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THE EFFECT OF EXPRESSIVE WRITING ON SECOND-GRADE MATH ACHIEVEMENT AND MATH ANXIETY

by

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Presented to the Faculty of the

Doctoral Department of the College of Education

George Fox University

in partial fulfillment for the degree of

DOCTOR OF EDUCATION

February 20, 2018

GEORGE FOX UNIVERSITY

COLLEGE OF EDUCATION

"THE EFFECT OF EXPRESSIVE WRITING ON SECOND GRADE MATH ACHIEVEMENT AND MATH ANXIETY," a Doctoral research project prepared by HOPE WALTER in partial fulfillment of the requirements for the Doctor of Education degree in Educational Leadership.

This dissertation has been approved and accepted by:

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Abstract

Eighty second-grade students participated in a five day study to assess the potential benefits of utilizing expressive writing as a tool to reduce math anxiety and increase math achievement in highly math-anxious (HMA), primary-age children. This quasi-experimental design used a three-way mixed ANOVA to assess if students with high math anxiety, as measured on the MASYC-R survey, would show decreased levels of math anxiety after expressively writing about mathematical concerns for one week, compared to their peers who wrote expressively about a topic of choice.

At posttest, many students did show an increase in math achievement and a decrease in anxiety, however, results indicated no statistically significant three-way or two-way interaction between anxiety, time, and type of expressive writing within this study. Both the MASYC-R and the i-Ready computational assessment were found to be reliable measures for assessing math anxiety in young children and mathematical computation respectively. Utilization of a larger sample size, a longer time frame for the study, and incorporating a true control group are suggestions for future research in the area of expressive writing as a means to reduce math anxiety in young children.

Keywords: math anxiety, expressive writing, primary-age children, MASYC-R

Acknowledgements

As I feel I have probably written too much already, I will be brief. I have thoroughly enjoyed my time and experiences here at George Fox and in the dissertation process specifically. I decided I wanted to do research when I embarked on my thesis over a decade ago, and this dissertation process has reaffirmed that decision.

The ease and comfort I have felt over the past three years in this process would not have been possible without the following:

~My husband and mother who took care of the kids and household tasks while I was gone or engrossed in work. My kids who accepted when I could not attend a game or play with them, and who would bring me tea and rub my back. And to my international kids, who kept rooting me on from across the globe. Without them, this would not be possible.

~My cohort who kept me on pace and encouraged me along the way. Although we were a diverse group of individuals, we stood together and supported one another from day one. I specifically would like to thank Pam for keeping me on pace and Meagan for her procrastination antics and comic relief.

~My friends, both near and far. To the people in my everyday life who would cheer me on and keep me moving with coffee, chocolate, and nights out to relax, I appreciate you. I would like to thank Gribs for being my second set of eyes. To my friends far away, always keeping up and providing me with support even though we were coasts apart, decades of friendship can't be wrong. Family is not about blood. It is about those who will hold your hand when you need it the most.

~Lastly to my professors at George Fox. I was skeptical in coming to George Fox, and I was not sure it was the place for me. However, I never felt out of place, I always felt welcomed, and I constantly felt supported. I would like to thank Dr. Patrick Allen for showing me that professors can have more heart than I ever possibly imagined, and Dr. Ginny Birky for showing me that thoroughness is still a good thing and being Type A is ok.

I would especially like to thank Dr. Susanna Thornhill for being my APA eye. I appreciate your attentiveness. I am thankful to Dr. Dane Joseph for his keen statistical mind and his willingness to help me muddle through it after all these years. Lastly, I would like to thank Dr. Scot Headley. Although we had little time together, I always felt a connection to you. I appreciate your time, attention, and genuine concern for my work and me personally. I guess there is nothing left to do but smile, smile, smile.

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Chapter 1

Math anxiety is defined as a person's negative affective reaction to a situation involving mathematics or a feeling of tension, apprehension or fear that interferes with an individual's math performance (Ashcraft, 2002; Ashcraft & Moore, 2009; Jansen et al., 2013; MacKinnon-McQuarrie, Siegel, Perry, & Weinberg, 2014). According to statistical estimations, approximately 20% of the general population are considered highly-math anxious (Eden, Heine & Jacobs, 2013), indicating nearly one in five individuals will identify as highly-math anxious (HMA). The Programme for International Assessment (PISA) for 2012 reported 33% of 15-year-old students reported feeling helpless when asked to solve math problems (as cited in Chang & Beilock, 2016). Additionally, Ramirez, Chang, Maloney, Levine, & Beilock (2016) found 26% of first- and second-grade students self-reported medium to high levels of math anxiety.

The negative feelings towards and avoidance of mathematics in later years is problematic for our society (Kramarski, Weisse, & Kololshi-Minsker, 2010; Krinzinger, Kaufman, & Willmes, 2009). Ashcraft (2002) contends HMA individuals will tend to avoid math, which damages their math competency and their future career path. Additionally, math anxiety is associated with lower enrollment in math-intensive majors during college (Hembree, 1990). This "snowball" effect of early math anxiety can lead highly-capable students to avoid math courses and math-related careers (Ramirez, Gunderson, Levine, & Beilock, 2013). Ramirez et al. (2016) highlight the current problem, "with the high prevalence of math anxiety in our society, there has been growing attention to the question of how to reduce math anxiety among adults as well as children" (p.96).

Although few studies look at math anxiety in young children, it is well documented that positive early experiences in mathematics have far-reaching implications for future achievement in all academic areas, not limited to math-related content (Arnold, Fisher, Doctoroff, & Dobbs, 2002; Cameron, Steele, Castro-Schilo, & Grissmer, 2015; Claessens & Engel, 2013; DiPerna, Lei, & Reid, 2007; Duncan et al., 2007; Ramirez et al., 2016; Romano, Babchishin, Pagani, & Kohen, 2010). Therefore, early intervention for math anxiety is essential. Ramirez et al. (2013) suggest teaching students effective strategies in math content and providing students ways in which to alleviate the anxiety they experience while engaging in mathematical thinking.

