THE EFFECT OF EXPRESSIVE WRITING ON THE MATH ANXIETY SCORES OF MIDDLE SCHOOL STUDENTS ENROLLED IN A PUBLIC SCHOOL IN EAST TEXAS

By

Angela D. Ruark

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

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ABSTRACT

Math anxiety is a serious concern for educators and students. Students who may otherwise be successful can find themselves incapacitated to think and perform to their abilities due to this issue. Math anxiety negatively affects academic performance and deters students from pursuing math-based careers. This is particularly true for female students. Effective interventions are needed to address these issues. Expressive writing is one such intervention that has shown promise in reducing math anxiety with older students. This study investigated the impact of expressive writing on the math anxiety levels of middle school students according to group and gender. An experimental, pretest-posttest, control group design with random assignment was used for a sample of 40 students from a public middle school in East Texas. The *Modified Abbreviated Math Anxiety Scale* was administered as a pretest and posttest. Students were randomly placed into either the control or treatment group. Both groups completed journal entries each day. The treatment group also responded to a daily expressive writing prompt. The study was conducted over a two-week period. One-way ANCOVAs for data analysis found no significant differences according to group or gender. Results and their implications are discussed, and future research recommendations provided.

Keywords: math anxiety, expressive writing, working memory, gender, adolescents

Dedication

"I will give thanks to the Lord with my whole heart…" Psalms 9:1

This dissertation is dedicated to my husband, Bill, whose prayers, support, and encouragement made all of this possible. Thank you for never letting me say, "I can't." I am eternally grateful for you.

I would also like to dedicate this work to my sons, Matthew, Paul, and Joshua, who understood the commitment involved and cheered me on the entire time.

Finally, I would like to dedicate this work to my parents, Ron Baggett and Sandra Baggett-Dietrich, whose sacrifices early on helped make this a reality.

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Table of Contents

ABSTRACT....3
Dedication....4
Acknowledgments....5
List of Tables....9
List of Figures....10
List of Abbreviations....11
CHAPTER ONE: INTRODUCTION....12
Overview....12
Background....12
Problem Statement....23
Purpose Statement....27
Significance of the Study....27
Research Questions....29
Definitions....29
CHAPTER TWO: LITERATURE REVIEW....31
Overview....31
Theoretical Framework....31
Related Literature....44
Summary....61
CHAPTER THREE: METHODS....62
Overview....62
Design....62

Research Questions 63

Null Hypotheses 63

Participants and Setting...63

Instrumentation 66

Procedures 70

Data Analysis 72

CHAPTER FOUR: FINDINGS 74

Overview 74

Research Questions 74

Null Hypotheses 74

Descriptive Statistics 74

Results 76

Results for Null Hypotheses 81

Summary 82

CHAPTER FIVE: CONCLUSIONS 83

Overview 83

Discussion 83

Implications 88

Limitations 89

Recommendations for Future Research 90

Summary 91

REFERENCES 92

Appendix A: Survey with Demographics Questions and Instrument (Pretest and Posttest) 119

Appendix B: Permission to Use the Instrument 120

Appendix C: IRB Approval 121

Appendix D: Permission Requests 122

Appendix E: Consent Forms 124

Appendix F: Math Journal Examples 129

Appendix G: Course Listings and Descriptions 132

Appendix H: Teacher's Script for Informing Students of the Study 133

Appendix I: Informational Flyer for the Study 134

List of Tables

Table 1: Racial Demographics of the Sample According to Grade Level and Gender 65

Table 2: Group Composition According to Grade Level and Gender 66

Table 3: Reliability of the Modified Abbreviated Math Anxiety Scale..69

Table 4: Descriptive Statistics for the mAMAS Results 75

Table 5: Shapiro-Wilk Test of Normality Results for Group 78

Table 6: Shapiro-Wilk Test of Normality Results for Gender...80

List of Figures

Figure 1: Box and Whisker Plots for the Pretest and Posttest According to Group 76

Figure 2: Box and Whisker Plots for the Pretest and Posttest According to Gender.....................77

Figure 3: Scatterplots for the Assumption of Linearity According to Group 78

Figure 4: Scatterplots for the Assumption of Bivariate Normal Distribution by Group 79

Figure 5: Scatterplots for the Assumption of Linearity According to Gender 80

Figure 6: Scatterplots for the Assumption of Bivariate Normal Distribution by Gender 81

List of Abbreviations

Abbreviated Math Anxiety Scale (AMAS)

Analysis of Covariance (ANCOVA)

Institutional Review Board (IRB)

Math Anxiety Rating Scale (MARS)

Modified Abbreviated Math Anxiety Scale (mAMAS)

Scale for Early Mathematics Anxiety (SEMA)

Scholastic Aptitude Test (SAT)

Science, Technology, Engineering, and Math (STEM)

Statistical Package for the Social Sciences (SPSS)

CHAPTER ONE: INTRODUCTION

Overview

Math anxiety is an important topic for mathematics educators and students, particularly given the demand for qualified professionals in the fields of science, technology, engineering, and mathematics. The lack of females entering these fields is another area of concern, in which math anxiety plays a critical role. The intent of this study was to contribute to the body of knowledge surrounding math anxiety and methods to reduce its negative effects. This chapter describes the background of math anxiety, the impact it has in the context of school and society, and efforts to reduce its adverse influence on learning and performance. A summary of expressive writing is included that explains how it may be used to address math anxiety. The underpinning theories for math anxiety and expressive writing are briefly examined. The problem statement, purpose, and significance of the study are discussed. The research questions for this study are provided along with definitions of relevant terms.

Background

Math anxiety is an increasingly common ailment that causes a wide variety of issues for students and educators. Students who suffer from math anxiety report adverse physical and mental symptoms when faced with mathematical calculations or test situations. These symptoms include heart palpitations, sweating, nausea, shortness of breath, and mental confusion caused by doing or simply thinking about math (Finlayson, 2014). Students with math anxiety tend to have a negative attitude toward math, exhibit lower math achievement, and respond by avoiding the subject as much as possible, even at the expense of a college major or potential career (Beilock & Maloney, 2015). The gravitation away from mathematics and related subjects has been occurring to such an extent that the number of competent professionals in science, technology, engineering, and mathematics (STEM) fields is severely lacking, and even more so for women in these areas (Beilock & Maloney, 2015; Wang & Degol, 2017). To address this need, tremendous pressure is placed on educators to develop math-competent individuals, and students must meet more rigorous standards at earlier grade levels. For those who have math anxiety, these mandates fuel the cycle of dislike, avoidance, and lower achievement. Because math anxiety has such an impact on students across a broad spectrum of grade levels, educators are faced with how best to understand, mitigate, and prevent this epidemic for their students (Bosmans & De Smet, 2015; Jameson & Fusco, 2014; Maloney & Beilock, 2012; Novak & Tassell, 2017).

Educators and researchers have been grappling with math anxiety since its earliest accounts linked it to poor math performance and dislike of the subject, a disposition potentially inherited from math teachers themselves (Kelly & Tomhave, 1985; Tulock, 1957). Fear of the inability to understand math and belief of inevitable failure has long been considered a phobia toward the subject that results in students avoiding math as much as possible (Gough, 1954). The emotional aspect of math anxiety has significant influence. Early accounts described by students include feelings so intense that they experienced extreme nervousness and drew a mental blank when faced with a math problem (Dreger & Aiken, 1957). Richardson & Suinn (1972) later formalized math anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Richardson & Suinn (1972) also described math anxiety as its own unique condition, though it would take several years to be fully recognized.

Many students with math anxiety do not lack in ability. Their poor math performance can be attributed to their avoidance of the subject rather than actual skill (Tobias, 1987; Tulock, 1957). Early research addressed the struggles of otherwise successful students. Math anxiety clinics and programs were established to help. At Wesleyan University and Wellesley College, students who participated in their programs found that once their math anxiety was managed, they were more comfortable taking math courses (Stent, 1977). The progress made by the clinics helped underscore the psychological impact of math anxiety and highlighted the need for innovative approaches in teaching to overcome it.

As the focus moved from defining math anxiety toward addressing the root of the problem, ideas emerged that incorporated both psychological and educational elements. Suggestions that initially included counseling for math anxiety and assistance in improving test-taking skills evolved into changing how math was taught. The quality of mathematics instruction was shown to play a pivotal role in students developing math anxiety. Jackson and Leffingwell (1999) suggested that teachers who chided students for asking questions or were unwilling to explain concepts more than once helped create student anxiety toward mathematics. Teaching methods of watch, drill, and repeat were largely blamed for the math anxiety epidemic because these methods did not help students develop true comprehension, whereas problem solving-based instruction did help students develop comprehension (Betz, 1978; Greenwood 1984). Further, teachers who demonstrated a willingness to expound on concepts using multiple methods were believed to reverse and prevent the onset of math anxiety (Gough, 1954).

The attitude exuded by the teacher was also understood to be a significant contributor to students' attitudes towards mathematics and whether or not math anxiety would take root. Teachers who unwittingly or otherwise espoused gender stereotypes concerning mathematics were shown to contribute to students developing math anxiety and low self-efficacy in mathematics, particularly female teachers of female students (Jackson & Leffingwell, 1999; Kelly & Tomhave, 1985). Negative attitudes towards mathematics were also deemed preventable and changeable. When a student's confidence in math was restored, math anxiety could be lessened or relieved. Hembree (1990) found that when false ideas about a student's math capability were corrected and confidence instilled, math anxiety decreased. The emphases on self-efficacy, understanding, and problem solving have continued to gain ground since their initial suggestion, and remain a focus today (Foley, Herts, Borgonovi, Guerriero, Levine, & Beilock, 2017; Ramirez, Chang, Maloney, Levine, & Beilock, 2016; Tulock, 1957).

The philosophical changes in math instruction come at an opportune time as math anxiety plays an increasingly significant role in school and the workplace. The rise of STEM career fields has created a deficit of approximately one million professionals (President's Council of Advisors on Science and Technology, 2012). As math anxiety causes students to continue to avoid math-based majors and jobs, these professions remain unfilled. In the field of education, however, there is a different concern; teachers could be contributing to the dilemma. Elementary teachers who have math anxiety may unwittingly pass their struggles on to their students (Ramirez, Gunderson, Levine, & Beilock, 2012). They tend to teach "how" without teaching "why." Math-anxious teachers have been shown to be less willing to answer questions and they have a tendency to stick to emphasizing algorithms in their lessons, rather than teaching for understanding (Gresham, 2009; Jackson & Leffingwell, 1999; Ramirez, Hooper, Kersting, Ferguson, & Yeager, 2018; Wilkins, 2008). In other words, they demonstrate avoidance behaviors characteristic of math anxiety sufferers. The literature has long shown and continues to underscore that when teachers have math anxiety, there is a direct negative effect on student achievement (Ramirez, et al., 2018; Stent, 1977). Female students of female teachers appear to be particularly susceptible to "catching" math anxiety. This may be attributed to how young girls identify with their female teachers, then apply the negative emotions and attitudes they observe in their teachers to themselves. These attitudes and ideas include stereotypical beliefs concerning girls and mathematics (Beilock, Gunderson, Ramirez, Levine, & Smith, 2010; Gunderson, Ramirez, Levine, & Beilock, 2012). But teachers alone are not the source. There are other external factors that contribute to the stereotypical belief that math is not a girls' subject. Before girls have the ability to recognize math-gender stereotypes, they adopt behaviors that align with them (Galdi, Cadinu, & Tomasetto, 2013). This suggests the influence of parents on reinforcing stereotypes of girls and math. Research shows that mothers, who hold stereotyped ideas that girls are not as capable as boys of learning and achieving in math, produce the same ideas in their daughters, which can lead to math anxiety (Tomasetto, Mirisola, Galdi, & Cadinu, 2015). Parental influence of math anxiety extends beyond mothers and daughters and is not just associated with stereotype beliefs. When parents have math anxiety, they also exhibit avoidance behaviors and negative attitudes toward math. The math anxiety mindset and behavior patterns are passed on to their children. The literature indicates that math-anxious parents hamper their children's achievement and can actually make the problem worse when they try to help their children with math homework (Casad, Hale, & Wachs, 2015; Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015; Soni & Kumari, 2015). The transmissibility of math anxiety from parent to student and from teacher to student compounds the problem. Anti-math sentiments appear to surround students both at home and school. In the classroom, the influence of the teacher is critical for learning math as teachers introduce concepts, reasoning, and patterns of thinking to students. All of these factors may be perpetuating the problem for the next generation of learners.

To break the cycle of math anxiety, researchers and educators are approaching the issue from different viewpoints. Part of the struggle with the issue of math anxiety is the nature of its origin and its persistence once it has developed. There are several theories that explain the effects of math anxiety. The deficit theory posits that when foundational concepts are missed at some point, or if a math learning disability is present in a student, learning deficits occur and can lead to math anxiety (Carey, Hill, Devine, & Szucs, 2016). Earlier deficit models for test anxiety explain similar results. Tobias (1985) describes the deficits as stemming from either study skills, in which learning is insufficient, or from test-taking skills, in which students are not able to recall learned material. The idea is that gaps in learning, learning difficulties, and poor performance can all lead to math anxiety. The literature provides evidence for the deficit model's explanation of how math anxiety originates (Hembree, 1990; Ma & Xu, 2004; Wang, et al., 2014; Wu, Barth, Amin, Malcame, & Menon, 2012). In contrast, the literature also abounds with evidence for the opposite idea: that math anxiety is the cause of deficits in math ability and lower math achievement. The debilitating anxiety model suggests that math anxiety hinders learning and performance because it causes stress and makes thinking difficult (Carey et al., 2016). This appears to be the case for learning math, taking tests, and even more so for math tests with time limits (Ashcraft & Moore, 2009; Foley, Herts, Borgonovi, Guerriero, Levine, & Beilock, 2017). The gender gap in math majors and related careers in science, engineering, and technology (STEM), is supported by the debilitating anxiety model. Because females experience more math anxiety than males, including that caused by stereotyped beliefs, they tend to avoid college majors and careers that are math-based (Beilock & Maloney, 2015; Beyer, 2014; Carey et al., 2016; Wang & Degol, 2017). Although both the deficit theory and debilitating anxiety model are well-supported by the literature, which is the more accurate theory remains unclear.

Another theory, however, incorporates the ideas of both the deficit theory and the debilitating anxiety model. The reciprocal theory describes the circular nature of math anxiety

(Carey et al., 2016). What makes this theory so plausible is that is explains the vicious cycle of math anxiety (Gunderson, Park, Maloney, Beilock, & Levine, 2018). Once begun, a snowball effect occurs. Math anxiety creates learning deficits and hurts performance, which makes more math anxiety. Greater math anxiety leads to even more learning deficits and lower achievement. The circular nature of math anxiety also occurs with math self-efficacy, though it is unevenly reciprocated. A lower concept of self in mathematics has been shown to have a greater impact on math anxiety rather the other way around (Ahmed, Minnaert, Kuyper, & Van der Werf, 2011). The connection between math anxiety and math self-efficacy is important because it touches on the deeper roots of math anxiety that involve beliefs and emotions rather than maintaining a focus on the effects.

The control-value theory of achievement emotions provides a framework to better understand part of the psychological underpinnings of math anxiety. The theory, put forth by Pekrun (2006), explains that emotions related to both learning and being tested on math help determine whether or not an individual believes he or she is capable of success. In other words, what an individual believes about how much control he or she has over the outcome in math is influential in that outcome. That achievement-related emotions are an important consideration in math anxiety is evident throughout the literature. What a student believes about his or her abilities and emotions related to those beliefs impacts both learning and achievement. If a student does not believe he or she is able to succeed in math, the student tends to live up to that belief (Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017; Van der Beek, Van der Ven, Kroesbergen, & Leseman, 2017). Thus, emotions are an integral part of the math anxiety phenomenon. Not only do negative and distressing emotional reactions to math anxiety affect a student's beliefs about his or her abilities, but they have also been shown to physically affect the brain.

Researchers are investigating the neurological impact of math anxiety. Magnetic resonance imaging shows that regions of the brain affected by math anxiety are also related to physical pain (Lyons & Beilock, 2012). Other studies indicate that math anxiety disrupts working memory resources "otherwise devoted to skill execution" (Shi & Liu, 2016, p. 2). The processing efficiency theory helps explain why math anxiety can make it difficult for people to do math calculations, learn new material, and perform optimally on tests. The theory, put forth by Eysenck and Calvo (1992), describes how stress and worry hinder academic performance and impairs motivation by co-opting working memory resources, especially for cognitively demanding tasks and evaluations. Other authors support the idea of the processing efficiency theory as a framework to comprehend the effects of math anxiety (Foley, Herts, Borgonovi, Guerriero, Levine, & Beilock, 2017; Miller & Bischel, 2004). A significant amount of the literature is dedicated to describing and understanding the negative impact that math anxiety exerts on working memory processes. For a wide variety of ages, math anxiety has been shown to hurt achievement because it interferes with working memory processes, especially in females (Ashcraft, Krause, & Hopko, 2007; Ganley & Vasilyeva, 2014; Passolunghi, Caviola, De Agostini, Perin, & Mammarella, 2016; Shi & Liu, 2016). More specifically, the visual-spatial portion of working memory appears to be uniquely connected to math anxiety and lower math performance and may provide insight into the gender aspect of math anxiety. Studies suggest that visual-spatial working memory skills are particularly hindered by math anxiety and because these skills tend to be less prominent in women than men, when math anxiety manifests, women are more susceptible (Ganley & Vasilyeva, 2014; Maloney, Waechter, Risko, & Fugelsang, 2012; Novak & Tassell, 2017). However, stereotypes are still a factor where working memory is concerned. Studies also suggest that working memory capacity in females is hindered by math-related stereotype threat. The threat of being judged to fit a stereotyped belief may cause females to have even more apprehension about their performance (Shapiro & Williams, 2012; Spencer, Logel, & Davies, 2016; Tine & Gotlieb, 2013). Based on these findings, interventions that address the neurological aspect of math anxiety may prove to be effective.

Some researchers, however, argue that math anxiety need not be detrimental, but can be useful to promote motivation. In a study examining math motivation and math anxiety, researchers found that for individuals who possess intrinsic math motivation, a moderate amount of math anxiety helped them better perform on computation-based math tasks (Wang, et al., 2015). However, for individuals lacking motivation for mathematics, their performances were negatively impacted by math anxiety. Thus, the attitude a student develops and maintains toward math appears to be a factor in how that individual is affected by math anxiety. This underscores the importance of changing students' and teachers' ideas of mathematics and how it is taught. However, to successfully address math anxiety, the sources of its origins must be understood.

