Future research needs to continue to determine the causes of math anxiety and how to prevent them in the classroom and in current curriculum.

The author recognizes interventions need to be created that can be monitored by a standardized assessment to reduce math anxiety in the classroom. Currently, such intervention options to reduce math anxiety seem to be non-existent. If such interventions do exist, they are incredibly hard to find. In this author's opinion, using Title I resources and interventionists for the purpose of reducing math anxiety in the classroom should be deemed just as important as a child receiving mathematical interventions for academic reasons.

Math anxiety is the stress associated with unsuccessful problem solving or scenarios involving the use of mathematics (Ashcraft, 2002). Math anxiety does impact children in the primary grades by causing physical and mental symptoms (Bluman, 2011), avoidance in future mathematical careers, courses, and situations (Ramirez et. al., 2013) and the continuation of false societal beliefs to occur (that girls are good at reading, and boys are good at mathematics) (Beilock, et. al., 2010). By using a variety of strategies to reduce math anxiety in the classroom, educators can provide the support and truth needed to help students in the primary grades no longer avoid mathematics but, instead, enjoy mathematics.

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