Statement of Problem

It is well established that math anxiety has a significant effect on math performance in both adults and children (Geist, 2010; Krinzinger et al., 2009; Maloney & Beilock, 2012; Ramirez et al., 2013; Ramirez et al., 2016; Sgoutas-Emch & Johnson, 1998; Tobias, 1978). The research on math anxiety has spanned decades, however research has been limited regarding math anxiety in primary-age children until recently.

Ramirez et al. (2016) found the math anxiety/math achievement relationship was most pronounced in students with high working memory. This suggests students who have competent aptitude perform less than their ability due to the anxiety disrupting their more advanced problem-solving strategies. They contend, “the aforementioned results bolster the significance of the work reported here as it suggests that young students who are quite competent may show suboptimal math performance because math anxiety usurps their potential cognitive advantage” (Ramirez et al., 2013, p. 198).

Wu, Barth, Amin, Malcarne, & Menon (2012) indicate recent studies using standardized, age-appropriate math achievement measures showed math anxiety is negatively correlated with math achievement, even at the earliest stages of math learning. Furthermore, research by Wu et al. (2012) and Ramirez et al. (2013) found high levels of math anxiety have a significant and negative impact on working memory (WM) and early math achievement. Therefore, students with potential for academic success could benefit from a math anxiety intervention in order to increase their performance.

Statement of Purpose

The educational research focusing on interventions for math anxiety are often intended for high school and college students. These interventions, however, are limited and nearly non-existent in helping math-anxious, primary-age children. Ramirez et al. (2013) suggest the importance of developing interventions for young children who may be developing math anxiety.

Expressive writing has been an effective technique in the reduction of anxiety across a wide range of disciplines (Bond & Pennebaker, 2012; Fernández Sedano, Páez Rovira, & Pennebaker, 2009; Pennebaker & Francis, 1996; Sayer et al. 2015; Spera, Buhrfeind, & Pennebaker, 1994). Furthermore, a ProQuest Central search for peer-reviewed articles on expressive writing with children from 2003-2017 indicates the use of expressive writing in diverse settings and content areas, including preadolescent peer problems, promoting resilience in juveniles in the justice-system, and emotionally and behaviorally disturbed elementary students. Despite the use of expressive writing in therapeutic environment and within special education, only a few studies have used expressive writing in a mathematical environment.

The use of expressive writing in the reduction of math anxiety and the improvement of math performance was found in two studies by Park, Ramirez, & Beilock (2014) and Ramirez & Beilock (2011). Expressive writing has produced positive results for college students with math anxiety (Park et al., 2014), as well as for high school math students (Hines, Brown, & Myran, 2016). The use of expressive writing to mitigate negative math thoughts and increase cognitive space in the working memory has been successfully indicated with adults (Maloney & Beilock, 2012; Park et al., 2014). Research has shown that expressively writing about negative thoughts regarding mathematics increased high-stakes test performance in ninth-grade students (Park et al., 2014). Table 1 provides a review of research using expressive writing as an intervention for math anxiety on achievement.

Table 1

Previous studies that have shown expressive writing about mathematics increases achievement

Study	Year	Sample Size of Subjects	Setting	Writing Intervention	Results
Ramirez and Beilock	2011	20 college students	Laboratory High-stakes testing	Control vs. EW: Math	Expressive Writing Math increased performance by 5% Control group decreased performance 12%
Ramirez and Beilock Replication study[*]	2011	47 college students	Laboratory High-stakes testing	Control vs. EW: Math Worries EW: Neutral topic	Expressive Writing Math increased performance by 4% Control and Neutral Expressive Writing decreased in performance by 7%
Park, Ramirez, and Beilock	2014	80 college students 44 HMA, 36 LMA	University classroom Testing followed	Control vs. Expressive writing	HMA in the control group performed worse than HMA in the expressive writing Expressive writing reduced the performance gap between HMA and LMA
Hines, Brown, and Myran	2016	93 ninth-grade geometry students	High school classroom	EW: Neutral topic vs. EW: Math Worries	Both groups had a significant decrease in math anxiety. Cognitive processing on writing was measured; not specifically math achievement

Although expressive writing has been shown to be an effective intervention in some educational settings, it has yet to be utilized with younger students. Daiute and Buteau (2012) contend expressive writing with children is seldom studied. Furthermore, their research suggests young children (ages 7-8 years old) can utilize writing as a way to make personal gains and could be useful for student self-reflection. Ganley noted a lack of research in interventions for elementary, math-anxious children (personal communication, August 2017). Pennebaker surmised stringent rules from ethic committees limits the research with children under the age 18 (personal communication, September 2017). More research with younger children is needed to determine if expressive writing has an impact on math anxiety and math achievement.

Research Questions

The purpose of this study was to examine the impact of expressive writing on math anxiety and math achievement on second-grade students. Specifically, this research sought to answer:

1. Does expressively writing about mathematical worries decrease self-reported math anxiety in second-grade students who are highly math-anxious (HMA)?

2. Does expressively writing about mathematical worries increase math achievement in second-grade students who are highly math-anxious (HMA)?

3. Is there a statistically significant difference in math achievement between self-reported math-anxious students who write expressively about mathematics compared to students who write expressively about a free-choice topic?