The underlying basis for what ultimately causes math anxiety may be found in some of the earliest learning theories: classical and operant conditioning. Classical conditioning is named as the explanation by Bergin and Bergin (2018) for the involuntary response that occurs when triggered by the negative stimulus of math anxiety. Other researchers agree and consider math anxiety as a learned reaction of fear to a negative stimulus (Ashcraft, Krause, & Hopko, 2007; Pizzie & Kraemer, 2017). When confronted by a negative math stimulus, math-anxious individuals have a tendency to try to avoid the situation in one way or another. This can take the form of rushing through assignments and tests or avoiding math altogether (Lyons & Beilock, 2012; Skaalvik, 2018). Skinner's (1990) operant conditioning provides the theoretical basis for understanding how this behavior develops and persists. When a specific behavior removes the negative stimulus, the behavior is reinforced. Yet, just as these behavior-stimulus associations can be learned, they can be unlearned (Bergin & Bergin, 2018, Skinner, 1990). In the classroom, this idea is employed by adopting teaching practices and educational activities that attempt to remove or reduce negative associations with math and strive to minimize math anxiety.

The educational approach to solving the math anxiety problem is capitalizing on the shift in instructional practices from traditional, teacher-centered lectures to constructivist ideas that are student-centered (Beilock & Willingham, 2014; Greenwood, 1984; Parkay, Anctil, & Hass, 2014; Tobias, 1991). Non-traditional student-centered ideas include a wide variety of approaches that specifically target math anxiety. Parental involvement, individual tutoring, the use of computer games, and listening to classical music are some of the methods in use today (Feng, Suri, & Bell, 2014; Supekar, Iuculano, Chen, & Menon, 2015; Verkijika, & De Wet, 2015; Vukovic, Roberts, & Wright, 2013). One promising strategy that is student-centered and has a neurological component is expressive writing.

Expressive writing involves writing a description of feelings about hurtful or painful experiences (Pennebaker & Beall, 1986). Expressive writing activities have been shown to reduce general anxiety symptoms and activate working memory resources (Alparone, Pagliaro, & Rizzo, 2015; Kellogg, Mertz, & Morgan, 2010; Smyth & Pennebaker, 2008). Similar effectiveness and results have been shown when expressive writing is used for math anxiety. In studies with college students, expressive writing interventions applied prior to math tests were associated with lowered math anxiety and increased achievement (Park, Ramirez, & Beilock, 2014; Ramirez & Beilock, 2011).

Expressive writing appears to be effective in helping math anxiety because it capitalizes on the tenets of social learning theory. Social learning theory posits that self-efficacy is a key element of successful learning and influences academic success (Bandura, 2006; Villavicencio & Bernardo, 2015). Expressive writing supports self-efficacy. As students participate in expressive writing, they practice meta-cognition and self-reflection, which have been shown to improve self-efficacy (Schumann & Sibthorp, 2016; Tavil, 2014). These practices encourage students to think about their thoughts and feelings as they write, creating a measure of objectivity concerning emotions associated with a negative experience. This objectivity reduces the impact of intrusive, stressful thoughts and their associated feelings (Kellog, Mertz, & Morgan, 2010; Klein & Boals, 2001). By minimizing the influence of distracting thoughts, expressive writing tackles the cognitive aspect of math anxiety by freeing up working memory resources. In studies using expressive writing interventions, results suggest that students are able to reduce their stress, think more clearly, and perform better (Frattarolli, Thomas, & Lyubominsky, 2011; Park, Ramirez, & Beilock, 2014; Ramirez & Beilock, 2011; Shen, Yang, Zhang, & Zhang, 2018). Expressive writing appears to counteract the fear and avoidance response to the negative stimuli associated with math anxiety by encouraging habits that reduce stress, build self-efficacy, and protect cognition. Thus, expressive writing may prove to be beneficial to students as a means to overcome math anxiety.

In summary, math anxiety is a complex problem that negatively affects learning, achievement, and student perspectives of mathematics. It involves cognition, emotions, and social elements (including gender), and has implications for educators, researchers, parents, and students. Math anxiety is underscored by several theories that address its causes and effects while providing avenues for possible remedies. Research has indicated that math anxiety develops at an early age, and unless remedied, eventually drives students away from mathematics courses and fields (Passolunghi, Caviola, De Agostini, Perin, & Mammarella, 2016; Supekar, Iuculano, Chen, & Menon, 2015). However, students and educators do not have to view the condition as irreversible or inevitable; there are antidotes. Studies show expressive writing to be an effective intervention that reduces math anxiety in college and high school students (Hines, Brown, & Myran, 2016; Maloney, Sattizahn, & Beilock, 2014; Park, Ramirez, & Beilock, 2014). However, math anxiety begins at earlier grade levels. To fully address the problem of math anxiety, effective interventions should be examined for younger populations of students.

Problem Statement

The use of expressive writing as a math anxiety intervention is relatively new, and little research on the topic has been conducted. Expressive writing has been shown to be effective for reducing math anxiety in college and high school students when applied as a single writing session and once a day for three days (Hines, Brown, & Myran, 2016; Maloney, Sattizahn, & Beilock, 2014; Park, Ramirez, & Beilock, 2014). According to Suarez-Pellicioni, Nunez-Pena, & Colome (2016), research on using expressive writing as an intervention for math anxiety is needed. Travagin, Margola, & Revenson (2015) specifically call for more research that varies the duration, frequency, and application of expressive writing for use with adolescents. This is important given how research indicates that math anxiety affects students beyond their performance on tests and much earlier than college and high school. Math anxiety has been shown to cause mental and physical stress, avoidance behavior, and poor overall math performance in students of all ages, including those in kindergarten (Hirvonen, Tolvanen, Aunola, Nurmi, 2012; Passolunghi, Caviola, De Agostini, Perin, & Mammarella, 2016; Supekar, Iuculano, Chen, & Menon, 2015). Students with math anxiety tend to avoid math by rushing through or not completing assignments and homework. When this occurs in the earliest grade levels, critical concepts are often missed. The problem compounds as students encounter more complex math in middle school, high school, and college, further hurting achievement and promoting avoidance behavior (Beilock & Maloney, 2015; Hirvonen, Tolvanen, Aunole, & Nurmi, 2012). Based on the research conducted thus far, expressive writing appears to specifically address the stress and avoidance issues math anxiety causes. Because it has shown immediate benefit when used prior to tests, expressive writing may also be an answer to the calls from the literature for effective ways to treat math anxiety when it occurs (Foley, Herts, Borognovi, Guerriero, Levine, & Beilock, 2017; Ramirez, Chang, Maloney, Levine, & Beilock, 2016). Others suggest a change in how students think about mathematics (Finlayson, 2014). The more recent emphasis on science, technology, engineering, and math (STEM) in middle and high school grades has been instrumental in beginning this change by making math relevant and applicable to students' lives. The literature shows a focus on middle school students' perceptions of STEM, their self-efficacy in STEM, and strategies to promote and include STEM education (Brown, Concannon, Marx, Donaldson, & Black, 2016; English, 2017; Franz-Odendaal, Blotnicky, French, & Joy, 2016). This is an important development, especially given the contribution of math anxiety to the current shortage in students choosing STEM college majors and careers (Beilock & Maloney, 2015). In high school, there is increased pressure to achieve on high-stakes tests and take advanced courses to prepare for college. The problem is further compounded as math anxiety hinders achievement on standardized tests, such as the Scholastic Aptitude Test (SAT) (Anis, Krause, & Blum, 2016). By the time students enter college, math anxiety has had such detrimental effects that when students can choose their courses of study, it is no surprise that they avoid math.

Math anxiety may also explain the gender disparity in STEM majors and careers. Females tend to experience greater math anxiety than males and are less likely to choose a college course of study in a STEM subject (Goetz, Bieg, Ludtke, Pekrun, & Hall, 2013; Moakler and Minsun 2014). There are two potential explanations for this. The first is that math-gender stereotypes influence females from an early age and eventually cause them to seek other avenues that are not math related. Social cues that young girls pick up on from parents and teachers (especially female teachers who have math anxiety themselves) influence their ideas, attitudes, and behaviors, and eventually turn them away from math, even though girls typically outperform boys in math from elementary to just before middle school (Galdi, Cadinu, & Tomasetto, 2013; Gibbs, 2010; Mizala, Martinez, & Martinez, 2015; Tomasetto, Mirisola, Galdi, & Cadinu, 2015). The second potential explanation for the shortage of females in STEM majors and careers is a neurologically-based one. Research suggests that females do not utilize visual-spatial working memory resources to the same extent as males, and when math anxiety is present, those resources are used even less, resulting in hindered math self-efficacy and math performance (Maloney, Waechter, Risko, & Fugelsang, 2012). Gibbs (2010) notes a change in achievement and attitudes towards math that occurs in females nearing middle school. Thus, it makes sense to attempt to find ways to reduce math anxiety and support girls' participation in math before they are older. Moakler and Minsun (2014) also suggest that females should be more supported in learning mathematics beginning in middle school.

Unless useful interventions are found to address math anxiety in younger grades, efforts to promote STEM may not have the needed impact to slow down the later exodus from these very subjects in college. Passolunghi, Caviola, De Agostini, Perin, & Mammarella (2016) recognize that not enough research exists that examines math anxiety in middle school students. Much of the math anxiety research involving middle school students focuses on defining how math anxiety affects this age group of students. The literature supports the proposition that math anxiety has a direct negative impact on math achievement for middle school students and affects females to a greater extent than males (Hill, Mammarella, Devine, Caviola, Passolunghi, & Szucs, 2016). This parallels Ganley and Lubienski’s (2016) findings that middle school girls are less confident than boys in mathematics by a greater margin than they were in elementary school. Other math anxiety research with middle school students examines potential causes. While acknowledging the definite roles the environment and classroom experiences play, evidence for parental influence is also found in the literature. Wang et al. (2014) showed that in addition to external factors, genetics may significantly contribute to the development of math anxiety. Other research supports this idea. Soni & Kumari’s (2015) findings suggest a link between parents’ negative attitudes and math anxiety levels and their children’s negative attitudes and levels of math anxiety. While the existence of math anxiety in middle school students is well-supported in the literature, studies involving effective measures to combat the problem in middle school students are lacking. Further, little or no research exists investigating the use of expressive writing with middle school students to reduce math anxiety. The current study seeks to add to the body of knowledge by investigating the effectiveness of expressive writing as an intervention for math anxiety, specifically for adolescents in middle school. The problem is that the literature is lacking in research on using expressive writing to lower math anxiety in middle school students.

Purpose Statement

The purpose of this quantitative, experimental, control group study was to examine the impact of expressive writing on the math anxiety scores of male and female middle school students. The sample for the study was comprised of 40 middle school students who attend a public middle school in East Texas. The independent variable was participation in an expressive writing activity and contained two levels, participation or no participation. Expressive writing can be defined as writing for a pre-determined length of time for one or more instances about thoughts and feelings associated with a traumatic or worrying experience or situation (Smyth & Pennebaker, 2008; Travagin, Margola, & Revenson, 2015). The dependent variable was math anxiety scores. Math anxiety is defined as adverse mental and physiological responses to a mathematical situation (Beilock & Maloney, 2015; Hembree, 1990). The covariate was pre-existing math anxiety before the treatment.

Significance of the Study

This study has significance for the issue of math anxiety in education and in society. Math anxiety affects students of all ages, from early elementary through adulthood and can be severe enough to cause mental distress and activate pain networks in the brain, contributing to a widespread dislike and avoidance of mathematics (Jameson & Fusco, 2014; Lyons & Beilock, 2012; McMullan, Jones, & Lea, 2012; Ramirez, Gunderson, Levine, & Beilock, 2013; Vukovic, Kieffer, Bailey, & Harari, 2013). The mass aversion to mathematics due to math anxiety has created a dearth of professionals in math-based career fields, leading to a push for more rigorous math standards in all grade levels to prepare students to fill the void (Beilock & Maloney, 2015; Nunez-Pena, Suarez-Pellicioni, & Bono, 2013). Females especially tend to avoid math in college and careers, and the gender discrepancy in math-based domains persists. This can be explained by the greater prevalence of math anxiety in females, that comes from stereotype beliefs and cognitive factors (Franceschini, Galli, Chiesi, & Primi, 2014; Maloney, Waechter, Risko, & Fugelsang, 2012). In addition, the need for math-competent individuals continues to rise proportionally with technological advances and integration into every day society. Educators are thus tasked with finding effective methods for reducing and preventing math anxiety. This study sought to examine the effectiveness of a potential intervention for math anxiety: expressive writing. Very few studies have examined expressive writing as a means to reduce math anxiety.

This study has significance for teachers, parents, and students. Teachers need effective methods to reduce math anxiety in students. When concepts become difficult, math anxiety may present. If left unchecked, a detrimental cycle of anxiety, dislike, avoidance, and missed concepts can begin. This study adds to the body of knowledge of addressing math anxiety by examining the effectiveness of an intervention that can be applied at any point in the math anxiety cycle. Likewise, parents need tools that can assist them to help their children overcome math anxiety. Because this study applied this intervention during homework, it has importance as a useful approach for parents. The need for reliable methods of reducing math anxiety that can be applied in the classroom and at home is evident throughout the literature (Beilock & Maloney, 2015; Finlayson, 2014, Ramirez, Chang, Maloney, Levine, & Beilock, 2016; Soni & Kumari, 2017). Students also need strategies for dealing with and preventing math anxiety. The brief period of time (approximately one minute) used for the expressive writing activity intervention in this study can be easily and quickly completed prior to a math assignment or test to reduce or prevent math anxiety. When math anxiety is reduced, students learn and perform better (Brunye, Mahoney, Giles, Rapp, Taylor, & Kanarek, 2013; Chang & Beilock, 2016).

Middle school math is foundational for high school and college mathematics and addressing math anxiety during this critical time in a student's life may be beneficial for later student success. Given the importance of a solid background in mathematics, the need for studies investigating potential solutions for math anxiety in middle school students is evident. Studies have shown that expressive writing is effective for lessening math anxiety in high school students and in college students (Hines, Brown, & Myran, 2016; Park, Ramirez, & Beilock, 2014). However, there are few, if any, studies that have examined the use of expressive writing as a potential solution for math anxiety in middle school students. This study sought to help fill the gap in the literature concerning the use of expressive writing to help reduce math anxiety for middle school students.

Research Questions

RQ1: Is there a significant difference between the math anxiety scores of middle school students who participate in an expressive writing activity and those who do not participate while controlling for pre-existing math anxiety?

RQ2: Is there a significant difference between the math anxiety scores of male and female middle school students while controlling for pre-existing math anxiety?

Definitions

1. *Expressive writing* – Expressive writing is an exercise in which an individual writes for a specified period of time for one or more instances about his or her emotions and thoughts associated with a stressful experience or situation (Smyth & Pennebaker, 2008; Travagin, Margola, & Revenson, 2015).
2. *Math anxiety* – Math anxiety is a negative reaction to a mathematical situation that produces stress, worry, fear, or panic; can include biological responses such as

perspiration, rapid heartbeat, and other physical symptoms (Beilock & Maloney, 2015; Hembree, 1990).

3. *Math avoidance* – Math avoidance is a behavior that involves selecting other than math-based courses and careers due to math anxiety; can include rushing through math problems (in school or everyday life) and guessing answers in order to sidestep dealing with mathematics and mathematics problems (Maloney, Sattizahn, & Beilock, 2014; Jameson & Fusco, 2014).
4. *Metacognition* – Metacognition is defined as actively thinking about and evaluating one's thought processes as they are taking place (Martinez, 2006; Smith, 2014).
5. *Self-efficacy* – Self-efficacy is the belief in one's ability to achieve a desired goal (Bandura, 1997).
6. *Working memory* – Working memory describes the portion of the brain that stores, sorts, recalls, and utilizes information that is in active use, and the processes involved in those actions (Ma, Husain, & Bays, 2014; Oberauer, Farrell, Jarrold, & Lewandowsky, 2016).

CHAPTER TWO: LITERATURE REVIEW

Overview

Chapter two examines the underlying theories and related research for this study. A description of math anxiety and the factors that contribute to its origination, including parents and instructional methods are discussed. The issues caused by math anxiety are overviewed, along with a brief discussion of math anxiety's contribution to the lack of females in math-related fields. Attempts to address math anxiety from the literature are discussed. Math anxiety's impact on working memory and self-efficacy is also described in light of research that shows how they may be the avenues through which expressive writing has potential as an effective intervention.

Theoretical Framework

The complex construct of math anxiety includes many different facets that explain why and how it occurs and has the impact it does on individuals. Math anxiety involves thought processes, emotions, and social elements, both internal and external. To address these elements, this study is based on a theoretical framework that includes the deficit theory, the debilitating anxiety model, reciprocal theory, the control-value theory of achievement emotions, processing efficiency theory, classical and operant conditioning, and social learning theory.

Deficit Theory

The deficit theory espouses the idea that math anxiety is caused when a student performs poorly in mathematics (Carey, Hill, Devine, & Szucs, 2016). Much like Tobias' (1985) previous deficit model, Carey et al.'s (2016) deficit theory describes how deficiencies in learning and test-taking skills lead to higher anxiety and lower performance. Whether the poor performance stems from an inherent learning disability in math, a difficult concept, a missed lesson, or a bad experience in class, the same math anxiety results. The deficit theory provides a theoretical framework to understand why both typically developing students and those with learning disabilities acquire math anxiety, not just one group or the other. According to Wang et al. (2014), both genetics and surroundings, which contribute to learning difficulties, may play a role in the development of math anxiety. When a student has a math learning disability, there will be deficits in learning and subsequent negative emotions regarding math (Rubinsten & Tannock, 2010). Wu, Barth, Amin, Malcame, & Menon (2012) suggest that children with lower performance in math are more likely to develop higher levels of math anxiety. This makes sense when math anxiety is viewed through the lens of the deficit theory. The deficits in math learning, that have occurred from either a cognitive disability or lack of achievement cause math anxiety to develop (Carey et al., 2016). Poor math achievement and negative incidents involving math can cause memories of such a type to lead to math anxiety. As deficits in learning and achievement cause feelings of anxiety associated with math, and negative memories surface, the student struggles with math-related tasks, and the desire to perform on those tasks decreases (Hembree 1990; Ma & Xu, 2004). This results in poor study habits and poor test-taking skills, the roots of lower performance in students with higher levels of anxiety than their classmates, as supported by the deficit theory (Carey et al., 2016; Tobias, 1985).