Limitations and Delimitations

The research surrounding math anxiety and math achievement is abundant. Research has investigated socioeconomic status, gender, parental support, parental math anxiety, teacher math anxiety, and environmental components related to student math anxiety (Chang & Beilock, 2016). Furthermore, math anxiety research, as it relates to math achievement, includes processing, problem solving, working memory, brain research, and the connection of math anxiety to other forms of anxiety (test anxiety, state anxiety, and general anxiety) (Ashcraft, 2002; Ashcraft & Krause, 2007; Ashcraft & Moore, 2009; Mattarella-Micke, Mateo, Kozak, Foster, and Beilock, 2011; Ramirez et al., 2013; Vukovic et al., 2013; Wu et al., 2017). It was not feasible to analyze all possible fields of math anxiety research within this study.

Therefore, the delimitations of this research included HMA students in second grade, as it is suggested that these students, in particular, are the ones who have the potential for success when anxiety is removed (Ashcraft, 2012; Ashcraft & Moore, 2009; Wu et al., 2013; Wu et al., 2012). Students were tested to assess their level of math anxiety. All students in the study received expressive writing, but it was assumed the maximum potential benefit for treatment of math anxiety would be on HMA students. Although it was surmised the students with high WM would benefit the most, WM was not assessed during this study.

The lack of a covariate to measure WM was a limitation of this study. Although looking at math aptitude may be beneficial in future research, the purpose of this research was to assess the effectiveness of expressive writing on math anxiety. Therefore, math aptitude and working memory were not part of the current study. However, math achievement was assessed to determine if there was an increase in achievement after treatment.

Another limitation to the study includes the sample that was utilized. The researcher chose this convenience sample due to the teachers’ and principal’s willingness to participate. The school selected was very homogeneous (78% of the school population identified as white) and only two languages were listed as spoken within the school (Oregon Department of

Education, 2016). The school was also a high-performing school (71.5% of the students in the district met standards for the 2015-2016 school year in mathematics). This was high compared to similar schools (45.1%) and Oregon state overall (44.9%). These school demographics effectively limit the transferability of the results to a greater second-grade population.

Furthermore, the use of the four different second-grade classrooms limited the amount of researcher control on the environment. To help control this aspect of the research, the researcher selected one individual (a certified substitute teacher) to administer the instructions for the anxiety assessment to students in all four classrooms. This allowed for more consistency in delivering the anxiety assessment to students. Henceforth, this person will be referred to as the research assistant. Furthermore, scripts for the administration of the math assessment and for the subsequent days of writing intervention were given to each teacher. Additionally, all teachers conducted the pre and post measures and the writing intervention at the same time during the day to maintain consistency.

Utilization of materials from the i-Ready program provided another limitation to the study. As this program was used within the classrooms already, it could not be surmised whether the factor of time, treatment, or utilization of a typical i-Ready worksheet within the school day had an effect on the potential academic gains of the students. Time could have cause growth and academic gains, as could continual math practice, or a testing effect could have improved scores over time. Comparing the two groups of participants helped to minimize this possible limitation.

Definition of Terms

Control group: operationalized as the students who were expressive writing about a topic of choice for 10 minutes a day

Expressive writing: writing for approximately 10 minutes a day about something stressful or traumatic over a period of approximately three to five days (Pennebaker & Francis, 1996; Ramirez & Beilock, 1996)

Expressive writing as the treatment in this research was operationalized as students being directed to write expressively about math worries or concerns that are stressful or traumatic for them for 10 minutes at the beginning of the school day.

Math anxiety: a person's negative affective reaction to a situation involving mathematics or a feeling of tension, apprehension or fear that interferes with an individual's math performance (Ashcraft, 2002; Ashcraft & Moore, 2009; Jansen et al., 2013; MacKinnon-McQuarrie, Siegel, Perry, & Weinberg, 2014)

Highly-math anxious: operationalized as a score of 31 or more on the MASYC-R

Moderate-math anxious: operationalized as a score between 20-30 on the MASYC-R

Low-math anxious: operationalized as a score below 20 on the MASYC-R

MASYC-R: The Math Anxiety Scale for Young Children-Revised created by Harari, Vukovic, and Bailey (2013) and revised by Ganley and McGraw (2016) was the math anxiety scale used in this research (See Appendix A)

Math achievement: performance on the designated math assessment; operationalized as the score (0-22) on the i-Ready computational fluency assessment (Appendix B)

High-math achievement: operationalized as a score of 18 or above on the i-Ready assessment

Moderate level-math achievement: operationalized as a score of 14-17 on the i-Ready assessment

Low-math achievement: operationalized as a score of 13 or less on the i-Ready assessment

Treatment group: operationalized as expressive writing about math concerns or worries for 10 minutes a day

Summary

Math anxiety has a negative relationship with math achievement (Cargnelutti, Tomasetto, and Passolunghi, 2017; Harari et al., 2013; Ramirez et al., 2013). Research indicates the cognitive load from math anxiety impedes the ability to do higher level mathematics processing, and therefore performance decreases (Ashcraft & Moore, 2009; Vukovic et al., 2013). This impacts students who could potentially perform well on advanced mathematical tasks.

Expressive writing has been used in many clinical and behavioral settings to decrease anxiety in anxious individuals (Bond & Pennebaker, 2012; Fernández Sedano, Páez Rovira, & Pennebaker, 2009; Pennebaker & Francis, 1996; Sayer et al. 2015; Spera, Buhrfeind, & Pennebaker, 1994). Several studies have found expressive writing to be an effective tool in minimizing math anxiety with young adults and teens (Hines, Brown, & Myran, 2016; Park et al.; 2014; Ramirez & Beilock, 2011). Further research needs to be conducted to determine if expressive writing is beneficial for young children in the reduction of math anxiety.