The deficit theory also provides a framework to explain how math anxiety persists through childhood and is still present in adults. The issues can be traced back to deficiencies in foundational math concepts that should have been acquired in earlier years (Maloney and Beilock, 2012). The ideas of the deficit theory also provide theoretical background for why some students show a tendency to adopt negative attitudes about math from peers, teachers, and parents, adding a social learning element. Maloney, Sattizahn, & Beilock (2014) suggest that children who enter school with deficits in early mathematical reasoning are more likely to notice and acquire others' negative attitudes related to math.

The deficit theory posits that the presence of deficiencies in math learning instigates math anxiety (Carey et al., 2016). However, there is also evidence that a converse relationship exists.

The Debilitating Anxiety Model

The debilitating anxiety model proposes the reverse of the deficit theory: that math anxiety causes deficits in learning and achievement as well as poor performance (Carey et al., 2016). The model posits that when math anxiety is present, the student has difficulty acquiring new skills and understanding of concepts. It also explains why students (both with learning disabilities and typically developing) with math anxiety have trouble on assessments and tests. Students with math anxiety tend to experience negative physiological reactions, such as intense nervousness and mental blocks when presented with math tasks or tests, particularly timed ones (Ashcraft, 2002; Ashcraft & Moore, 2009; Foley, Herts, Borgonovi, Guerriero, Levine, & Beilock, 2017). The negative reactions contribute to and cause poor performance. The detrimental effects math anxiety has on student learning and achievement is well-documented throughout the literature (Hembree, 1990; Nunez-Pena, Suarez-Pellicioni, & Bono, 2013; Wu, Barth, Amin, Malcame, & Menon, 2012). Carey et al.'s (2016) debilitating anxiety model is reminiscent of earlier interference models for test anxiety which state that higher anxiety causes lower performance. The anxiety interferes with student thinking as their mental attention is diverted to handling the negative feelings (Tobias, 1985). Although test anxiety and math anxiety have been shown to be distinct conditions, they both introduce debilitating cognitive factors that hinder performance (Maloney, Sattizahn, & Beilock, 2014). Math anxiety, however, extends the hindrance to regular classroom activities and situations involving math in everyday life, for individuals of all ages. The debilitating anxiety model may help explain why, from elementary aged-students to pre-service teachers, math anxiety negatively impacts achievement and the acquisition of new math skills (Carey et al., 2016; Novak & Tassell, 2017; Ramirez, Chang, Maloney, Levine, & Beilock, 2016).

The shortage of females in math and math-based careers may be partly explained by the debilitating anxiety model. According to the debilitating anxiety model, math anxiety hinders both learning and performance (Carey et al., 2016). Math anxiety appears to be more prevalent among females than males at all levels of school (Beilock, Gunderson, Ramirez, Levine, & Smith, 2010; Goetz, Bieg, Ludtke, Pekrun, & Hall, 2013; Hembree, 1990; Hill, Mammarella, Devine, Caviola, Passolunghi, & Szucs, 2016). As female students experience math anxiety, the gap between their achievement in mathematics and male student achievement in mathematics widens. There is evidence to suggest that this phenomenon begins just prior to middle school, and by the time students reach college, the disparity between the number of males and females choosing math and math-based majors is significant (Gibbs, 2010; Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011). As math-based career fields have long been associated with males, the lack of women in these fields may have another explanation provided by the debilitating anxiety model. Carey et al. (2016) suggest that the debilitating anxiety model explains what happens when math-gender stereotypes induce anxiety that hinders math performance via stress and overtakes working memory processes. The debilitating anxiety model provides a basis to understand the end results of the female experience with math anxiety, however, it does not adequately answer why this occurs in the first place.

Although the debilitating anxiety model succinctly explains how math anxiety affects learning and performance, it does not address the underlying psychological and physiological reactions that occur when math anxiety manifests (Artemenko, Daroczy, & Nuerk, 2015; Lyons & Beilock, 2012). Both the deficit theory and the debilitating anxiety model are well-supported in the literature, yet they contradict one another. Another theory exists, however, that encompasses the ideas of both the deficit theory and the debilitating anxiety model: the reciprocal theory (Carey et al., 2016).

The Reciprocal Theory

Carey et al.'s (2016) reciprocal theory suggests that both learning deficits and math anxiety influence one another, creating a vicious cycle of math anxiety and impediments to learning and achievement. The relationship between math anxiety, learning, and performance appears to have a circular nature (Ashcraft, Krause, & Hopko, 2007; Foley, Herts, Borgonovi, Guerriero, Levine, & Beilock, 2017; Haciomeroglu, 2017). Once the cycle begins, math anxiety hinders learning and achievement, which, in turn, creates more anxiety about math, which can introduce self-defeating behaviors and attitudes that further exacerbate the problem. The reciprocal theory provides a framework to understand that once math anxiety begins, it reinforces itself and can be difficult to overcome. This helps clarify that why, after more than 60 years of research, it is still an issue (Ashcraft, 2002; Betz, 1978; Gunderson, Park, Maloney, Beilock, & Levine, 2018; Hembree, 1990). However, as with the deficit theory and the debilitating anxiety model, the underlying elements that create conditions favorable for math anxiety to develop in an individual are not fully addressed by the reciprocal theory. Other findings indicate a reciprocal relationship between math anxiety and math self-concept and offer a hint that an underlying belief may have some influence. Ahmed, Minnaert, Kuyper, & Van der Werf (2011) describe this relationship and note that it is not balanced; low math self-concept exerts a stronger influence on creating math anxiety, than the reverse. This makes the inclusion of theories that help explain emotions, behaviors, and beliefs about self as a result of math anxiety relevant.

The Control-Value Theory of Achievement Emotions

The notion that math self-concept plays a critical role in the development and perpetuation of math anxiety is supported by Pekrun's Control-Value Theory of Achievement Emotions (2006). The theory distinguishes two types of achievement emotions: those that pertain to current achievement, such as learning activities, and emotions that pertain to outcomes, such as assessments and evaluations (Pekrun, 2006). According to Pekrun (2006), these emotions relate to how much control an individual believes he or she has over success or failure in a subject, similar to the ideas in Bandura's (1997) self-efficacy and Skinner's (1990) locus of control. It is almost as if the way an individual regards his or her own potential and abilities in math becomes a self-fulfilling prophecy. In both elementary and middle school-aged students, self-efficacy, along with self-regulation that incorporates metacognition and other problem-solving strategies have been shown to mitigate the impact of math anxiety (Jain & Dowson, 2009; Kramarski, Weisse, & Kololshi-Minsker, 2010). Van der Beek, Van der Ven, Kroesbergen, & Leseman (2017) also found that self-concept has a significant effect on emotions and achievement and offer support for the Control Value Theory of Achievement Emotions.

Another important consideration is that there are gender differences in the amount of attention given to regulating emotions during difficult mathematical experiences. This may help explain the greater prevalence of math anxiety in female students, or at least provide evidence that females are more acutely aware of their emotions, and thus their math anxiety, than are males. When faced with challenging math situations in the classroom, girls tend to focus more than boys on regulating their emotions as they attempt to solve problems, whereas boys tend to focus more on the problem at hand (De Corte, Depaepe, Eynde, & Verschaffel, 2011). The emotional aspect of learning would then appear to be an integral factor in understanding and addressing math anxiety. Pekrun's (2006) theory posits that achievement emotions play a powerful role in determining success or failure. This appears to hold valid for the relationship between math anxiety, math self-efficacy, and math achievement. As a student's math self-efficacy improves, emotions and brain processes regulated, and measures of success are achieved, the detrimental effects of math anxiety lessen (Henschel & Roick, 2017; Hoffman & Spatariu, 2008; Jansen, Louwerse, Straatemeier, Ven der Ven, Klinkenberg, & Van der Mass, 2013). Pekrun's theory provides a framework to understand how math anxiety, emotions, self-efficacy, and math achievement relate to one another.

Processing Efficiency Theory

Interestingly, self-efficacy alone cannot prevent math anxiety. There is also evidence to suggest that working memory is part of the equation of how math anxiety hinders student learning and performance. Hoffman (2010) found that as math problems increase in complexity, self-efficacy diminishes, working memory is encumbered, math anxiety increases, and performance declines. The negative impact of math anxiety may be more pronounced for those who rely heavily on working memory to solve problems. Ramirez, Chang, Maloney, Levine, & Beilock (2015) found that children with greater working memory capacity are hindered more than those with lower working memory capacity when experiencing math anxiety. However, this may be mitigated when there is a strong math self-efficacy present. Math self-concept has also been shown to work in conjunction with working memory to help reduce the negative effects of math anxiety on performance, bringing in the ideas of the processing efficiency theory (Justicia-Galiano, Martin-Puga, Linares, & Pelegrina, 2017).

When a task that requires concentration is being performed and anxiety is present, working memory capabilities are reduced and more effort than otherwise is required to complete the task. This is the premise of the processing efficiency theory (Eysenck & Calvo, 1992). The theory addresses the impact that anxiety has on achievement. By distracting available working memory resources, math anxiety decreases the processing of information, resulting in impaired performance and efficiency. That there is a relation between working memory, math anxiety, and performance is evidenced in the literature. Foley, Herts, Borgonovi, Guerriero, Levine, & Beilock (2017) suggest that the processing efficiency theory can explain the impact of math anxiety on cognitive processes. Math anxiety has been demonstrated to inhibit the use of working memory for math tasks, resulting in lower performance (Passalunghi, Caviola, De Agostini, Perin, & Mammarella, 2016; Shi & Liu, 2016). Working memory may also be a strong component for the gender differences in math anxiety. Ganley and Vasilyeva (2014) found that math anxiety negatively impacted working memory capability in females more than males, resulting in lower test scores in females. Evidence also suggests that the more difficult the test, the greater the disparity in performance between genders, likely due to the distracted working memory capacity (particularly visual-spatial processing) in females caused by math anxiety (Ganley & Vasilyeva, 2014; Gibbs, 2010; Maloney, Waechter, Risko, & Fugelsang, 2012). Miller and Bichsel (2004) demonstrated similar findings and offer further support for the Processing Efficiency Theory. The visual-spatial type of working memory processes appear to have strong correlations with math anxiety. Research demonstrates that those with low visual-spatial abilities were more at risk of developing math anxiety, and that high visual-spatial ability countered math anxiety (Ashkenazi & Denan, 2017; Maloney, et al., 2012). This may explain why, that when working memory is improved or activated prior to activities or tests, the negative effects of the anxiety decrease. Findings suggest that working memory training can be effective in reducing anxiety as a trait and on tests (Hadwin & Richards, 2016).

The processing efficiency theory provides a framework to understand how brain mechanisms respond to math anxiety; namely, that math anxiety distracts working memory resources, causing reasoning abilities to be hampered and rendered less accurate. While the theory addresses the brain-function aspect, it does not address why the emotions involved so strongly impact thought processes.

Classical and Operant Conditioning

Perhaps the explanation lies in how math anxiety has been likened to a conditioned fear response to a negative stimulus (Pizzie & Kraemer, 2017). Ashcraft, Krause, & Hopko (2007) characterize math anxiety as “a stimulus- and situation-specific learned fear” (p. 330). This may provide clarity to understand why math anxiety causes such a strong aversion to math in some individuals. Pain and fear centers in the brain are activated by math anxiety and induce avoidance behavior (Bement, Weyer, Keller, Harkins, & Hunter, 2010; Finlayson, 2014; Lyons & Beilock, 2012). Such responses are not surprising when math anxiety is viewed through the lenses of classical and operant conditioning. Classical conditioning describes how a response, such as fear, becomes associated with a stimulus (Bergin & Bergin, 2018; Lazarus, Davison, & Polefka, 1965; Watson & Rayner, 1920). Bergin and Bergin (2018) portray math anxiety as a result of classical conditioning in which negative emotions (caused by a bad experience) become associated with math and are automatically aroused by simply looking at a math problem. As students with math anxiety experience fear, pain, and other unpleasant physiological and emotional responses, their behavior changes. Skinner’s ideas on operant conditioning explain this. He argues that certain behaviors are adopted when reinforced (Miller, 2016; Skinner, 1990). For example, students with math anxiety tend to avoid math when possible (Finlayson, 2014). When math is avoided, the negative feelings are reduced or removed, and the avoidance behavior is reinforced. By removing a negative stimulus, the likelihood of the behavior that caused the removal is increased (Bergin & Bergin, 2018). On the other hand, these same ideas can be used to stop or change a behavior. The idea of extinction posits that removing the reinforcement can also remove the behavior (Bergin & Bergin, 2018, Skinner, 1990). Many interventions for math anxiety attempt to reduce or remove the negative feelings associated with math to encourage participation and perseverance in students.

Of equal importance, the underlying causes of negative feelings and attitudes towards math must also be addressed. Behavior theorists explain these causes by connecting the reinforcement of behaviors to imitation. Children who observe certain behaviors as they are reinforced (positively or negatively) are said to tend to adopt the positive models (Miller, 2016). The idea that children observe, learn from, and imitate those around them is encompassed by social learning theory.

Social Learning Theory

Social learning theory, rooted in classical learning theory (classical and operant conditioning), posits that children learn through observation and interaction with peers, parents, teachers, and others (Miller, 2016). Bandura (2006) put forth the idea that children regulate their behaviors to match those of parents, peers, and others whose approval they desire and wish to emulate as a natural means of self-preservation. Learning through observation and imitation as supported by social learning theory may explain why parents and teachers can transmit math anxiety to their children and students. When parents exhibit negative attitudes towards, or make negative comments concerning mathematics, their children observe and adopt those practices.

Soni & Kumari (2015) found that math anxiety in parents was an influential factor in the development of math anxiety in their children. When parents display avoidance behaviors towards math situations that involve their children, this sends a subtle, yet impactful negative message. However, Soni & Kumari (2015) also found that parents who display positive attitudes toward math and promote math learning and discussion at home can foster a similar attitude toward math in their children that helps prevent math anxiety. Social learning theory describes how parents can teach either negative or positive behaviors and dispositions, which can have far-reaching implications.

Social learning theory also explains how teachers have a similar impact as parents on their students' development of math anxiety. Teachers with math anxiety may unwittingly pass the problem on to students. Math-anxious teachers who are uncomfortable with the subject and tend to evidence avoidance behaviors influence their students to adopt similar attitudes and actions (Chernoff & Stone, 2014). This is particularly notable in female elementary teachers and their female students. Gunderson, Ramirez, Levine, & Beilock (2012) suggest that girls may associate the idea that females are less successful in math when they observe their female teachers with math anxiety and then adopt that belief regarding their own abilities.

Social learning theory also provides an explanation of how math anxiety causes lower levels of self-efficacy in mathematics, especially in girls. Self-efficacy, a component of social learning theory, is the belief in one's ability to achieve a desired goal (Bandura, 1997; Miller, 2016). In the classroom, when teachers unwittingly exhibit math-anxious behaviors, students perceive these cues. Underlying negative attitudes towards mathematics, which stem from teachers' own unresolved math anxiety, carry over into and affect the quality of lessons and instruction. A math-anxious teacher with low math self-efficacy is less likely to be willing to answer difficult questions posed by students, or may evidence anger in the response, because the teacher may question his or her own abilities in mathematics (Holzberger, Philipp, & Kunter, 2013; Jackson & Leffingwell, 1999; Ramirez, Hooper, Kersting, Ferguson, & Yeager, 2018).

Mathematics teaching style is also influenced by a teacher's math self-efficacy. A confident teacher is more likely to engage students in thoughtful discussion whereas one who is less confident may avoid class discussions and stick to traditional instruction, such as simply copying problems and applying formulas (Ramirez, Hooper, Kersting, Ferguson, & Yeager, 2018). This is particularly true for math-anxious teachers. Chernoff & Stone (2014) suggest that teachers who have math anxiety gravitate toward teaching practices that are more focused on drill practice and memorization, and these practices contribute to students acquiring math anxiety. By continuing practices of listen, watch, and repeat, teachers initiate or continue the cycle of math anxiety by not allowing room for in-depth discussion of concepts and the principles behind them. Such instructional methods contribute to lower math achievement, lower math self-efficacy, and a negative attitude toward math in students. Ramirez, Hooper, Kersting, Ferguson, & Yeager (2018) found that teachers with math anxiety exhibit behaviors and instructional practices that unwittingly communicate their negative attitudes toward math to students, and learning is negatively impacted. In other words, when students realize their teachers dislike math, they learn to dislike it and their achievement suffers.

Social learning theory also helps explain how stereotype beliefs concerning girls and math are perpetuated. Stereotype ideas are learned from social interactions and observations (Miller, 2016). Through attitudes and behaviors, influential figures in an individual's life may demonstrate beliefs and ideas that the individual adopts as his or her own. Teachers and parents can inadvertently contribute to the math and gender stereotype issue. This is evidenced in a study that showed that pre-service elementary teachers tend to have lower expectations for the mathematics achievement of female students than for male students (Mizala, Martinez, & Martinez, 2015). Findings by Tomasetto, Mirisola, Galdi, & Cadinu (2015) suggest a significant relationship between mothers' stereotype beliefs regarding girls and math and the math self-efficacy of their daughters. Other findings indicate that even before girls have a clear understanding of math-gender stereotypes, they make associations that align with them, demonstrating learned behaviors (Galdi, Cadinu, & Tomasetto, 2013). When math-gender stereotype ideas are adopted, both math performance and math self-efficacy can suffer, particularly when under stereotype threat. Stereotype threat describes the apprehension an individual may feel about others' perceptions and mistreatment of himself or herself based on a stereotype (Spencer, Logel, & Davies, 2016). Women, in particular, can be susceptible to stereotype threat in math. Franceshcini, Galli, Chiesi, & Primi (2014) demonstrated that, for females who accept the math-gender stereotype, math self-efficacy is lowered when under stereotype threat and uplifted when the threat is removed. The powerful influence that stereotype threat has is unmistakable. Stereotype threat that is related to math has also been shown to hinder working memory capabilities more in females than males and plays a pivotal role in the gender gap in STEM fields (Schmader & Johns, 2003; Shapiro & Williams, 2012; Tine & Gotlieb, 2013).