The current research intended to assess if expressive writing about mathematical worries helped alleviate math anxiety in HMA students and increase mathematical performance. This research has the potential to benefit students who have already begun to feel the negative impact of math anxiety at an early age. Providing a free, quick technique for reducing anxiety and increasing performance in primary-age students could be an important step in minimizing math anxiety in our society. It will contribute to a new area of research in the field of math anxiety.

Chapter 2

Literature Review

This literature review examines the historical context and causes of math anxiety. There is substantial evidence indicating that math anxiety exists (Ashcraft, M. 2002; Ashcraft & Moore, 2009; Geist, 2010; Hembree, 1990; Tobias, 1978), yet the research on primary-age students with math anxiety is limited (Wigfield & Meece, 1988; Wu, Barth, Amin, Malcarne, & Menon., 2012). Of greater concern is the impact math anxiety has on performance and future success in mathematics (Geist, 2010; Krinzinger et al., 2009; Maloney & Beilock, 2012; Ramirez et al., 2013; Ramirez, Chang, Maloney, Levine, & Beilock, 2015; Sgoutas-Emch & Johnson, 1998; Tobias, 1978). Successful treatment of math anxiety has been well-established (Bandura, 1997; Hembree, 1990; Jansen et al., 2013), with expressive writing prior to mathematical tasks as a quick, simple, and inexpensive treatment option (Park et al., 2014).

The benefits of expressive writing in reducing anxiety and increasing mathematical achievement is documented (Furner & Berman, 2003; Park et al., 2014; Sgoutas-Emch & Johnson, 1998), however, much of the research focuses on the cognitive gains in mathematics as opposed to reducing mathematical anxiety (Cohen, Miller, & Firmender, 2004; Park et al., 2014; Pugalee, 2001). Implementation of expressive writing as a technique for reducing math anxiety and increasing performance has been documented (Furner & Duffy, 2002; Rule & Harrell, 2006; Sgoutas-Emch & Johnson, 1998). However, the research on expressive writing for reducing anxiety and improving achievement has mainly focused on adults or older children (Furner & Berman, 2003; Rule & Harrell, 2006). Therefore, this study will focus on early intervention of math anxiety for young children through expressive writing. The purpose of this study is to assess if expressive writing prior to mathematics instruction is beneficial to highly math anxious

(HMA) second-grade students' academic achievement and reduction of student self-reported mathematical anxiety.

Types of Anxiety in Students

Student anxiety has been assessed historically through three main measures of anxiety: test, state and trait. State and test anxiety refer to anxiety that occurs within a specific situation. Test anxiety is a physical or mental distress specific to testing situations that may disturb recall of prior knowledge (Hembree, 1990). State anxiety, however, focuses on a specific incident or activity which evokes stressful negative feelings, as opposed to trait anxiety which is a general anxiety that can transfer to a range of different situations. Ng and Lee (2015) suggest "trait test anxiety refers to an individual's disposition to perceive test situations as threatening and to respond to such threats with state anxiety" (p.141). Although these types of anxiety can impact one another, and all can be utilized in assessing school students, Bieg et al. (2014) suggest many previous studies focused on the general, habitual, trait anxiety in assessment. It can be argued that assessment of trait anxiety is limiting, due to the subjective nature and semantical knowledge of trait measures (Bieg et al., 2014: Roos et al., 2015). However, recent studies are utilizing state anxiety to provide a more accurate episodic and contextual basis for anxiety measures (Bieg et al., 2014).

Differentiating between trait anxiety and state anxiety is a primary focus of research on school students' anxiety (Bieg, Goetz & Lipnevich, 2014; Roos et al., 2015). Specifically, a trait-state discrepancy has been found in student self-assessments. Both Bieg et al. (2014) and Roos et al. (2015) found an overestimation in trait anxiety compared to state anxiety which can be attributed to beliefs about anxiety (trait) as compared to actual occurrences of anxiety (state).

The current research will focus on measures of state anxiety for mathematics in primary-age students.

Differentiating Math Anxiety from Other Anxieties

Math anxiety, test anxiety, and general trait anxiety all share commonalities (Bieg et al., 2014; Hembree, 1990; Roos et al., 2015). Hembree's (1990) meta-analysis of math anxiety examines the construct of anxiety, listing test anxiety and math anxiety as two sub-constructs of anxiety. His research suggests that both forms of anxiety affect performance, while improved performance provides relief for both anxieties, and both types of anxiety respond well with behavioral treatments. Furthermore, math anxiety, while subject-specific, tends to function more like trait anxiety, as it is more pervasive without much fluctuation throughout the content (Beasley, Long, & Natali, 2001). However, research has shown specific distinctions between general trait anxiety and test anxiety in relation to math anxiety.

Wu et al. (2012) used hierarchical regression analysis to conclude trait anxiety could not explain the significant variance in math achievement among subjects. Devine, Fawcett, Szucs, & Dowker's (2012) regression model indicated math anxiety's effect on math performance in girls, when controlling for test anxiety. Wang et al. (2015) also concluded that math anxiety had an effect on math performance, however, general anxiety did not. Additionally, Wu et al. (2012) use of the Scale for Early Mathematics Anxiety (SEMA) indicated math as a specific anxiety independent of general anxiety or test-related anxiety. Although some have argued that math anxiety is a form of test anxiety, and there is some correlation between the two, it can be argued that math anxiety is different and distinct from test anxiety (Hembree, 1990; Wu et al., 2012). Research spanning over several decades has established math anxiety as separate from test anxiety and general anxiety (Beasley et al., 2001; Devine et al., 2012; Hembree, 1990; Wang et al., 2015).

What is Math Anxiety?

Math anxiety is defined as a person's negative affective reaction to a situation involving mathematics or a feeling of tension, apprehension or fear that interferes with an individual's math performance (Ashcraft, 2002; Ashcraft & Moore, 2009; Jansen et al., 2013; MacKinnon-McQuarrie, Siegel, Perry, & Weinberg, 2014). Three main effects of math anxiety are: physiological reactions, cognitive processes, and behavioral components (Kramarski et al., 2010; Krinzinger et al., 2009). The cognitive aspect refers to intrusive thoughts which can disrupt the learning process and have no mathematical function. The physiological reactions are affective. These include nervousness, tension, feelings of nausea, or increased heart rate, blood pressure, or cortisol levels. Behavioral reactions refer to an individual's avoidance of mathematics and math-related courses, or completion of a mathematical task in order to reduce the anxiety they feel.

It can be argued that the most significant consequences of math anxiety is avoidance of mathematics (Hembree, 1990; Ramirez et al., 2013), which has a domino effect on learning of mathematical concepts and negatively impacts mathematical achievement (Ashcraft, 2002; Hembree, 1990; Krinzinger et al., 2009; Maloney, Risko, Ansari, & Fugelsang, 2010; Rule & Harrel, 2006). Although not defined as a disability, Ashcraft and Moore (2009) suggest, "Math anxiety functions as a disability in the sense that there are well-investigated and negative-personal, educational and cognitive consequences of math anxiety" (p.198).

One of the initial contributors to the study of math anxiety, Sheila Tobias, suggests millions of adults are affected by math anxiety, blocking them from personal and professional opportunities (Tobias, 1978). Recent research suggests only seven percent of Americans have had a positive mathematics experience throughout their educational career, and two-thirds of adults fear and loathe math (Furner & Duffy, 2002; Harari et al., 2013). Ashcraft and Moore (2009) estimated seventeen percent of the population have high levels of math anxiety.

Maloney et al. (2010) state basic mathematics skills have been shown to be a crucial predictor of future life success. Additionally, Dowker, Sarkar, & Looi (2016) found low achievement and participation in mathematics to be a major concern for many countries, bringing an increased focus on math anxiety and achievement as countries seek individuals with quantitative reasoning skills in many educational and occupational situations. The impact of math anxiety can have far-reaching, adverse consequences for students, including avoidance of math courses and math-related career choices (Hembree, 1990; Ramirez, et al., 2013).

Hembree (1990) argued that math anxiety is of national importance. He suggested math anxious individuals will avoid advanced courses, limiting their career opportunities, and disrupt our country's resources in the areas of science and technology. Eden, Heine, and Jacobs (2017) suggest this does not just affect the individual but has far-reaching effects for the society. This is of particular concern today with the United States' emphasis of STEM education (Science, Technology, Engineering, and Math) and its impact on the global community. Math anxiety causes physical, emotional, and cognitive effects on an individual's math achievement, impedes future career choices, and has greater implications for the society as a whole.

Causes of math anxiety. The development of math anxiety has been thoroughly researched (Ashcraft & Krause, 2007; Finlayson, 2014; Geist, 2010; Hembree, 1990; Tobias, 1978). Socioeconomic status, gender, parental support, and teacher math anxiety can all impact who develops math anxiety independent of individual aptitude (Arnold et al. , 2002; Furner &

Duffy, 2002). Furner and Berman (2003) suggest lower socioeconomic status could lead to less exposure to educational experiences that would support positive math experiences. They also suggest a child's parents or teachers, who have either negative feelings towards mathematics themselves, can pass those anxieties onto the child. Vukovic, Roberts, and Wright's (2013) research focused exclusively on the role of parental involvement and its effect on math anxiety and performance. Their survey findings of 78 second grade children's parents suggest an inverse correlation between parent involvement (specifically home support and expectations for mathematics) and a child's math anxiety. Therefore, students who have more parent support at home with high mathematics expectations tend to experience less math anxiety than their peers (Vukovic et al., 2013).

Gender research indicates females tend to rate themselves lower and express more anxiety about mathematics than males (Hembree, 1990; Wigfield and Meece; 1988). The discrepancies regarding math anxiety and gender may depend more on how anxiety is measured (cognitive vs. affective) and on what aspects of mathematics are involved (Dowker et al., 2016). It should be noted, however, that gender differences have not been found in primary-age students and math anxiety (Harari et al., 2013; Ma, 1999; Wu et al., 2012).

Specific mathematics methodologies can also be linked to math anxiety (Finlayson, 2014; Linder, Smart, & Cribbs, 2002). Results from a multi-method study on elementary students' math motivation and anxiety include these possible causes of math anxiety: emphasizing basic skills, strict adherence to a fixed curriculum, instructor-focused classroom, working independently, emphasis on textbooks and workbooks, lack of student and teacher motivation, and extensively using direct instruction (Linder et al., 2002). These findings support results of

Finlayson's (2014) survey on pre-service teachers' self-described causes of math anxiety and Furner and Berman's (2003) review of research on math anxiety.

Additionally, the classroom environment can be linked to math anxiety (Beilock & Willingham, 2014; Finlayson, 2014; Geist, 2010. A mathematics classroom that is hostile, expresses an uncaring attitude, presents a gender bias, embarrasses students publicly, or has unrealistic expectations can all create math anxiety in students (Finlayson, 2014; Furner & Duffy, 2002). A skills-based classroom, which focuses on timed tests, rote memorization, and high-stakes assessments can also contribute to math anxiety (Finlayson, 2014; Furner & Duffy, 2002; Geist, 2010). Geist (2010) suggests, like Finlayson (2014), an over-reliance on textbooks and a shift from students constructing their own knowledge and concepts can undermine a student's natural thinking process causing anxiety and negative feelings towards mathematics.