Social learning theory offers a basis for understanding how self-efficacy and stereotype underscore the math anxiety problem. Yet within the problem there may reside a solution. Self-efficacy (from social learning theory), in conjunction with the processing efficiency theory (that explains working memory processes as impacted by math anxiety), also provide a theoretical framework for the proposed math anxiety intervention in this study. Expressive writing is an opposing force to math anxiety because it increases what math anxiety decreases: self-efficacy and processing efficiency (working memory capacity) (Huang & Mayer, 2016; Kirk, Schutte, & Hine, 2011; Klein & Boals, 2001; Schroder, Moran, & Moser, 2017). When an individual engages in expressive writing, self-reflection and metacognition occur as the individual writes about anxious, stressful, or hurtful feelings and emotions related to an experience or situation. The placement of feelings on paper provides the individual a more objective viewpoint that helps reduce the effects of the negative emotions that typically arise from a hurtful experience (Kellog, Mertz, & Morgan, 2010; Klein & Boals, 2001; Park, Ayduk, & Kross, 2016). Because expressive writing helps mitigate such adverse emotions, it may prove to be effective. Much like a positive stimulus that can reduce the effects of a negative one, expressive writing can free up otherwise challenged working memory resources (Miller, 2016; Park, Ramirez, Beilock, 2014). In this study, expressive writing was used to attempt to lessen the strength of the negative stimuli caused by math anxiety. The nature of expressive writing that promotes metacognition and addresses emotional influences on learning may prove to be an important factor for math anxiety due to its positive impact on both self-efficacy and working memory.

Related Literature

A Description of Math Anxiety

Math anxiety is a debilitating condition that affects students and adults of all ages. The symptoms it elicits in sufferers are both physical and mental. The physical effects of math anxiety include, but are not limited to nervousness, shaking, rapid heartbeat, breathing irregularities, and sweating (Finlayson, 2014). Mental effects range from stress to mental confusion to panic. While these symptoms may seem innocuous and fleeting, they can have a profound effect on an individual. The feelings of confusion, hopelessness and frustration are more than just the result of being stuck on a math problem. Math anxiety can affect regions of the brain associated with fear and pain (Artemenko, C., Daroczy, G., & Nuerk, 2015; Lyons & Beilock, 2012). These effects help explain why students who suffer from math anxiety tend to avoid math, related subjects, activities, and career fields. What is striking, however, is that math anxiety is not indicative of true math ability. The literature shows that math anxiety can be severe enough to hurt achievement even in those who are good at math (Ashcraft & Moore, 2009; Foley, Herts, Borgonovi, Guerriero, Levine, & Beilock, 2017).

Math anxiety in elementary grades. Math anxiety can manifest in children in the primary grades and if left untreated, the problem can compound over time. Studies have shown elevated levels of stress-related cortisol in six- and seven-year old children after being told they were about to work with numbers (McQuarrie, Siegel, Perry, & Weinberg, 2014). Older elementary students registered brain activity in regions connected to negative emotions as they completed simple arithmetic (Foley et al., 2017). Students at these ages may not be able to verbally explain what they are experiencing; however, their actions and behaviors are characteristic of math anxiety. Often, the tell-tale signs of math anxiety in younger students involve avoiding math tasks and showing a dislike of math in general. These actions and behaviors create a detrimental effect on learning, which, in turn, causes students to dislike math more and increase their math anxiety. As this occurs, task-avoidance behavior increases, and math performance suffers. This leads to even more avoidance behavior, which further decreases learning and achievement. Hirvonen, Tolvanen, Aunola, & Nurmi (2012) found that when math task-avoidance behavior begins, learning is impaired in the present, future improvements are harder to make, and avoidance behavior increases with time. For early elementary students, it remains unclear which occurs first, the math anxiety or poorer performance. What is evidenced, however, is that math anxiety in elementary students is directly correlated to lower math achievement (Suárez-Pellicioni, Núñez-Peña, & Colomé, 2016).

Math anxiety in middle school and high school. The negative impact on performance due to math anxiety is also evident in middle and high school students. Math anxiety negatively affects success on class assignments and test performance, particularly when there is an emphasis on college readiness and increased pressure for achievement (Hill, Mammarella, Devine, Caviola, Passolunghi, & Szucs, 2016). However, the inverse of this relationship is also supported in the literature. Students who experience less math anxiety show better achievement on assignments and tests (Foley et al., 2017). It would follow that if math anxiety can be reduced, math achievement would improve. Some argue, however, that math anxiety is not necessarily a detrimental factor, but can be a motivating factor in math achievement. Wang et al. (2015) found that, for individuals with higher intrinsic math motivation, a small amount of math anxiety boosted performance. This may be related to how these individuals view mathematics. Viewing a math problem as a challenge to be met, rather than an insurmountable obstacle can help prevent math anxiety from hindering performance. Maloney, Sattizahn, & Beilock (2014) suggest that an intentional change in perspective as part of a set of problem-solving strategies is an effective way to regulate negative emotions when faced with a math anxiety-inducing problem.

Math anxiety in college. The most prominent result of math anxiety's impact, however, is seen in college students. The culmination of years of compounding math anxiety for many individuals has led to massive math avoidance. Once students have entered college and are able to choose their areas of study, they are not choosing mathematics or related subjects. The result is a significant lack of professionals in science, technology, engineering, and math (STEM) fields, such that Beilock & Maloney (2015) call it a "STEM crisis" and suggest math anxiety is to blame (p. 5). It is estimated that as many as four out of five students in community college and one out of four students in four-year programs suffer from math anxiety (Beilock & Willingham, 2014). This is especially true for females. Even when women obtain a degree in math or math-related field, they tend to not work in those fields. Research shows that they are more inclined to work in the health industry or pursue teaching (Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011).

Math anxiety in females. Females have been shown to experience greater amounts of math anxiety than males (Hill, Mammarella, Devine, Caviola, Passolunghi, & Szucs, 2016). However, the impact on math achievement does not begin to manifest until late elementary to middle school. Girls have been shown to perform better in math than boys in early childhood until approximately the fifth grade, when foundational learning for later STEM skills begin (Gibbs, 2010). As students progress to high school and college, and math becomes more complex, the adverse effects of math anxiety become more pronounced. Not only do females continue to exhibit and experience greater math anxiety than males, but they begin to turn away from math and math-related college and career aspirations (Hill, Mammarella, Devine, Caviola, Passolunghi, & Szucs, 2016). In spite of the fact that women account for nearly 50% of the workforce, they represent less than one-fourth of those who work in STEM fields (Beede et al., 2011). One important career path, however, is that of the elementary education teacher. Statistical data from 2015 shows that almost 90% of elementary teachers are female (United Nations Educational, Scientific, and Cultural Organization Institute for Statistics). This is critical information because of the impact female elementary teachers with math anxiety have on their students. The literature indicates that math anxiety can be passed from teacher to student, and that this is particularly true for female students of female elementary teachers (Beilock, Gunderson, Ramirez, Levine, & Smith, 2010). One plausible explanation is that gender stereotypes play a role in this situation.

From an early age, female students adopt stereotypical beliefs and attitudes (oftentimes from teachers and parents) that math is a subject meant more for males (Galdi, Cadinu, & Tomasetto, 2013; Mizala, Martinez, & Martinez, 2015; Tomasetto, Mirisola, Galdi, & Cadinu, 2015). This idea appears to persist in females throughout adolescence and at older ages regardless of math ability and achievement. The literature gives credence to the idea that math self-efficacy in adolescent females is negatively impacted by the math-gender stereotype even when math performance is equitable for males and females (Ganley & Lubienski, 2016; Goetz, Bieg, Ludtke, Pekrun, & Hall, 2013; Passolunghi, Ferreira, & Tomasetto, 2014; Shapiro & Williams, 2012). This suggests that perceived gender stereotypes in math and low math self-efficacy may be reinforcing one another, at least in younger females. Finnigan and Corker (2016) found that stereotype threat is not as detrimental on adult women's math performance as previously thought. These findings contrast other research showing the negative relation between math stereotype threat and women's attitudes towards math and math-related careers (Good, Rattan, Dweck, 2012; Pennington & Heim, 2016). The literature indicates that math anxiety, as result of stereotype threat, plays an influential role in females preferring professions with little or no relation to mathematics.

Causes of Math Anxiety

Attempting to solve the problem of the gender gap in STEM fields as well as the overall lack of STEM professionals by the time a student is in college may be too late. From the earliest research on math anxiety through that of today, math anxiety research subjects have been predominantly college students. However, the problem likely initiated long before the student entered college. The literature shows that math anxiety is evidenced in all ages of students and manifests as early as first grade (Harari, Vukovic, & Bailey, 2016). What is needed is an understanding of what causes math anxiety to begin and practical strategies to prevent, reduce, and remove the factors that contribute to math anxiety's effects.

Math anxiety has a dual nature; its mechanisms are both internal and external. Both cognitive and social factors work in conjunction to cause and perpetuate the problem. Genetic pre-disposition, whether as an actual math-learning disability, a weakness in spatial reasoning, or a tendency to worry is believed to contribute, along with parental and teacher influences and stereotypes (Eden, Heine, & Jacobs, 2013; Finlayson, 2014; Maloney, Waechter, Risko, & Fugelsang, 2012). It is often difficult to pinpoint a single event or issue that initiates math anxiety. What is achievable, however, is recognizing and understanding how so many elements come together to produce a problem that once begun, will compound unless specifically addressed.

The classroom. However the initial problem begins, the nature of learning mathematics may be a contributing factor to math anxiety. Each subsequent concept builds upon previous ones, requiring students to draw on and apply prior knowledge (Geary, Berch, Ochsendorf, & Koepke, 2017). Students, at any age, who miss a concept, may be at risk of falling behind in mathematics and developing math anxiety. This is supported by the Deficit Theory (Carey, et al., 2016). Once a student is lacking a critical component to understanding mathematics, later topics that require that component are naturally more difficult. If the foundational material is not gained by the student, the deficit in learning can cause the math anxiety cycle to begin. As the issue compounds, negative feelings increase and lead to struggle, more dislike of math, and avoidance behaviors, which intensify the problem. Both the Debilitating Anxiety Model and the Reciprocal Theory explain this phenomenon (Carey et al., 2016; Haciomeroglu, 2017; Nunez-Pena, Suarez-Pellicioni, & Bono, 2013).

The effect of more difficult math content as a contributor to math anxiety is also worth consideration. It would make sense that as the level of complexity of math problems increases, math anxiety also increases. Findings by Ashcraft, Krause, and Hopko (2007) indicate this is the case. When students begin to reach middle school age and more abstract mathematics concepts are introduced, the issue can compound as tasks and problems become more challenging and build upon previous learning. At this age, the effects of math anxiety begin to more profoundly affect female students' performance and math self-efficacy (Gibbs, 2010). With timed tests, the obstacles become even greater. Individuals with math anxiety also tend to require longer periods of time to solve problems and perform calculations and make more mistakes when doing so (Ashcraft & Faust, 1994). Added pressure from timed tests or the stigma of being the last one to finish adds even more potential for math anxiety. Research indicates that timed tests can cause math anxiety (Boaler, 2014). Testing of math concepts appears to also affect students according to gender. Taylor and Fraser (2013) found that high school girls experienced more math anxiety associated with testing than boys, however, boys experienced more math anxiety than girls when learning math concepts. Their research also indicated that classroom environmental factors including time for tasks and student interactions play an important role in affecting math anxiety (Taylor et al., 2013). Other research makes the case that when the quality of the learning environment decreases, negative attitudes towards math and math anxiety increases (Deieso & Fraser, 2018). This suggests the role of teachers' classroom management and instructional practices is an integral part of the math anxiety equation.

Parents. Math anxiety is not just acquired in the classroom, however. Adults who never resolved math anxiety issues carry them throughout their lives. This is due, at least in part, to how math is an integral part of everyday life. Adults with math anxiety have difficulty calculating change, tips, dosages for medication, and estimating taxes (Beilock & Maloney, 2015). When these adults have children, the dislike of mathematics is observed and acquired. As children bring home math homework and parents make derogatory statements regarding math or have difficulties in helping, children observe and adopt these attitudes and behaviors. The literature shows that when parents have math anxiety and exhibit a negative attitude toward math, children are more likely to acquire math anxiety and have a similar disposition towards the subject (Soni & Kumari, 2015). It is also interesting to note that when math-anxious parents try to help their children with their homework, the effect is worse than if they had not helped at all (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). The learned response and behaviors children adopt from observing their parents, if left unchecked, can continue into adulthood, and impact their academics, careers, and everyday lives. Math anxiety in parents has been evidenced to lead to math anxiety in their children, as well as a greater dislike of math and lower math performance (Casad, Hale, & Wachs, 2015). This has implications for adulthood. Many adult learners with math anxiety exhibit low math self-efficacy that can be traced to a learning deficit from previous years (Jameson & Fusco, 2014). Math-gender stereotypes that contribute to math anxiety can also be learned from parents. This is most pronounced in mother-daughter relationships. When mothers have stereotyped beliefs regarding girls' math ability, daughters tend to assume those same ideals, which is related to the development of math anxiety (Casad, et al., 2015; Tomasetto, Mirisola, Galdi, & Cadinu, 2015). On the other hand, parents can also contribute to their children's success. Parents who promote math at home and exhibit a positive attitude for it can prevent math anxiety from developing. Studies show that children of parents who engage in math discussions at home have less math anxiety (Soni & Kumari, 2015).

Teachers. Not only do parents have an influential role in the development of math anxiety in their children, but teachers do as well. What is disconcerting is that it has long been known that many elementary teachers do not like math, have low self-efficacy in math, and that it impacts their students (Stent, 1977). The problem has still not been solved. Research indicates that teachers in a variety of grade levels are continuing to bring their own math anxiety from their years as students into the modern classroom. These teachers often have limited comprehension of math, due to math anxiety caused by their previous teachers, and they themselves exhibit similar negative attitudes and avoidance behaviors (Bekdemir, 2010; Finlayson, 2014; Macpherson, 2016; Wilson, 2013). However, this issue seems to be particularly true for female elementary teachers and their female students (Chernoff & Stone, 2014). This warrants further investigation considering that elementary teachers are predominantly female (Goldring, Gray, & Bitterman, 2013; United Nations Educational, Scientific, and Cultural Organization Institute for Statistics). For these teachers of younger students, the prevalence of math anxiety is somewhat alarming. Elementary teachers are the ones who introduce thinking patterns and foundational math concepts to students. The potential for math anxiety to develop in the new generation of students is of concern. When teachers lack confidence in their own math abilities, their teaching styles are less flexible, quality of instruction suffers, and student learning is hindered (Holzberger, Phillipp, & Kunter, 2013; Ramirez, Hooper, Kersting, Ferguson, & Yaeger, 2018). A teacher who feels confident in mathematics and in teaching it will be more likely to field questions from students, discuss problems in more detail, and offer more problem-based learning. A less confident teacher who has math anxiety and low math self-efficacy will not be as comfortable in answering questions or discussing math concepts in depth. It is easier for this teacher to lecture, demonstrate, and drill students, and adhere to a more traditional method of teaching (Gresham, 2009; Jackson & Leffingwell, 1999; Ramirez et al., 2018; Wilkins, 2008). This suggests that students of math-anxious teachers are at risk of being left with memorization without much understanding.

Teaching methods. In fact, it is the traditional method of teaching that has long been known to be a major contributor to students developing math anxiety (Greenwood, 1984). Almost as soon as math anxiety became a topic of interest and cause for concern, the traditional lecture style of teaching mathematics was identified as an influential factor (Tulock, 1957). Traditional methods emphasize memorization over understanding and repetitive practice over application. Timed drills, a major component of traditional teaching methods, has been shown to increase math anxiety (Boaler, 2014). With the increase in technology over the last few decades, the need for mathematically capable professionals has grown. This need has caused a renewed focus on teaching and learning math that has challenged traditional schools of thought. However, the new direction in philosophy of teaching mathematics from traditionalist to constructivist has been long in coming. Transformations in educational practices in mathematics from teacher-centered lectures to student-centered instruction have taken even longer to become standard. This is an important change in teaching methods, because teachers who do not have math anxiety can still cause it in their students. When teachers rush through lessons or do not provide adequate explanations, students are left frustrated and anxious (Macpherson, 2016). Much of the struggle students encounter in math is the lack of understanding that occurs when the focus is on memorization over comprehension. Therefore, the current emphasis on student-centered constructivist teaching methods is timely and welcomed.

Addressing Math Anxiety

Constructivist ideas. Although student-centered instruction is a major shift in educational philosophy and practices, it is a needed one. Student-centered instruction considers the whole child. The emphasis on the emotional aspect of learning is important, particularly where math anxiety is concerned. Constructivist student-centered instruction focuses more on processes and problem-solving in relevant applications rather than a timed worksheet, one of the major instigators of math anxiety (Boaler, 2014). Other research supports this idea. Nunez-Pena, Bono, & Suarez-Pellicioni (2015) suggest that simply removing the time element from a math test helps reduce math anxiety. Taking a problem-solving approach that offers multiple entry points to a problem can also relieve math anxiety. A problem-solving approach focuses on solution strategies and removes the pressure of right or wrong answers. Relevant application provides a familiar context for students that piques interest and increases engagement in learning, preventing important concepts from being missed, while helping to prevent or reduce math anxiety. Chernoff & Stone (2014) suggest that offering freedom to choose how to solve a problem and demonstrate learning can help reduce math anxiety for students. Creating these types of problems for students takes more time and effort for teachers, however, these are the very type of problems that constructivism promotes and are believed to be most preventive of math anxiety.

Brain-based learning. Constructivist student-centered learning also incorporates brain-based learning. Brain-based learning is significant for math anxiety issues because it incorporates and addresses the emotional side of learning. The idea behind brain-based learning is that if students' minds are engaged, and their senses and emotions are involved, lessons are more impactful (Shaugnessy, 2016). If those emotions involve math anxiety, then the impact could be detrimental. Guarding against math anxiety-causing teaching practices is essential for brain-based learning. Innovative student-centered methods that follow such ideas have seen measures of success in reducing math anxiety. Including manipulatives as aids for elementary students performing arithmetic helps preclude math anxiety and improve performance (Allen & Vallee-Tourangeau, 2016). Using computer games for math practice, playing classical music, and individual cognitive tutoring have shown reduced math anxiety in students of all ages (Mavridis & Tsiatsos, 2017; Feng, Suri, & Bell, 2014; Supekar, Iuculano, Chen, & Menon, 2015). However, most of these methods are not sustainable on a daily basis. A change in how students perceive mathematics may be what is needed.

Mindset. Transforming the perception of math from threatening to challenging can help students overcome math anxiety. This change in mindset concerning math has been shown to enable students to experience less math anxiety and perform at higher levels (Maloney, Sattizahn, & Beilock, 2014). Constructivist teaching strategies that emphasize problem-solving can also relieve pressure and math anxiety for students. When students learn and use a variety of problem-solving techniques, they show greater achievement on math tasks and exhibit lower levels of math anxiety (Ramirez, Chang, Maloney, Levine, & Beilock, 2016). As students begin to achieve success, their perceptions of math can improve as well as their math self-efficacy. These factors play an important role in overcoming math anxiety.

Math Anxiety and Math Self-Efficacy

Self-concept in math plays a defining role in math anxiety. When a student has a negative belief about his or her abilities to succeed in math, math anxiety increases and performance in math suffers. Jameson (2014) found math self-concept and math self-efficacy were the most influential factors in a child developing math anxiety. Students who do not view themselves as math-capable or consider math as relative to their lives will naturally not be as engaged in class. They will be less likely to perform to their potential, giving rise to a greater chance of math anxiety developing. Research indicates that the less an individual recognizes math as relative to his or her identity, the higher the measure of math anxiety, and the more that math was recognized as part of an individual's identity, the lower the measure of math anxiety (Necka, Sokolowski, and Lyons, 2015). Math self-efficacy alone, however, is not enough to fully counteract the effects of math anxiety. The neurological impact math anxiety exerts is significant and must be addressed.

Math Anxiety and Working Memory

In addition to activating fear and pain centers in the brain, math anxiety inhibits important thinking processes. Because students experiencing math anxiety become preoccupied with associated negative emotions and thoughts, certain brain functions that would typically be used to solve math problems are unavailable. Math anxiety essentially hijacks these functions, known as working memory (Shi & Liu, 2016). Working memory includes cognitive functions that allow for active retention and processing of information (Wilhelm, Hildebrandt, & Oberauer, 2013). These processes are particularly necessary in order to manipulate numbers to perform arithmetic calculation (Klados, Simos, Micheloyannis, Margulies, & Bamidis, 2015). The necessity of working memory resources may be particularly significant for elementary and middle school students whose mathematical tasks are primarily arithmetic in nature. When these cognitive functions are impeded by math anxiety, foundational concepts may be missed. Research indicates that math anxiety significantly hampers working memory processes, and can cause students to fall behind in learning, particularly those who have high working memory capacity (Foley, et al, 2017; Mattarella-Micke, Mateo, Kozak, Foster, & Beilock, 2011;

Moustafa, Tindle, Ansari, Doyle, Hewedi, & Eissa, 2017). Thus, math anxiety may have a direct negative impact on math achievement through working memory. More specifically, the visual-spatial processes in working memory have come into focus as critical for mathematical thinking and problem solving. Studies show a negative correlation between visual-spatial working memory and math anxiety and a positive relationship with math ability for learning and achievement (Ashkenazi & Denan, 2017; Lambert & Spinath, 2018; Szucs, Devine, Soltesz, Nobes, & Gabriel, 2014).

Interestingly, visual-spatial working memory may also explain the differences in math anxiety among males and females. Maloney, Waechter, Risko, & Fugelsang (2012) suggest that stereotype alone cannot account for the greater amount of math anxiety in females over males. They suggest that women are more math-anxious than men because they are not as adept at visual-spatial thinking (Maloney, Waechter, Risko, & Fugelsang, 2012). They are not the only ones to suggest this idea. Ganley & Vasilyeva (2014) found similar results. Their research provides evidence of a significant relationship between math anxiety, reduced visual-spatial working memory processes in females, and poorer performance (Ganley & Vasilyeva, 2014). Thus, working memory, and specifically visual-spatial working memory, is likely an important factor in understanding and mitigating math anxiety. Incorporating interventions that target working memory resources may prove beneficial in reducing the effects of math anxiety.

Relationships between working memory, math anxiety, and math self-efficacy are also beginning to emerge. Math anxiety causes stress and lowers math self-efficacy while consuming working memory resources (Ashkenazi & Denan, 2017; Jameson & Fusco, 2014; Nunez-Pena, Suarez-Pellicioni, & Bono, 2013). When math anxiety sets in, not only do students worry about solving a problem, they struggle to believe they are capable, and their cognitive processes become engaged in dealing with these thoughts rather than the task at hand. The findings of Justicia-Galano, Martin-Puga, Linares, & Pelegrina (2017) suggest that both working memory and math self-efficacy in middle school-aged children play significant roles in the impact of math anxiety on performance. Future interventions may be more effective if they incorporate these aspects.

Expressive Writing

Expressive writing supports both working memory and math self-efficacy and may be particularly suited to address the emotional, psychological, and neurological aspects of math anxiety. The problems math anxiety causes, including psychological reactions, low self-efficacy, and hindered working memory, are the very issues expressive writing relieves. Primarily used as a tool to help individuals deal with general anxiety and trauma, expressive writing has potential application for a broader area of concern. Expressive writing involves writing about feelings connected to a traumatic, hurtful, or stressful experience or situation (Pennebaker & Beall, 1986). Regardless of the length of time spent writing and the number of writing occurrences, expressive writing appears to have positive benefits. Park, Ramirez, & Beilock (2014) found that a single seven minute-session of expressive writing prior to a math test was beneficial for high math anxiety students. Perhaps one of the most compelling examples of the effectiveness of expressive writing comes from Burton and King's "two-minute miracle" (2008), in which only two expressive writing sessions of two minutes each showed significant improvements in health for undergraduate participants. College students are not the only age group that benefits from expressive writing. Travagin, Margola, & Revenson (2015) demonstrated that participation in expressive writing resulted in significant improvement in overall school performance for adolescents, and especially for adolescents with psychological problems.

When an individual participates in an expressive writing activity, certain psychological benefits are gained. Expressive writing provides an outlet to create a sense of detachment from a stressful experience. The writing allows an individual to remove him or herself from a difficult situation, narrate it objectively, and find meaning in the experience (Park, Ayduk, & Kross, 2016). By helping regulate negative emotions, expressive writing removes distracting thoughts so tasks can be successfully completed. Kellogg, Mertz, & Morgan (2010) suggest that expressive writing lessens the negative emotional impact of anxious thoughts, resulting in liberated working memory processes.

Perhaps what makes expressive writing effective at reducing the effect of anxious thoughts and creating objectivity is that it also allows for a mental re-framing of a stressful situation. Alparone, Pagliaro, & Ilaria (2015) suggest that when expressive writing is employed, a true change in cognition occurs regarding the source of stress or anxiety, and outlook improves. This may also explain how expressive writing has helped delinquent adolescents increase belief in their resilience to be successful after their detention (Greenbaum & Javdani, 2017). Expressive writing also promotes behaviors related to resiliency that improve self-efficacy: self-reflection and metacognition (Schumann & Sibthorp, 2016; Tavil, 2014).

Expressive Writing and Math Anxiety

Expressive writing is uniquely connected to math anxiety. Math anxiety introduces distracting stressful thoughts that obstruct working memory resources, while expressive writing helps by providing an outlet for those thoughts that lessens their impact, (Alparone, Pagliaro, & Rizzo, 2015; Kellogg, Mertz, & Morgan, 2010; Schroder, Moran, & Moser, 2016; Smyth & Pennebaker, 2008). Math anxiety lowers self-efficacy, while expressive writing improves it through objective self-reflection (Griggs, Rimm-Kaufman, Merritt, & Patton, 2013; Huang &

Mayer, 2016; Kirk, Schutte, & Hine, 2011; Schroder, Moran, & Moser, 2017). This may be because expressive writing shares the same theoretical foundations in social learning theory and processing efficiency theory as math anxiety, however, from an opposite perspective. Expressive writing may offer the remedy for reducing conditioned responses from a negative stimulus, such as those caused by math anxiety (Pizzie & Kraemer, 2017). Expressive writing provides the outlet to release and manage anxious and stressful thoughts and emotions that math anxiety induces and could potentially reduce the affects math anxiety has on math achievement.

Perhaps this is why expressive writing has been shown to be a successful intervention in lowering math anxiety in college and high school students. Park, Ramirez, & Beilock's (2014) study with college students indicates that a brief expressive writing activity just prior to a math test reduced math anxiety and improved performance. They suggest that expressive writing may be useful to help students who are competent in math but suffer from math anxiety (Park, Ramirez, & Beilock, 2014). Another study by Hines, Brown, & Myran (2016) utilized fifteen minutes of expressive writing once a day for three days for high school students who did not pass a state standardized math test. Their results indicate the impact of expressive writing. Expressive writing was related to both reduced general anxiety and mathematics anxiety, however, the control group (who completed a writing activity meant to be emotionally neutral) also showed reduced math anxiety. The researchers believe that there may have been emotional topics in the control group writing that explains the results (Hines, Brown, & Myran, 2016). The effectiveness of expressive writing in reducing anxiety is not limited to math. Expressive writing has also been shown to help middle school students reduce peer-related anxiety when used with a cognitive focus and improve their self-concept as they transition to high school (Facchin, Margola, Molgora, & Revenson, 2013; Travagin, Margola, Dennis, & Revenson, 2016).

Because expressive writing has been shown useful in reducing anxiety in adolescents, and math anxiety in high school and college students, the application of expressive writing for middle school students' math anxiety makes sense. However, not enough literature exists that examines using expressive writing for math anxiety in middle school students. Research calls for investigating expressive writing's potential for different age groups and in various settings (Hines, Brown, & Myran, 2016; Suarez-Pellicioni, Nunez-Pena, & Colome, 2016; Travagin, Margola, & Revenson, 2015). This current study sought to contribute to the body of knowledge by investigating the effectiveness of an expressive writing activity on the math anxiety levels of middle school students.

Summary

Chapter two provided a discussion of the multi-faceted problem of math anxiety and the theoretical framework that supports the ideas in this study. The underlying causes of math anxiety are rooted in social learning theory and classical and operant conditioning. Its resulting consequences are explained by the deficit theory, the debilitating anxiety model, reciprocal theory, the control-value theory of achievement emotions, and the processing efficiency theory. The intervention in this study, expressive writing, shares the same theoretical foundations, yet addresses math anxiety from opposite positions based in social learning theory and processing efficiency theory. Expressive writing is of interest in mitigating math anxiety in light of the counteracting effects it offers on the key math anxiety factors of stressful emotions and self-efficacy and in response to calls for further research. To contribute to the existing body of knowledge and address the gap in the literature, the current study investigated the usefulness of expressive writing for math anxiety in middle school students.

CHAPTER THREE: METHODS

Overview

A pretest-posttest control group design with random assignment was used to investigate the effectiveness of expressive writing on the math anxiety scores of middle school math students in East Texas. A description of the research design, the research questions, and the null hypotheses is provided. Descriptions of the population, sample, groups, and setting are given. An examination and description of the instrumentation used to collect data is provided in detail, along with its development and justification for selecting it for this study. Specific procedures to conduct this study are given to allow for future replication. The data analysis used in this study is described, including the type of analysis, a rationale for the analysis, assumption tests, alpha level, and effect size.

Design

This study investigated the effects of an expressive writing activity on the math anxiety scores of middle school students. A pretest-posttest control group design with random assignment was used. This design was appropriate for this study because the participants were randomly assigned to the treatment group or the control group (Gall, Gall, & Borg, 2007, p. 405). In addition, both the treatment and control groups completed a pretest and a posttest, and there was manipulation of the independent variable (Gall et al., 2007).

The independent variable was participation in expressive writing. Expressive writing can be defined as a writing for a pre-determined length of time for one or more instances about feelings relating to an experience that caused difficult or stressful thoughts or emotions (Smyth & Pennebaker, 2008; Travagin, Margola, & Revenson, 2015). The dependent variable was math anxiety score. Math anxiety is defined as an adverse reaction to a situation involving mathematics that can generate undesirable mental symptoms such as stress or panic and can produce negative biological responses such as rapid heartbeat and sweating (Beilock & Maloney, 2015; Hembree, 1990). The covariate in this study was pre-test math anxiety scores.

Research Questions

RQ1: Is there a significant difference between the mean math anxiety scores of middle school students who participate in an expressive writing activity and those who do not participate while controlling for pre-existing math anxiety?

RQ2: Is there a significant difference between the mean math anxiety scores of male and female middle school students while controlling for pre-existing math anxiety?

Null Hypotheses

$H_0$1: There is no significant difference between the mean math anxiety scores of middle school students who participate in expressive writing and those who do not participate while controlling for pre-existing math anxiety.

$H_0$2: There is no significant difference between the mean math anxiety scores of male and female middle school students while controlling for pre-existing math anxiety.

Participants and Setting

This study was conducted at a public junior high school in East Texas during the fall semester. The public school is situated in the upper East Texas region, a large geographical region located in the northeast portion of Texas. The region is home to several cities with populations near 100,000 and numerous smaller cities and towns in both rural and suburban areas. Per capita income in the upper East Texas region ranges from $30,000 to $49,000 and the major industries include forestry, agriculture, and manufacturing (Hegar, 2016). The population in the region is predominantly white, followed by Hispanic and African-American.

Public Schools

The public schools in the upper East Texas region serve students from kindergarten through twelfth-grade in urban, suburban, and rural areas. They serve students of all abilities, including remedial, on-level, advanced, and those with special needs. Courses and content align to the Texas Essential Knowledge and Skills state standards (Texas Education Agency, 2012).

Sample

The sample was comprised of students in seventh grade from the population of 800 students in grades seven and eight that attend a public junior high school in East Texas. The school was selected based on the researcher's professional relationships with the superintendent of the school district and the principal's interest in the study. The sample of students was taken from the students in the seventh-grade math classes. The number of participants in the sample was 40 students, which according to Gall, Gall, & Borg (2007, p. 145), exceeds the minimum requirement for a large effect size with statistical power of .7 at the .05 alpha level.

Participants. The students in the sample were comprised of 10 males and 30 females in grade seven. The average age of the students in the sample was 12 years old. Table 1 provides the racial demographics of the students in the sample according to grade level and gender.

Table 1

Racial Demographics of the Sample According to Grade Level and Gender

	7th Grade		
Ethnicity	Male	Female	Total
White	5	24	29
African-American	4	1	5
Hispanic	0	3	3
American Indian	1	0	1
Asian	0	1	1
Pacific Islander	0	0	0
Other	0	1	1
Total	10	30	40
Percent	25	75	100

The students in the sample were enrolled in mathematics classes that included 7th-Grade Math and Pre-AP Math (see Appendix G for course listings and descriptions). These courses cover topics such as percents, ratios, number sets, order of operations, linear equations, functions, measurement, and data (Texas Education Agency, 2012). Curricula align to the Texas Essential Knowledge and Skills state standards and include adopted textbooks from a national publisher and numerous resources selected by teachers. Classes are taught using a combination of lecture, direct instruction, online videos, and hands-on activities. Students take notes, complete worksheets, and participate in activities during class. Homework includes work completed on paper and videos of lesson previews.

Groups

The control group and the treatment group were formed by randomly placing students into each group. The control group (No Expressive Writing Group) consisted of 22 students, 3 males and 19 females. The ethnicities of this group included 77.27% White, 4.55% African-American, 9.09% Hispanic, 0% American Indian, 4.55% Asian, 0% Pacific Islander, and 4.55% Other. The average age of the students was 12 years old. The treatment group (Expressive Writing Group) consisted of 18 students, 7 males, and 11 females. The ethnicities of this group included 66.67% White, 22.22% African-American, 5.56% Hispanic, 5.56% American Indian, 0% Asian, 0% Pacific Islander, and 0% Other. The average age of the students was 12 years old. Table 2 provides the composition of the control and treatment groups.

Table 2

Group Composition According to Grade Level and Gender

	7th Grade		
Group	Male	Female	Total
Control	3	19	22
Treatment	7	11	18
Total	10	30	40

Instrumentation

To measure the math anxiety scores of middle school students, the *Modified Abbreviated Math Anxiety Scale* (mAMAS) created by Carey, Hill, Devine, & Szucs (2017) was used (see Appendix A for instrument). The developers of the mAMAS were contacted to request permission to use the scale. A response was provided that indicated that no permission is required to use this instrument (see Appendix B for permission to use the instrument). This scale was developed based on the *Abbreviated Math Anxiety Scale* (AMAS) (Hopko, Mahadevan, Bare, & Hunt, 2003). The modified version of this scale was developed by adapting the content of the response items to specifically measure math anxiety in children of late elementary school age to middle school age students (ages 8 to 13 years) (Carey, et al., 2017). The questions from the AMAS were modified to describe and address issues that students in middle school and adolescence encounter in mathematics class and use terminology that is familiar to this age group of students. The development of the scale was for the purpose of measuring math anxiety in adolescent and middle school students in response to the need for a scale that specifically targets those ages. Previous scales focused on either college students or elementary students, such as the AMAS developed by Hopko, Mahadevan, Bare, & Hunt (2003), *Mathematics Anxiety Rating Scale* (MARS) developed by Richardson & Suinn (1972), and the *Scale for Early Mathematics Anxiety* (SEMA) developed by Wu, Barth, Amin, Malcarne, & Menon (2012). The developers tested the mAMAS using a large sample of over one thousand early adolescent and adolescent students from twenty-five different schools in England (Carey et al., 2017). Both exploratory and confirmatory analysis were conducted, and the resulting mAMAS is comprised of items nearly all of which loaded onto a single factor for math anxiety (Carey et al., 2017). The mAMAS was selected for its validity, its relation to a widely-known math anxiety scale (AMAS), and its relevance to the age group in the current study. An earlier version of the scale (a modification of the AMAS for eight to eleven-year-old British children) was used prior to its factor structure being investigated (Zirk-Sadowski, Lamptey, Devine, Haggard, & Szucs, 2014). To this researcher's knowledge, the mAMAS has not been widely used due to its recent validation. However, the AMAS, from which the mAMAS is derived, has been previously used to examine math anxiety in adults and graduate students, and has been validated in other studies (Carey et al., 2017; Cipora, Szczygiel, Willmes, & Nuerk, 2015; Jameson & Fusco, 2014; Primi, Busdraghi, Tomasetto, Morsanyi, & Chiesi, 2013; Vahedi & Farrokhi, 2011). The mAMAS has been verified for reliability and construct validity (Carey et al., 2017). Considering the age group of the participants in the current study, and the development, reliability, and construct validity of the mAMAS, this instrument is an appropriate scale for this study.