Math anxiety can be attributed to lack of self-confidence, fear of failure, students' lack of knowledge, and student non-engagement (Bodovski & Farkas, 2007; Finlayson, 2014). Maloney and Beilock (2012) suggest both social influences, as well as cognitive predispositions contribute to math anxiety. Many factors need to be considered when determining the cause of math anxiety. Many of the causes of math anxiety can be remediated (Beilock & Willingham, 2014; Finlayson, 2014; Furner & Berman, 2003; Geist, 2010; Maloney & Beilock, 2012), and therefore provide purpose and significance in early detection and remediation for primary-age children with math anxiety. Creating a valid and reliable measure to assess primary-age children with math anxiety was an important first step.

Measures of math anxiety. The first objective test of math anxiety, the Numerical Anxiety Scale, was created in 1957 (Ashcraft & Moore, 2009). This measure was the first to distinguish between general anxiety and math anxiety and provided the foundation for math anxiety measurements. The Mathematics Anxiety Rating Scale (often called MARS), created in 1972, uses a five-point Likert scale to assess anxiousness in subjects given mathematical scenarios. However, due to its length, the MARS is time consuming to both administer and score (Ashcraft & Moore, 2009; Krinzinger et al., 2009). Since its creation, several modified versions of the MARS have been created to include an abbreviated edition (sMARS), an edition suitable for older elementary children (MARS-E), and one for middle school age children (MASC), (Ashcraft & Moore, 2009; Wu et al., 2012).

The Mathematics Anxiety Survey was the first to use pictures on the Likert scale to depict anxiety for younger children, and it continues to have good internal structure (Jameson, 2013). Most recently, Caviola, Primi, Chiesi, & Mammarella (2017) used one of the most commonly used scales, the Abbreviated Math Anxiety Scale (AMAS) developed by Hopko et al. (2003). They used this assessment, a five-point Likert-type scale, to look at two main factors, math learning and math testing (anxiety) with children ages eight to eleven.

Additional math anxiety measurements continue to be created based on the MARS. In order to more effectively administer math anxiety scales in children and continue to have good reliability, the following scales have been created for the specific use with primary-age children.

Math anxiety measures for children. The first math anxiety scale designed specifically for primary-age children is the Math Anxiety Questionnaire (MAQ) created by Thomas and Dowker in 2000. The MAQ uses a five-point pictorial Likert scale with anchor terms indicating ‘very happy’ to ‘very unhappy’ and ‘very worried’ to ‘very relaxed.’ Four different types of questions indicate self-perceived performance, attitudes in math, unhappiness related to math problems, and anxiety related to math problems (Wood et al., 2012) on seven math-related situations and one ‘training’ situation. Krinzinger et al.’s (2009) experiment on math anxiety and ability in early primary schools in Germany utilized the MAQ, and even with German translations, it had a strong reliability (α = .83-.91, depending on grade level).

A replication study in Brazil assessed MAQ's validity and reliability, which was consistent with the German population (α = .87) (Wood et al., 2012). Both concluded the MAQ to be a valid measure of math anxiety in primary-age children. Furthermore, they showed its consistency when used with diverse cultural backgrounds. However, it should be noted, Krinzinger et al. (2009) suggested the word "worrisome" with young children was a limitation, perhaps due to translation issues or terminology too advanced for primary children, and suggested using a physiological measure in the future. Replication of the MAQ is recommended within the United States.

Wu et al. (2012) created the Scale for Early Mathematics Anxiety (SEMA) based on the MARS, for use with second and third grade students. This measure provided a narrow age range in their assessment and intended to control for general trait anxiety, previously neglected in other math anxiety assessment. A 20-question, written survey was read to subjects. A five-point Likert pictorial scale and verbal replies were recorded. This measure noted an internal consistency (α = 0.87), suggesting a highly reliable and valid measure. Findings also indicated SEMA scores were not statistically correlated with trait anxiety ($r = 0.08$, $R^2 = 0.01$, $p = 0.37$), indicating general trait anxiety differs from math anxiety and did not explain the amount of variance in math achievement (Wu et al., 2012). Researchers included the SEMA in the appendix, encouraging others to utilize this tool with primary-age children.

Wu, Willcutt, Escovar, and Menon (2014) utilized the SEMA again with 366 second and third grade students to assess math achievement and achievement in relation to internalizing and externalizing behaviors in students with math learning disabilities, low achievement, and typical developing students. Wu, Chen, Battista, Smith, Willcutt, & Menon (2017) recently used structural equation modeling to look at the relationship between math anxiety, attention problems, working memory, and reading skills on 330 children from second to fourth grade. Findings indicated the effects of math anxiety and attention on working memory were significant ($p < 0.01$).

Cargnelutti, Tomasetto, and Passolunghi (2017) also found it to be a consistent measure (α = 0.86-0.87, second and third grade respectively) in a longitudinal study following 80 second graders onto third grade. It should be noted the SEMA scale was converted to a four-point pictorial Likert scale, as pilot studies indicated student difficulty in selecting from the five-point Likert (Cargnelutti et al., 2017). Their research found a direct link between math anxiety and performance in third grade and an indirect effect of math anxiety on performance in second grade.

Jameson (2013), however, noted weaknesses in all of the aforementioned children's measures. As suggested, some of the measures are intended for adults, and therefore, are not appropriate for children. Secondly, some are only intended for older children, and again, these are not appropriate for primary-age children. However, Jameson (2013) contends the scales that are utilized with young children are lacking because they ask students to correlate an emotion with a numerical value. Something, Jameson (2013) suggests, that is difficult because the emotion has no connection to the number; hence making a child circle a number to describe a feeling ineffective. Therefore, she created the Children's Anxiety in Math Scale (CAMS), which used a Likert-scale as well, however the pictures were the measure to be circled by the student instead of a number. When it was tested on elementary students from first to fifth grade, results of her exploratory factor analysis indicate good internal consistency and resulted in a three-factor solution of general math anxiety, math performance anxiety, and math error anxiety, as well as a strong reliability (α = .86) (Jameson, 2013). Additional studies using the CAMS, especially with primary-age children are needed to confirm results from the aforementioned study.