The construct validity of the mAMAS was evaluated using factor analysis that showed consistent structure with the AMAS (Carey et al., 2017, p. 2). The developers of the mAMAS compared this scale to the *Child Test Anxiety Scale* and the second edition of the *Children's Manifest Anxiety Scale* (Carey et al., 2017; Reynolds & Richmond, 2012; Wren & Benson, 2004). By doing so, the developers of the mAMAS were able to provide validity that this scale specifically measures math anxiety apart from general and test anxiety. Since a Likert-type scale is used in the mAMAS, the reliability was determined using ordinal alpha and Cronbach's alpha. There are two subscales in the mAMAS, the Learning subscale that measures math anxiety in relation to activities involving learning mathematics content, and the Evaluation subscale, which measures math anxiety in relation to being assessed on mathematics content. Table 3 provides the data for the reliability of the mAMAS, the Learning subscale, and the Evaluation subscale (Carey, et al., 2017).

Table 3

Reliability of the Modified Abbreviated Math Anxiety Scale

	Cronbach's Alpha		
Scale	Grade 4	Grade 7	Grade 8
Overall	.85	.86	.86
Learning subscale	.74	.80	.80
Evaluation subscale	.78	.81	.81

Note. Data from "The Modified Abbreviated Math Anxiety Scale: A Valid and Reliable Instrument for Use with Children," by E. Carey, F Hill, A. Devine, and D. Szucs, 2017, *Frontiers in Psychology*, 8, p. 6.

The mAMAS consists of nine items; five measure the Learning subscale, and four measure the Evaluation subscale. Responses to the items are selected on a Likert-type scale that includes a happy face emoticon representing the lowest anxiety level and a sad face emoticon representing the highest anxiety level (Carey et al., 2017). Respondents select from the following: 1 = low anxiety, 2 = some anxiety, 3 = moderate anxiety, 4 = quite a bit of anxiety, and 5 = high anxiety (Carey, et al., 2017). Possible scores range from 9 to 45 points. A score of 9 indicates the lowest possible score for math anxiety and a score of 45 indicates the highest possible score for math anxiety. No other intermediate descriptors of math anxiety scores were provided by the developers of the scale.

The mAMAS is a recently validated instrument that is referenced as one of only two instruments that have been shown to be valid and reliable to measure math anxiety in primary school children (Caviola, Primi, Chiesi, & Mammarella, 2017). The mAMAS is a modification of the AMAS, created by adjusting the language to apply to younger students (Carey, et al., 2017). Caviola, Primi, Chiesi, & Mammarella (2017) demonstrated the validity and reliability of an Italian version of the AMAS for Italian primary school children with a Cronbach's Alpha of .77. A Polish version of the AMAS used with adults was also shown to be valid and reliable with an overall Cronbach's Alpha of .85 (Cipora, Szczygiel, Willmes, & Nuerk, 2015). Brown & Sifuentes (2016) demonstrated the validity and reliability of a Spanish version of the AMAS with post-secondary students with a Cronbach's Alpha of .917. The Cronbach's Alpha values found in these studies are all considered to be within acceptable to high levels of reliability (Warner, 2013). Because of the close relationship of the mAMAS to the AMAS, the reliability of the AMAS provides support for the reliability of the mAMAS.

The mAMAS was administered as a pretest by the researcher on the first day of the study. On the final day of the study, the mAMAS was administered again by the researcher. Administration of the instrument took approximately twenty minutes to complete.

Procedures

Permission from the Institutional Review Board (IRB) was obtained (see Appendix C for IRB approval). Written permission to conduct the study was also obtained from the superintendent and principal of the participating school (see Appendix D for permission request letter and permissions). The researcher met with participating teachers to discuss informing students of the study (see Appendix H for the script to inform students of the study).

Three weeks prior to the study, the researcher met with the principal and participating teachers to review procedures and deliver scripts, flyers, and consent forms (see Appendix E for consent forms and Appendix I for the flyer). Two weeks prior to the study, teachers informed students of the study during math classes using a script and informational flyer and elicited participation using the incentive of a $100 prepaid Visa® gift card drawing. The teachers distributed the informational letter and consent forms to students and their parents/guardians.

Teachers explained that parental and student consent was required, and the form had to be signed and returned to the teacher on a specified day prior to the study. Prior to the study, the researcher met with the participating teachers to retrieve the consent forms. To help increase participation, a pizza party was offered for all participating students. The researcher provided all needed materials, including copies of the survey, secure envelopes, pencils for students, and math journals (see Appendix A for the survey and Appendix F for math journal examples). Participating teachers were encouraged to contact the researcher at any time prior to and during the study.

Each pretest survey, math journal, and posttest survey was matched using a predetermined code. The code indicated the grade level, control or treatment group, and student number. Coordinating pretest surveys and math journals were placed into packets (with coordinating codes). The packets were randomly shuffled by the researcher. On the first day of the study, participating students met the researcher in a designated classroom in the school during each math class. The researcher randomly distributed a packet to each participant, randomly assigning each participant to either the control group or the treatment group. Participants completed the surveys and placed them into secure envelopes. The researcher collected the surveys. Teachers maintained a spread sheet that matched each student name with the code on the packet received.

The surveys were scored by the researcher and all data was entered into the Statistical Package for the Social Sciences (SPSS). During the study, the researcher periodically emailed teachers to remind participating students to complete their math journals each night and return them to class on the date of the posttest survey to be collected by the researcher. The final day of the study, the researcher returned to the school to administer the survey again as a posttest and collected math journals. Participating students met with the researcher in a designated classroom. The researcher matched each posttest survey code to the student's code. Participants completed the posttest surveys. The surveys were collected by the researcher. After all materials were collected and verified by the researcher, the researcher asked a neutral party to randomly select a participating student as the $100 Visa® gift card winner. The gift card was given to the winning student's teacher to be awarded to the student. Gift cards were also given to the participating teachers ($50) as tokens of appreciation. The week following the study, a pizza party for the participants was provided by the researcher. The researcher scored the results of the posttest surveys. An individual score was determined by adding the values provided from the responses to the scale items. The data from the study was kept confidential, coded, and entered into SPSS for analysis.

Data Analysis

A one-way ANCOVA was conducted to determine if a statistically significant difference existed between the adjusted mean math anxiety scores of middle school students who participated in the expressive writing activity and those who did not participate. Since gender may also be an influential factor in math anxiety, a second one-way ANCOVA was conducted to determine if there was a statistically significant difference between the mean math anxiety scores of male and female middle school students. The one-way ANCOVA was an appropriate choice to analyze the data according to group and according to gender because it controls for pre-existing math anxiety as a covariate (Gall, Gall, & Borg, 2007; Green & Salkind, 2017).   Data screening was performed to prescreen for outliers and inconsistencies, according to Green & Salkind (2017). To meet the assumptions needed to proceed with each one-way ANCOVA, several tests were conducted on the data according to group and according to gender (Green &

Salkind, 2017). The Shapiro-Wilk Test for Normality was conducted on the data to validate the assumption that the data was normally distributed in each group. The Shapiro-Wilk Test for Normality was appropriate for the sample size since it was less than fifty, and the results according to group and gender both showed the assumption was met (Warner, 2013). The Levene's Test of Equality of Error Variances was performed to check for homogeneity of variance. The assumptions of linearity and bivariate normal distribution were verified by scatterplots of the data created for each level of group and scatterplots created for each level of gender. The one-way ANCOVA tests were run at the 95% confidence level. Partial eta squared was used to measure effect size for each (Warner, 2013).

CHAPTER FOUR: FINDINGS

Overview

Chapter Four provides a discussion of the findings of the current study, including the descriptive statistics, assumption tests, and the results of the two one-way ANCOVA tests. The results for each of the null hypotheses and related statistical data are presented.

Research Questions

This study examined two research questions. The questions are as follows:

RQ1: Is there a significant difference between the mean math anxiety scores of middle school students who participate in an expressive writing activity and those who do not participate while controlling for pre-existing math anxiety?

RQ2: Is there a significant difference between the mean math anxiety scores of male and female middle school students while controlling for pre-existing math anxiety?

Null Hypotheses

$H_0$1: There is no significant difference between the mean math anxiety scores of middle school students who participate in expressive writing and those who do not participate while controlling for pre-existing math anxiety.

$H_0$2: There is no significant difference between the mean math anxiety scores of male and female middle school students while controlling for pre-existing math anxiety.

Descriptive Statistics

This study examined the effectiveness of an expressive writing intervention on math anxiety scores of seventh-grade students attending a public junior high school. Participants (N = 40) were randomly assigned to the control group (n = 22) or the treatment group (n = 18). Data for this study was obtained from the administration of the Modified Abbreviated Math Anxiety

Scale (mAMAS), given as a pretest and posttest to all participants. The mAMAS was created and validated by Carey, Hill, Devine, & Szucs (2017).

During the study, students in the control group and the treatment group completed math journals each night for two weeks. Both groups answered journal questions that asked for the date, number of math homework problems assigned that day (if any), and the due date (if applicable). The treatment group students also completed an expressive writing prompt in their journals. The prompt asked students to write for at least one minute regarding how they felt about math that day.

Potential scores on the mAMAS range from 9 to 45. In this study, scores on the mAMAS pretest ranged from 11 to 39 and scores on the mAMAS posttest also ranged from 10 to 37. The mean pretest scores were 25.18 for the control group (n = 22) and 26.22 for the treatment group (n = 18). The adjusted means scores for the posttest were 23.51 for the control group and 23.82 for the treatment group. The mean pretest scores were 23.50 for males (n = 10) and 26.37 for females (n = 30). The adjusted means scores for the posttest were 22.911 for males and 23.896 for females. The data for the mAMAS results are provided in Table 4.

Table 4

Descriptive Statistics for the mAMAS Results

Group	*N*	Pretest Mean Score	S.D.	Posttest Mean Score	S.D.	Adjusted Means	S.E.
Control	22	25.18	7.17	23.09	7.48	23.511	.820
Treatment	18	26.22	7.67	24.33	7.85	23.820	.907
Male	10	23.50	7.88	21.00	8.06	22.911	1.221
Female	30	26.37	7.12	24.53	7.33	23.896	.700

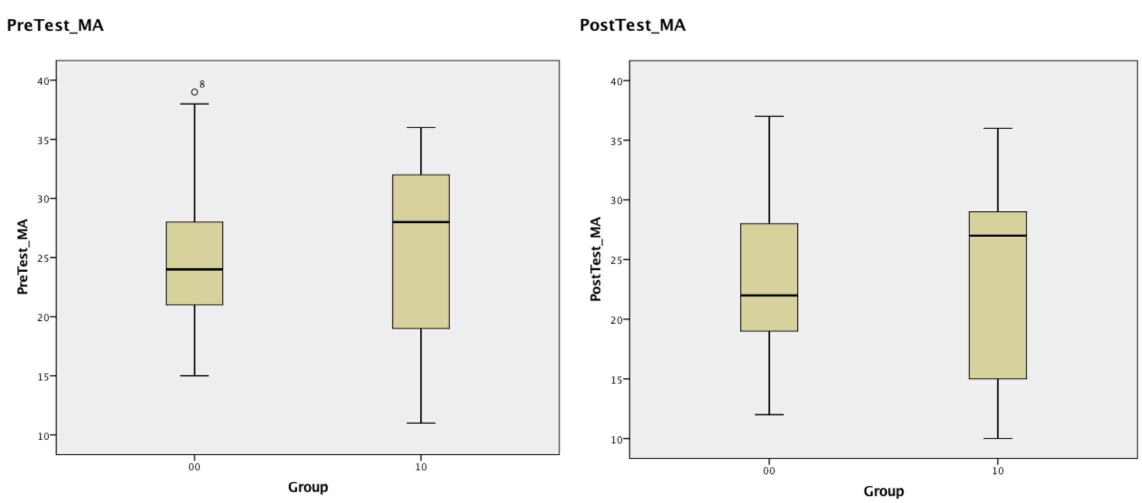
Results

Data Screening

To ensure validity in reporting, data screening was performed to prescreen for outliers and inconsistencies, according to Green & Salkind (2017). For student #10, a single mAMAS item (out of nine items) on the pretest survey was left blank. The procedure for entering a neutral score for that item was followed according to Warner (2013). A visual screening of the data was conducted. No raw scores totaling less than 9 or above 45 were found. Box and whisker plots were created to screen for outliers. To confirm that there were no outliers, the raw scores for the pretests and posttests were converted to standardized *z*-scores. No outliers were found as all scores fell within the acceptable standard *z*-score range of -3.3 to 3.3 (Warner, 2013). Figures 1 and 2 provide the box and whisker plots for the pretest and posttest according to group and gender.

Figure 1

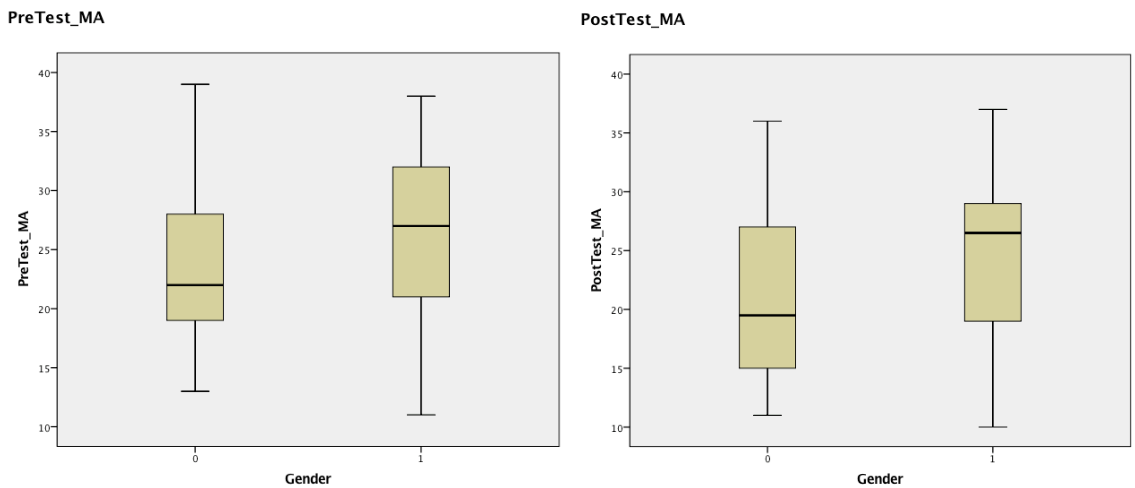
Box and Whisker Plots for the Pretest and Posttest According to Group



Note: 0 = Control 1 = Treatment

Figure 2

Box and Whisker Plots for the Pretest and Posttest According to Gender



Note: 0 = Male 1 = Female

Assumptions

Group. To meet the requirements for the one-way ANCOVA for group, several assumptions were met. These included the assumptions of bivariate normal distribution, the assumption of equal variances, the assumption of linearity, and the assumption of the homogeneity of slopes (Green & Salkind, 2017; Warner, 2013). To verify normality of the data, the Shapiro-Wilk test of normality was performed. The assumption of the normality of the data was met. See Table 5 for the Shapiro-Wilk Test results.

Table 5

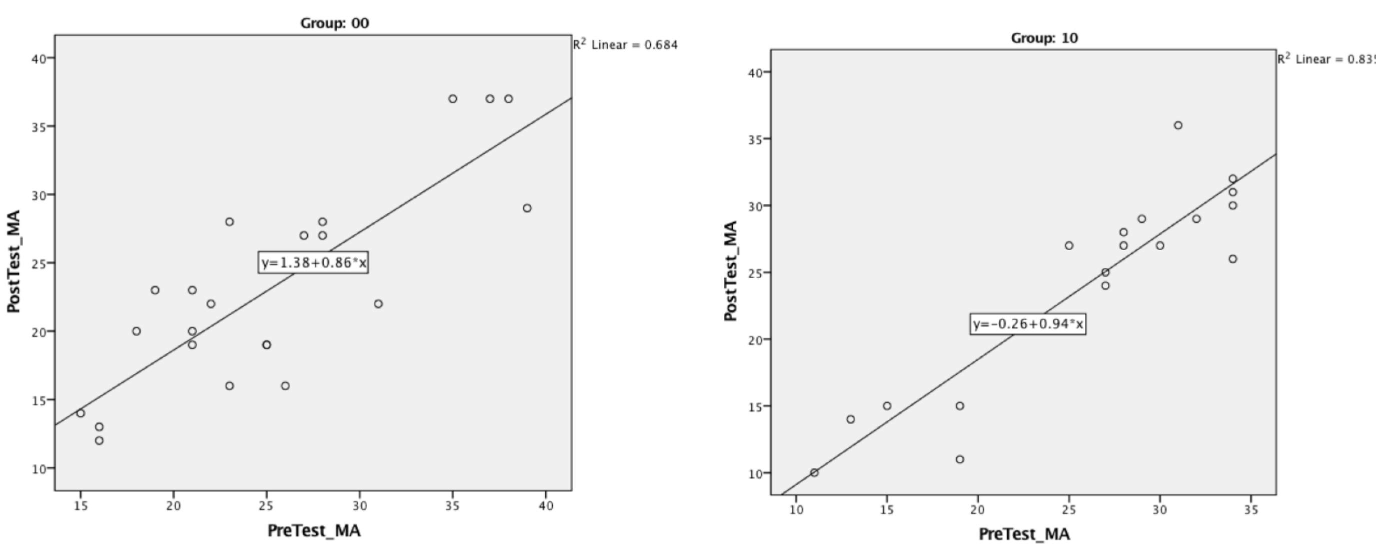
Shapiro-Wilk Test of Normality Results for Group

Standardized Residual for PostTest_MA	Group	Statistic	df	Sig.
Control	00	.954	22	.372
Treatment	10	.955	18	.502

The Levene's test for the assumption of the homogeneity of variances was met $F(1, 38) = 3.217$, $p = .081$. The assumption of the homogeneity of slopes was met for each level of the independent variable and pre-existing math anxiety score where $p = .669$. The assumption of linearity was verified by visual examination of scatterplots of the data created for each level of group. Figure 3 presents the scatterplots for the assumption of linearity.

Figure 3

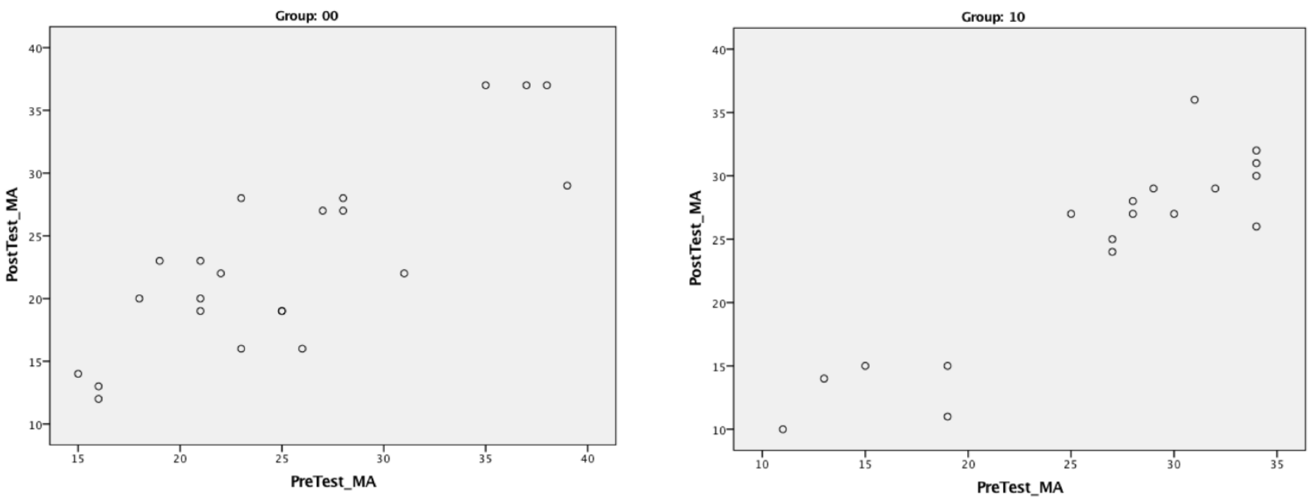
Scatterplots for the Assumption of Linearity According to Group



The assumption of bivariate normal distribution for each level of the independent variable was also met. Figure 4 provides the scatterplots for the assumption of bivariate normal distribution.

Figure 4

Scatterplots for the Assumption of Bivariate Normal Distribution by Group



Gender. To meet the requirements for the one-way ANCOVA for gender, several assumptions were met. These included the assumptions of bivariate normal distribution, the assumption of equal variances, the assumption of linearity, and the assumption of the homogeneity of slopes (Green & Salkind, 2017; Warner, 2013). To verify normality of the data, the Shapiro-Wilk test of normality was performed. The assumption of the normality of the data was met. See Table 6 for the Shapiro-Wilk Test results.

Table 6

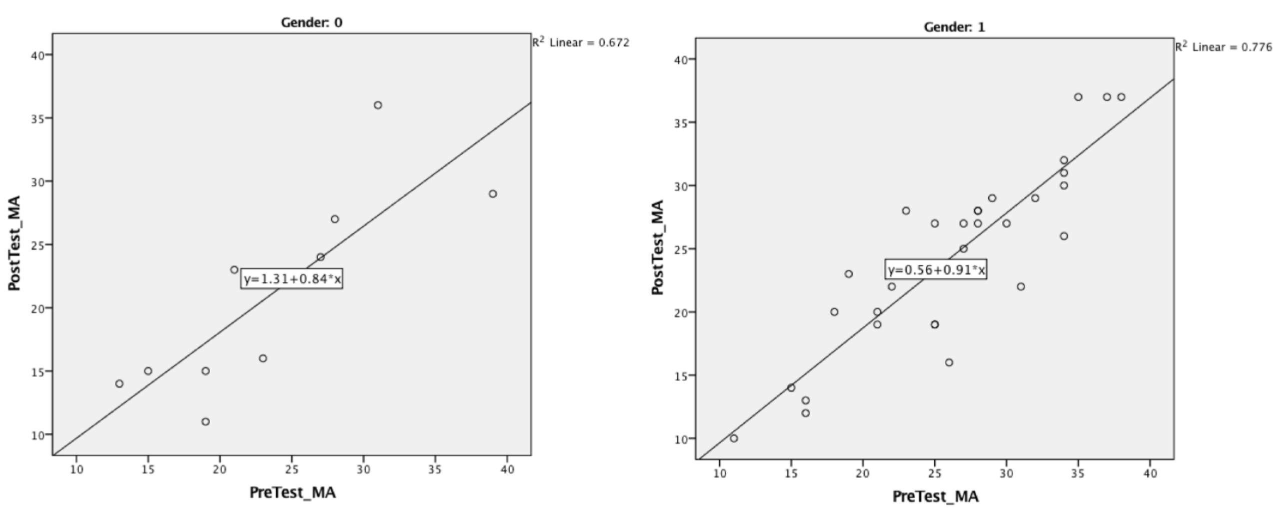
Shapiro-Wilk Test of Normality Results for Gender

Standardized Residual for PostTest_MA	Gender	Statistic	df	Sig.
Male	0	.956	10	.743
Female	1	.977	30	.738

The Levene's test for the assumption of the homogeneity of variances was met $F(1, 38) = 1.528$, $p = .224$. The assumption of the homogeneity of slopes was met for each level of the independent variable and pre-existing math anxiety score where $p = .716$. The assumption of linearity was verified by visual examination of scatterplots of the data created for each level of gender. Figure 5 presents the scatterplots for the assumption of linearity.

Figure 5

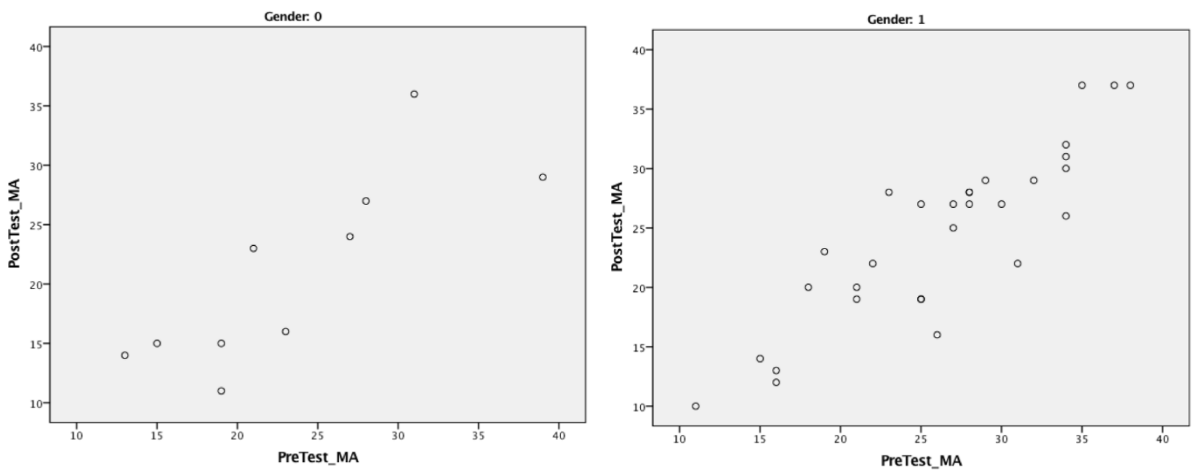
Scatterplots for the Assumption of Linearity According to Gender



The assumption of bivariate normal distribution was met for each level of the independent variable. Figure 6 provides the scatterplots for the assumption of bivariate normal distribution.

Figure 6

Scatterplots for the Assumption of Bivariate Normal Distribution by Gender



Results for Null Hypotheses

Results for Null Hypothesis One

The first null hypothesis states, "There is no significant difference between the mean math anxiety scores of middle school students who participate in expressive writing and those who do not participate while controlling for pre-existing math anxiety." The dependent variable, math anxiety score (adjusted means), was compared on each level of the independent variable, group (control – no expressive writing, treatment – expressive writing). To examine null hypothesis one, a one-way ANCOVA was conducted. The result was not significant $F(1, 37) = .064$, $p = .802$, $\eta^2 = .002$. There was a not a statistically significant difference in adjusted mean scores between the treatment group and control group. The research failed to reject null hypothesis one.

Results for Null Hypothesis Two

The second hypothesis states that, “There is no significant difference between the mean math anxiety scores of male and female middle school students while controlling for pre-existing math anxiety.” This hypothesis examined the differences in the dependent variable, math anxiety score (adjusted means) on each level (male and female) of the independent variable, gender. A one-way ANCOVA was conducted to examine hypothesis two. There was no statistically significant difference between the adjusted means scores according to gender $F(1, 37) = .484$, $p = .491$, $\eta^2 = .013$. The research failed to reject null hypothesis two.

Summary

Chapter four described the collected data from the current study and its statistical analysis. The analysis was performed on data collected from the mAMAS administered to participating students as a pretest and posttest survey. Descriptive statistics were provided for the current study. Two one-way ANCOVA tests with pre-existing math anxiety as a covariate, were conducted to examine the differences in adjusted mean math anxiety scores for participants in the control group and treatment group and the differences in adjusted mean math anxiety scores for males and females.

The results of the study indicate that there were no statistically significant differences between the adjusted mean math anxiety scores of participants in the control group and treatment group or between males and females. The treatment did not appear to significantly influence math anxiety scores. Gender also did not appear to influence math anxiety scores.

CHAPTER FIVE: CONCLUSIONS

Overview

Chapter Five discusses the findings of the study in the context of the body of knowledge and addresses the limitations of the study. Implications of the study are discussed and recommendations for future research are considered.

Discussion

This study investigated the effectiveness of an expressive writing intervention on the math anxiety scores of middle school students. An experimental, control-group design with random assignment and pretest and posttest was utilized to investigate the differences in math anxiety scores of students who participated in expressive writing and those who did not while controlling for pre-existing math anxiety. This study also examined the impact of gender on math anxiety levels while controlling for pre-existing math anxiety.

Research indicates that math anxiety affects students' learning, achievement, and later career goals (Chang & Beilock, 2016; Ramirez, Chang, Maloney, Levine, & Beilock, 2016; Suárez-Pellicioni, Núñez-Peña, & Colomé, 2016). By the time students have entered middle school, many, both male and female, have already acquired math anxiety from their parents and teachers, who themselves have math anxiety (Ganley and Lubienski, 2016; Hill, Mammarella, Devine, Caviola, Passolunghi, & Szucs, 2016; Maloney & Beilock, 2012). However, females appear to be especially susceptible due to stereotypical beliefs of society, as well as in the home. The literature suggests that mothers impose, however unwittingly, stereotyped ideas and attitudes regarding math onto their daughters (Casad, Hale, & Wachs, 2015; Tomasetto, Mirisola, Galdi, & Cadinu, 2015). Once students reach middle school, the negative impact of math anxiety is pronounced. These are the years when girls' performance in math begins to decline compared to boys (Gibbs, 2010). These are also the years in which mathematics concepts become more abstract, and some researchers have found significant connections between abstract concepts and working memory differences between males and females. They suggest that males utilize visual-spatial working memory processes which support abstract thinking more than females, and these differences become more pronounced in the presence of math anxiety (Ganley & Vasilyeva, 2014). Thus, the numerous factors of the math anxiety equation combine to create an exodus of young adults (especially females) from math and math-based college majors and professional careers. The result is a shortage in society and the workplace in STEM careers and a pronounced gender gap in those areas (Beilock & Maloney, 2015; Goetz, Bieg, Ludtke, Pekrun, & Hall, 2013; Moakler and Minsun 2014).

Much of the research has focused on examining the problem of math anxiety, its effect on students, and particularly female students, who experience greater levels of math anxiety even when their performance is equivalent to male student performance (Devine, Fawcett, Szucs, & Dowker, 2012). Other research has uncovered evidence of math anxiety's impact on the brain, in regions of pain and fear, as well as working memory (Suarez-Pellicioni, Nunez-Pena, & Colome, 2016). Math anxiety is a complicated construct comprised of social, emotional, and cognitive elements (Ashkenazi & Denan, 2016; Ramirez, Shaw, & Maloney, 2018). The multi-faceted complexity of math anxiety make it a difficult problem to solve.

The goal of this research was to add to the body of knowledge by building on previous work investigating expressive writing as a potential intervention for math anxiety. Park, Ramirez, & Beilock (2014) used a single, seven-minute expressive writing activity with college just prior to a math test. Their results suggest a significant decrease in math anxiety levels for participants who completed the activity compared to participants in the control group who sat quietly for the same amount of time prior to the test. Hines, Brown, & Myran (2017) implemented a three-day long study in which high school students wrote for fifteen minutes each day about non-emotional topics (no expressive writing control group) or they wrote about their feelings regarding math (expressive writing treatment group). Their results indicate a decrease in math anxiety levels for participants in both groups, suggesting that feelings may come into play even in writing about neutral topics, and thus some anxiety may be released. Expressive writing is grounded in the same theoretical framework as math anxiety that includes self-efficacy and social learning theory (Franceshcini, Galli, Chiesi, & Primi, 2014; Miller, 2016). This may explain why previous research has shown a significant impact on reducing math anxiety. Other research involving expressive writing has demonstrated that it may be more effective for males than females (Kirk, Schutte, & Hine, 2011; Klein & Boals, 2001). In addition, the literature calls for more research on expressive writing, and in particular with middle school students (Hines, Brown, & Myran, 2016; Suarez-Pellicioni, Nunez-Pena, & Colome, 2016; Travagin, Margola, & Revenson, 2015). Very few, if any, previous studies have been conducted that examine the use of expressive writing for math anxiety in middle school students. The current research was conducted to help fill the gap in the literature.

This study included volunteer participants in the seventh grade from a public middle school in East Texas. Participants were randomly assigned to either the control group or the treatment group. Both groups took the Modified Abbreviated Math Anxiety Scale (mAMAS) as a pretest and posttest survey. During the study, all participants completed a math journal each night for two weeks. Journals for both the control and treatment groups contained three benign questions that asked for each day’s date, the number of homework problems assigned for that day, if any, and the due date for the homework, if any. The journals for the treatment group contained a fourth question that asked each participant to take at least one minute and write how he or she felt about math for that day. The posttest was administered the day after the final day of student journaling.

Results for Research Question One

Research question one addressed the impact of expressive writing compared to no expressive writing on math anxiety scores for middle school students. No significant results were found between the adjusted mean scores of participants in the control group (no expressive writing) and participants in the treatment group (expressive writing). The research failed to reject the first null hypothesis. This suggests that the expressive writing intervention did not significantly lower the math anxiety scores during the period of the study.

These findings do not align with other existing research. However, a suggestion from Travagin, Margola, and Revenson (2015) indicates that expressive writing may be counterproductive for middle school students unless conducted over an extended period of time and have spacing of greater than one day in between writing instances. The current study was conducted over a two-week period of time and involved a brief writing session of at least one minute that occurred each day of the study. The results show that the two-week time period did not have a significant effect on math anxiety levels. In addition, it is unclear from the literature what amount of writing time is most effective for expressive writing. Significant results have been found with single and multiple writing sessions lasting as few as two minutes and as long as fifteen minutes (Burton & King, 2008; Hines, Brown, & Myran, 2016; Huang & Mayer, 2016; Park, Ramirez, & Beilock, 2014). However, these studies involved high school and college-age participants rather than middle school participants. Travagin, Margola, and Revenson (2015) suggest that there may be benefits of expressive writing for adolescents, yet it is not definitive.

The results of this study suggest that the use of expressive writing to reduce math anxiety in middle school students may not have benefit.

Results for Research Question Two

The second research addressed any differences between the adjusted mean scores according to gender. The results were not significant, and the research failed to reject null hypothesis two. Although the differences in adjusted mean scores between males and females was not statistically significant, it may be interesting to note that the number of female volunteer participants was three times the number of male participants. This is in agreement with the literature that demonstrates how females experience more math anxiety than males (Dowker, Sarkar, & Looi, 2016; Ferguson, Maloney, Fugelsang, & Risko, 2015; Goetz, Bieg, Ludtke, Pekrun, & Hall, 2013; Stoet, Bailey, Moore, & Geary, 2016). The gender demographics of this study may add support to the premise that females suffer from math anxiety to a greater extent in males and the difference is evidenced as early as middle school.

The findings of the current study contradict literature which proposes that expressive writing is effective for reducing stress and anxiety for both adolescent males and females (Horn, Possel, & Hautzinger, 2011; Shen, Yang, Zhang, & Zhang, 2018). Boals (2012) noted that expressive writing can introduce anxious thoughts for individuals who are not experiencing stress or are not writing about a significantly stressful situation. However, Travagin, Margola, & Revenson (2015) suggest that expressive writing may have either positive or negative effects on adolescents, depending on how they can manage and regulate negative emotions elicited by expressive writing. The findings of this research indicate that expressive writing may not have had an effect at all. In all groups (control, treatment, male, and female), the adjusted mean scores were lower than the mean pretest scores.

Implications

This study adds to the growing body of knowledge of math anxiety and provides a response to the call for research for the use of expressive writing with middle school students (Suarez-Pellicioni, Nunez-Pena, & Colome, 2016; Travagin, Margola, & Revenson, 2015). The current research is perhaps the first study to investigate the use of expressive writing as an intervention to reduce math anxiety in middle school students. The use of expressive writing specifically for math anxiety has only begun to be researched, and there are few other known studies that have been conducted. In those that have, however, the participants were college and high school students (Hines, Brown, & Myran, 2016; Park, Ramirez, & Beilock, 2014). Thus, the findings of the current research are valuable for researchers and educators.

The literature is still unclear on which math anxiety interventions are most effective. Foley, Herts, Borognovi, Guerriero, Levine, & Beilock (2017) call for more research to discover ways to reduce math anxiety's negative impact on learning and performance in the classroom. The results of the current study suggest that expressive writing may not be useful for some students of adolescent age, contradicting other literature that suggests that expressive writing may have benefit for all students (Hines, Brown, & Myran, 2016; Shen, Yang, Zhang, & Zhang, 2018).