Another child math anxiety measure was created by Ramirez et al. (2013), called the Child Math Anxiety Questionnaire. This is an eight-item measure of math anxiety for early elementary students based off of MARS as well. A three-faced sliding scale is used by subjects to self-assess their math anxiety. Ramirez et al. (2016) revised this questionnaire, by adding eight additional questions in order to broaden the range of math problems, perhaps due to the low initial reliability of their first study (Cronbach's α = 0.55). The three-faced sliding scale was also replaced with a Likert-type scale using five distinct emotion faces from “not nervous at all” to “very, very nervous” (Ramirez et al., 2016). After revisions to the CMAQ, the 16-item questionnaire showed far stronger reliability (Cronbach's α = 0.83).

Results indicated math anxiety is a negative predictor of a student’s use of advanced problem solving strategies in students who had a higher working memory and suggested math anxiety may affect a student’s strategic behavior for solving advanced problems (Ramirez et al., 2016). At present, no other studies have been found utilizing the CMAQ. However, this could be due to the current publication date of the revision of the CMAQ.

Harari et al. (2013) created another anxiety scale called the Mathematics Anxiety Scale for Young Children (MASYC). This 12-item, four-point Likert scale does not include pictures and uses the terms “yes,” “kind of,” “not really,” and “no.” Math anxiety was assessed on three factors: negative reactions (α = 0.70), numerical confidence (α = 0.72), and worry (α = 0.67) when measured on 106 first grade students. Vukovic et al. (2013) conducted additional research using the MASYC; this time treating math anxiety as unidimensional. Again, they found good reliability as well ($\alpha = 0.80$) in their research on 113 second grade students.

Ganley and McGraw (2016) revised the MASYC, deleting four items they found to be confusing to some children and adding five new items that could be used across various grade levels and eliminated the use of the word "like" from some of the questions (as these questions all loaded on one factor, numerical confidence). The MASYC-R contains 13 questions utilizing the same scale as the MASYC and continues to show strong reliability and validity ($\alpha = 0.87$). The MASYC-R allows math anxiety self-assessment across grade levels with vocabulary simplistic enough for students as young as first grade (Ganley & McGraw, 2016). Currently, Ganley is revising the MASYC-R, adding three more questions into her current research (personal communication, August 2017).

All these measures are self-reported anxiety scales, which are the most practical to use in a school setting. However, it should be noted that other measures have been used to assess math anxiety. The use of physiological measures are utilized more often in a clinical setting. These could include the recording of brain function, MRI functioning and cortisol secretions (Dowker, et al., 2016).

Sgoutas-Emch and Johnson (1998) used salivary cortisol levels. Although their results were not statistically significant, the journal group showed a decrease in anxiety via the salivary cortisol analysis (score of 103.3 to 96.50) while the control group showed an increase in anxiety at the end of the semester. Mattarella-Micke et al. (2011) found increased cortisol concentration levels in high working memory, math-anxious students. They found the higher working memory in HMA students, the worse they performed compared to lower working memory and low math-anxious subjects.

This supports the work of MacKinnon-McQuarrie et al. (2014), who used salivary cortisol levels to show a negative relationship between cortisol levels and math performance. Specifically, they found first graders (who are suspected of having math disability) with higher levels of cortisol predicted poorer performance on working memory for numbers and quantitative concepts. Krinzinger et al. (2009) also recommended the use of physiological measures, as opposed to self-reported measures when assessing math anxiety after their self-reported measure failed to show a negative correlation. Utilization of physiological measures such as heart rate, blood pressure, or cortisol levels may provide more accurate measures of anxiety, removing extraneous variables of self-report or misunderstanding terminology such as ‘worrisome” or ‘anxious’ (Krinzinger et al., 2009; Ramirez et al., 2013; Sgoutas-Emch & Johnson, 1998).

Measures of math anxiety are continuing to become more sophisticated and specialized to the subjects within each research study (Jameson, 2013; Ramirez et al. 2016; Wu et al., 2012). The MARS continues to be the foundation for development of math anxiety measures, however, some new instruments are showing strong measures of reliability and should be considered in future research with young children and math anxiety.

Math anxiety has been a detrimental factor impacting cognition, developing negative feelings towards math, and creating an avoidance mentality among students (Kramarski et al., 2010; Krinzinger et al., 2009). This is particularly concerning to our earliest learners, as math anxiety appears to have a ‘snowball’ effect on performance and attitude toward mathematics (Geist, 2010; Krinzinger et al., 2009; Maloney & Beilock, 2012; Ramirez, Gunderson, Levine, & Beilock, 2013; Ramirez et al., 2015; Sgoutas-Emch & Johnson, 1998; Tobias, 1978). Therefore, it is critical to investigate young students and their attitudes toward mathematics (Kramarski et al., 2010). However, students who experience math success, show a decrease in math anxiety, suggesting success leads to more practice and an increase in performance (Bandura, 1997; Hembree, 1990; Jansen et al., 2013).

Math Anxiety and Achievement

Research in the area of math anxiety is plentiful. More than six decades of research has been conducted on math anxiety, its effects on performance, and treatment for math anxiety (Dowker et al., 2016; Geist, 2010; Hembree, 1990; Tobias, 1978). It is well established that math anxiety has a significant effect on math performance in both adults and children (Geist, 2010; Krinzinger et al., 2009; Maloney & Beilock, 2012; Ramirez et al., 2013; Ramirez et al., 2016; Sgoutas-Emch & Johnson, 1998; Tobias, 1978), although the majority of research has been conducted on teens and adults.