This study also has implications for society. There still exists a shortage of individuals of both sexes in science, technology, engineering, and math (STEM) fields (Beilock & Maloney, 2015). There is an even greater lack of females in these areas that is attributable to the issue of math anxiety and stereotype threat (Maloney, Schaeffer, & Beilock, 2013). The problem of math anxiety has been shown to manifest at early ages, with a significant decrease in female performance evidenced by the time students enter middle school (Gibbs, 2010). The non-significant results of the current study suggest that expressive writing may not be effective for reducing math anxiety among female or male middle school students.

Limitations

Several threats to validity are recognized in this study. The length of time of this study, two weeks, may have been of sufficient duration to allow for outside events to occur that could have impacted the outcomes (Campbell & Stanley, 1963; Cook & Campbell, 1979). In contrast, a two-week time period may have been short enough to allow for students to recall the content of the pretest while taking the posttest, since they were identical. Gall, Gall, & Borg (2007) describe this phenomenon as students becoming "test-wise" (p. 385). This may account for the slight reduction in adjusted mean math anxiety scores for all groups.

Every effort was also made to prevent participants from disclosing any differences between the control group journal and the treatment group journal to reduce experimental treatment diffusion (Campbell & Stanley, 1963; Cook & Campbell, 1979). However, it is possible that this occurred to some extent because participants in both control and treatment groups were in the same classes. This could have caused a desire to be in a different group, which may have clouded the results. Another explanation for the non-significant results could be the John Henry effect, or compensatory rivalry by the control group (Campbell & Stanley, 1963; Cook & Campbell, 1979). That competitiveness such as this occurs and was evidenced in a ninth-grade math class, is discussed by Saretsky (1972). Although the experiment Saretsky (1972) describes involves math achievement rather than math anxiety, the age of the participants (ninth-grade) is similar to the ages of the participants in this current study, and the math anxiety scale used in this study could have been perceived as an achievement test of sorts.

Another limitation is that the results are only generalizable to the population of students that attend the school in East Texas where the study took place. The suggestions from this research may not be applicable to student populations in different grade levels, other schools, other geographic locations or other demographics. This adds a threat to external validity and should be included when considering the findings of this research.

Recommendations for Future Research

Several avenues of research related the current study are recommended. This study was conducted at a single middle school. Thus, a larger study involving several schools that use different teaching methods may prove useful. Boaler (2014), Greenwood (1984), and Ramirez, Hooper, Kersting, Ferguson, & Yeager (2018) contend that teaching methods have been shown to be a contributing factor to the cause and continuance of math anxiety, therefore more research involving varied teaching methods is recommended.

Another suggestion for future research includes working memory. Studies indicate that not only does math anxiety hinder working memory, but it appears to target visual-spatial working memory processes. According to Maloney, Waechter, Risko, & Fugelsang (2012), there is a distinct difference in the use of visual-spatial memory processes between males and females. Interventions that target visual-spatial learning may prove useful in adding to the body of knowledge in math anxiety and in math anxiety in females.

Finally, more research in the use of expressive writing is also recommended. Travagin, Margola, and Revenson (2015) indicate that varied writing times and greater spacing between sessions may alter how effective expressive writing is for adolescents. Since the current study is one of the first to utilize expressive writing for math anxiety in middle school students, more research is needed. Writing sessions of varying lengths spread out during a school year may yield different findings. Previous math anxiety studies involving college students utilized expressive writing just prior to a math test (Park, Ramirez, & Beilock, 2014). This would also be a valuable avenue to explore with middle school-aged students. More research on the effectiveness of expressive writing for math anxiety in middle school students may provide deeper understanding of how math anxiety impacts middle school students and particularly female students.

Summary

Chapter Five provided a discussion of the results of the current study in light of the research questions, null hypotheses, and the literature. The results showed no significant difference in adjusted mean scores according to group, and thus the research failed to reject the first null hypothesis. The results also showed no significant difference in adjusted mean scores according to gender, and the research failed to reject the second null hypothesis. Each finding was discussed with regard to previous research and possible explanations for the findings were given. Implications for researchers, educators, and society were discussed. The issue of gender differences in math anxiety remains a critical one. The limitations of the study were described in detail. Finally, recommendations for future research for math anxiety and its effects on learning performance and gender differences were provided.

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Appendix A: Survey with Demographic Questions and Instrument (Pretest and Posttest)

Math Anxiety Research Survey

Teacher: ___________________

1. Circle your gender: Male Female **2.** Circle your grade level: 6 7 8

3. Circle your age (years old): 10 11 12 13 14 15

4. Circle your ethnicity: American Indian Pacific Islander Hispanic African-American Asian White Other

The instrument can be accessed online here:
https://www.frontiersin.org/article/10.3389/fpsyg.2017.00011/full#supplementary-material

Appendix B: Permission to Use the Instrument

Seeking permission to use the mAMAS
E. Carey <ec[redacted]
Tue 6/27, 5:05 AM Ruark, Angela[redacted]
Flag for follow up. Start by Tuesday, June 27, 2017. Due by Tuesday, June 27, 2017.
Hi Angela,

No permission is required to use or modify the mAMAS. Whilst we have not used the scale with "math" instead of "maths", this is a very minor change in language merely making the mAMAS more similar to the AMAS, which has also been validated, so I see no reason why it should alter the reliability/validity of the scale.

Kind regards,
Emma

Appendix C: IRB Approval

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

April 20, 2018

Angela D. Ruark
IRB Approval 3226.042018: The Effect of Expressive Writing on the Math Anxiety Scores of Middle School Students Enrolled in Public and Private Schools in East Texas

Dear Angela D. Ruark,

We are pleased to inform you that your study has been approved by the Liberty University IRB. This approval is extended to you for one year from the date provided above with your protocol number. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Thank you for your cooperation with the IRB, and we wish you well with your research project.

Sincerely,

[redacted]

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
The Graduate School

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Appendix D: Permission Requests

Permission Request Letter to the Superintendent

February 19, 2018

[redacted]
Superintendent
[redacted]

Dear [redacted]

As a doctoral candidate in the School of Education at Liberty University, I am conducting research as part of the requirements for a doctoral degree. The title of my research project is The Effect of Expressive Writing on the Math Anxiety Scores of Middle School Students Enrolled in Public and Private Schools in East Texas. The purpose of my research is to determine if there is a difference between the math anxiety scores of middle school students who participate in expressive writing and those who do not participate in expressive writing.

I am writing to request your permission to conduct my research in [redacted]
Participants will be asked to complete the attached survey as a pretest on the first day of the study and as a posttest one or two days after the study. During the two-week study, each participant will be asked to complete a journal entry each night before math homework. Participants will be asked to complete the journal entry even if no homework is assigned for a night. Participants will be presented with informed consent information prior to participating. Taking part in this study is completely voluntary, and participants are welcome to discontinue participation at any time.

Thank you for considering my request. If you choose to grant permission, please provide a signed statement on official letterhead indicating your approval.

Sincerely,

Angela D. Ruark
Doctoral Candidate

Permission Request Letter to the Principal

February 20, 2018
[redacted]
Principal
[redacted]

Dear [redacted]

As a doctoral candidate in the School of Education at Liberty University, I am conducting research as part of the requirements for a doctoral degree. The title of my research project is The Effect of Expressive Writing on the Math Anxiety Scores of Middle School Students Enrolled in Public and Private Schools in East Texas. The purpose of my research is to determine if there is a difference between the math anxiety scores of middle school students who participate in expressive writing and those who do not participate in expressive writing.

I am writing to request your permission to conduct my research at [redacted] Participants will be asked to complete the attached survey as a pretest on the first day of the study and as a posttest within one week after the study. During the two-week study, each participant will be asked to complete a journal entry each night before math homework. Participants will be asked to complete the journal entry even if no homework is assigned for a night. Participants will be presented with informed consent information prior to participating. Taking part in this study is completely voluntary, and participants are welcome to discontinue participation at any time.

Thank you for considering my request. If you choose to grant permission, please provide a signed statement on official letterhead indicating your approval.

Sincerely,

Angela D. Ruark
Doctoral Candidate, Liberty University
adruark@liberty.edu
[redacted]

Appendix E: Consent Forms

PARENT/GUARDIAN CONSENT FORM

Title of Study: The Effect of Expressive Writing on the Math Anxiety Scores of Middle School Students Enrolled in Public and Private Schools in East Texas

Principal Researcher: Angela D. Ruark, Liberty University, Lynchburg, VA

Liberty University

Academic Department: School of Education

Dear Parent or Guardian,

You child is invited to be in a research study on math anxiety. Your child was selected as a possible participant because he/she is a middle school student who takes mathematics. Please read this form and ask any questions you may have before agreeing to allow your child to be in the study.

The study is being conducted by Angela Ruark, a doctoral candidate in the School of Education at Liberty University. Dr. Kurt Michael of Liberty University is the supervisor of the study. Your superintendent, [redacted], your principal, have granted permission for this study to take place at your school.

Background Information:

The purpose of this study is to determine if participating in an expressive writing activity reduces math anxiety. The results of this study will help math educators find ways to help prevent or reduce math anxiety for students such as yours. It is important because math anxiety sometimes makes it difficult for students to learn and do math.

Procedures:

If you agree to allow your child to participate in this study, the following activities will take place:

1. Your child will complete a pretest survey (approximate time: 20 minutes).
2. Your child will take a math journal home and complete a journal entry each night for two weeks (approximate time: 5 minutes per night for two weeks).
3. There will be two study groups. Control group students will complete a journaling exercise that does not include excessive journaling instructions (approximate time: 1 to 5 minutes per night for two weeks). Treatment group students will be given exclusive journaling instructions in addition to the regular journaling exercise (approximate time: 1 to 15 minutes per night for two weeks).
4. Your child will complete a posttest survey (approximate time: 20 minutes).

Your child, along with the other students in the math class, will be placed in either the control group or the treatment group by random selection. Your child may or may not receive the intervention (exclusive journaling instructions) as part of his or her participation.

Risks and Benefits of being in the Study:

The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

Participants in the treatment group may experience lower math anxiety.

As a benefit to society, this research will help educators make informed decisions regarding math anxiety.

Compensation:

Each participating student that returns a fully completed math journal by the date specified will be entered into a drawing for a $100 Visa® gift card.

Confidentiality:

The records of this study will be kept private. In any sort of report I might publish, I will not include any information that will make it possible to identify a subject. Research records will be stored securely and only the researcher will have access to the records.

- Data collected from participants will be anonymous.

- Each classroom teacher will keep a spreadsheet on his or her password protected computer to ensure that each survey (before and after) and journals are correlated. The researcher will not be able to identify students.

- The researcher will store all records in a locked cabinet or computer/drive. If digital, data will be code-named and password protected. Consent forms and assent forms will be stored separately from each other and from the study materials. The aggregate data may be used for future writings and studies regarding math anxiety. All data and artifacts will be destroyed after a period of three years.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to allow your child to participate will not affect his or her current or future relations with Liberty University or your child's school. If you decide to allow your child to participate, your child is free to not answer any question or withdraw at any time without affecting those relationships.

How to Withdraw from the Study:

If your child chooses to withdraw from the study, please contact the researcher at the email address/phone number included in the next paragraph. Should your child choose to withdraw, any data collected will be destroyed immediately and will not be included in this study.

Contacts and Questions:

The researcher conducting this study is Angela D. Ruark. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at adruark@liberty.edu or [redacted] You may also contact the researcher's faculty advisor, Dr. Kurt Michael, at kmichael9@liberty.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd, Green Hall 1887, Lynchburg, VA 24515 or email at irb@liberty.edu.

Please notify the researcher if you would like a copy of this information to for your records.

Statement of Consent:

I have read and understood the above information. I have asked questions and have received answers. I consent to allow my child to participate in the study.

(NOTE: DO NOT AGREE TO ALLOW YOUR CHILD TO PARTICIPATE UNLESS IRB APPROVAL INFORMATION WITH CURRENT DATES HAS BEEN ADDED TO THIS DOCUMENT.)

____

Signature of Parent Date

____

Signature of Investigator Date

Liberty University IRB Approval #3226.042018 Date of Approval: April 20, 2018

ASSENT OF CHILD TO PARTICIPATE IN A RESEARCH STUDY

What is the name of the study and who is doing the study?

My name is Mrs. Angela Ruark and I am a math teacher who is also doing research. I am conducting a research study with Liberty University on math anxiety in middle school-aged students.

Why are we doing this study?

We are interested in studying ways to help reduce math anxiety. Sometimes students feel nervous and anxious about math. We want to see if certain activities can help students feel better about math.

Why are we asking you to be in this study?

You are being asked to be in this research study because you are a junior high school student who studies math. Mrs. Ruark knows your superintendent and has asked him to help with this project. Other students at your school are also being asked to participate.

If you agree, what will happen?

If you participate in this study, you will take a survey before and after the study. It will not ask for your name. The survey will ask for which grade you are in, if you are male or female, how old you are, and what your ethnicity is. You will also read nine statements that describe situations about math. You will respond to each statement by selecting an answer that matches how you feel about the math situation. Please answer honestly. Your grade will not be affected by your responses.

Each day of the study, you will be asked to complete a brief math journal entry before completing your math homework. Complete the journal entry even if you do not have any math homework that day. Return your completed journal to your classroom to give to the researcher on the due date after the study.

Any information you provide during this study will not be shared with anyone, unless required by law. The results of this study will be maintained by the researcher, Angela D. Ruark. When the results of the study are published, your identity will be kept anonymous.

Do you have to be in this study?

No, you do not have to be in this study. If you want to be in this study, then tell the researcher. If you don't want to, it's OK to say no. The researcher will not be angry. You can say yes now and change your mind later. It's up to you.

Do you have any questions?

You can ask questions any time. You can ask now. You can ask later. You can talk to the researcher. If you do not understand something, please ask the researcher to explain it to you again.

Signing your name on the back of this form means that you want to be in the study.

Signing your name below means that you want to be in the study.

______________________________ ______________________
Printed Name of Student Date

____
Signature of Student

____
Signature of Researcher

Please return this form to your math teacher. Thank you!

Researchers:
Angela D. Ruark at adruark@liberty.edu
Dr. Kurt Y. Michael at kmichael9@liberty.edu

Liberty University Institutional Review Board
1971 University Blvd, Green Hall 1887, Lynchburg, VA 24515
email at irb@liberty.edu

Appendix F: Math Journal Examples

Cover Page

MATH ANXIETY RESEARCH STUDY

MATH JOURNAL

Do **not** write your name anywhere on this journal.

REMEMBER!

Complete each day's journal entry BEFORE you begin your math homework.

If you do not have math homework for the day, still complete the journal entry.

Return this fully completed journal to the researcher on ________________________
for an entry in a drawing for a $100 gift card for you.

Code:____________

Sample Control Group Journal Entry Page

Day 1

Instructions: Do not to share your journal with other students. Your journal entries will not be viewed by your teacher. Your responses will be kept anonymous. If you participate every day and turn in your journal at the end of the study, you will have the opportunity to be in a random drawing for a $100 gift card.

Answer the following questions to the best of your knowledge.

1) What is today's date? _______/________/ 2018
(Month) (Day)

2) How many math homework problems were you assigned today? ___________

3) If you were given homework, when is it due?
_______/________/ 2018
(Month) (Day)

==========**Do not write below this line**==========

Sample Treatment Group Journal Entry Page

Day 1

Instructions: Do not to share your journal with other students. Your journal entries will not be viewed by your teacher. Your responses will be kept anonymous. If you participate every day and turn in your journal at the end of the study, you will have the opportunity to be in a random drawing for a $100 gift card.

Answer the following questions to the best of your knowledge.

1) What is today's date? _______/________/ 2018
(Month) (Day)

2) How many math homework problems were you assigned today? ___________

3) If you were given homework, when is it due?
_______/________/ 2018
(Month) (Day)

4) **This question is very important**. Please take at least one minute to write about how you feel regarding math today and the math homework you are about to do. Use the space provided to the right. Be open and honest about your feelings toward math. Even if you do not have math homework, still write about how you feel about math today. Only the researcher will view your response. You do not have to use the entire space provided.

Please use this space to answer question #4
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Appendix G: Course Listings and Descriptions

7th Grade Courses

Course Title	**Grade Level**	**Course Description**
Math	7	Includes direct proportional relationships, numbers, operations, quantitative reasoning, algebraic thinking, geometric and spatial reasoning, measurement, probability, and statistics.
Pre-AP Math	7	Includes Algebra concepts, Geometry, Financial Literacy, Data, and Probability. Prepares students for 8th-Grade Algebra I.

**Course description information obtained from the school district website.*

Appendix H: Teacher's Script for Informing Students of the Study

Please read the following script word-for-word to each math class:

"We have been invited to participate in a research study on math anxiety. Math anxiety can be described as feeling nervous or anxious about math. If you participate in the study, you will help researchers figure out ways to help reduce and prevent math anxiety.

You are being asked to participate in this study because you are a middle school-aged student who studies math.

If you agree to participate, you will be asked to complete two short surveys and write brief entries in a math journal each night for two weeks.

Students who participate and turn in their completed math journals on the due date will be entered into a drawing for a $100 Visa gift card.

I will give you a flyer that talks about the research study and I will give you two permission forms. One is for your parents or guardians to read and sign and the other is for you to read and sign.

The permission forms must be turned in to me by Friday, September 7th, so you can participate.

I will now hand out the flyers and permission forms."

Appendix I: Informational Flyer for the Study

Research Participants Needed

Math Anxiety Research Study

- Are you a [redacted] student?
- Do you take math in school?

If you answered **yes** to either of these questions, you may be eligible to participate in a **math anxiety research study!**

How the Study Works

The purpose of this research study is to investigate ways to help with math anxiety. Participants will be asked to take a short survey, write a brief math journal entry each night for two weeks, and then take another short survey. Benefits include a possible reduction in math anxiety. Participants who return fully completed math journals on the due date will be entered into a drawing for a $100 Visa® gift card.

Math **students** in **grades 7** and **8** are eligible.

[redacted]

Please contact Angela Ruark at [redacted] adruark@liberty.edu for more information.

Liberty University IRB – 1971 University Blvd., Green Hall 1887, Lynchburg, VA 24515