Special attention has been focused on pre-service teachers with math anxiety, as they have the highest level of math anxiety of any college major, and their own math anxiety has been shown to have negative effects on their students (Alsup, 2005; Furner & Berman, 2003; Rule & Harrell, 2006). Finding a treatment for teachers and students alike is an area in the field of math anxiety that needs more research.

Interestingly, math anxiety does not correlate with intelligence (Ashcraft & Moore, 2009; Hembree, 1990; Tobias, 1978) and can inhibit performance even in high aptitude individuals (Hembree, 1990; Legg & Locker, 2009, Wu et al., 2014; Wu et al., 2017). Students who have effective study skills have been shown to not utilize them, presumably due to the intrusive, negative thoughts regarding mathematics (Kramarski et al., 2010). This produces significant concern for students with math anxiety in relation to their math performance.

Ashcraft and Moore (2009) refer to the *affective drop* in performance, as a drop in performance due to math anxiety that is independent of the competence or achievement of the individual. Harari et al. (2013) define math anxiety as a *performance-based anxiety* stating, "Mathematics anxiety involves physiological arousal, negative cognitions, escape and/or avoidance behaviours, and, when the individual cannot escape the situation, performance deficits" (p. 539). Although a linear relationship between math anxiety and math achievement has been established, some research suggests this relationship neglects to look at the complexity of emotion and cognition in mathematics (Wang et al., 2015).

It can be argued a moderate level of anxiety is useful in focusing students and keeping students alert. Mattarella-Micke et al. (2011) contend non-math anxious individuals might benefit from a heightened state of math anxiety. This is dependent on their interpretation of the (physiological) reaction. Although Wang et al. (2015) conducted thorough longitudinal research and a replication study, findings suggest only high-intrinsically motivated people benefit from moderate levels of math anxiety. A focus on reducing math anxiety and increasing math performance should be a continued focus for researchers, as highly-math anxious individuals can benefit from treatment.

Working memory and math achievement. Extensive research exists on math anxiety's effect on working memory and achievement (Ashcraft, 2002; Ashcraft & Krause, 2007; Ashcraft & Moore, 2009; Mattarella-Micke et al., 2011; Ramirez et al., 2013, Wu et al., 2017). Working memory, or short-term memory, is an executive function of the brain that stores limited information temporarily for holding, processing, or manipulating the given information. Negative, intrusive thoughts regarding mathematics consumes space in the working memory, which is needed for mathematical computation and problem solving. Ashcraft & Moore's (2009) compilation of published literature found a negative correlation between math anxiety and math achievement due to the increased demand on working memory (*r* = -0.31 in college students, and *r* = -0.34 for pre-college samples based off of Hembree's (1990) research).

Higher working memory students may have more performance issues, as their working memory is consumed with math anxious thoughts which prevents the use of their advance problem-solving strategies (Mattarella-Micke et al., 2011; Ramirez et al., 2013). It is clear that mathematical tasks that require more advanced mathematics and calculations are more likely to be affected by math anxiety. This includes larger numbers, procedural math, and counting (as opposed to subitizing), which require more working memory, and are more likely to be impacted by math anxiety (Ashcraft, 2002; Ashcraft & Krause, 2007; Ashcraft & Moore, 2009; Maloney et al., 2010; Mattarrella-Micke et al., 2011). The dual task of computation and negative, worrisome thoughts has been shown to significantly decrease performance (Ashcraft & Krause, 2007). The most intensive computation on working memory is decomposition, which requires multiple steps of dissecting and reconnecting numbers in order to solve a problem (Ramirez et al., 2016). This is of particular concern due to the current focus of decomposition through Common Core State Standards in Mathematics (CCSSM) occurring as early as kindergarten (CCSSM, 2017).

Math anxiety and achievement in children. Research involving young school-age children has been limited. Historically, research has been conducted on students from fifth grade through high school, while far less has been conducted on elementary-age students (Wigfield & Meece, 1988). Wu et al. (2012) highlight the limited research on early childhood math anxiety and its effect on achievement, noting that Hembree's (1990) meta-analysis of math anxiety only looked at seven (of the 122) studies that involve pre-college subjects; none of which examined students under fifth grade. Wigfield and Meece (1988) found similar levels of math anxiety in students in 5th through 12th grade. Although dated, this study showcased the importance of early identification of math anxiety. However, the past five years has brought about an influx of research on primary-age children and the effect of math anxiety on achievement.

Current research has begun to focus more on early elementary students, perhaps due to the early onset of math anxiety and the extensive research on the benefits of early success in mathematics. Wu et al. (2012) found only three studies looking at math anxiety in young children (as of their 2012 publication date). The first was a conference paper by Thomas and Dowker which found math anxiety occurring in children ages six to nine (as cited by Wu et al., 2012). Second was the research of Krinzinger el al. (2009), which found calculation ability correlating with student evaluation of math by first grade students ($p < .001$). Lastly, Ramirez et al. (2013) noted a negative relationship between math anxiety and math achievement in first and second grade children ($r = .281$, $p < .01$).

Following this research, Wu et al. (2012) created a new tool for measuring anxiety on second and third graders, the SEMA (Scale for Early Mathematics Anxiety), and concluded that math anxiety can be found in the beginning stages of schooling and negatively correlated with math achievement (math composite score; β -0.26, $t(126) = -2.62$, $p = 0.01$, $R^2 = 0.43$ and math reasoning; β -0.34, $t(127) = -3.66$, $p < 0.01$, $R^2 = 0.57$). Furthermore, the SEMA subscales (numerical processing anxiety and situational performance anxiety) were correlated with math reasoning ($p = -0.27$, $p < 0.01$; $p = -0.28$, $p < 0.01$, respectively), but not numerical operations ($p = -0.13$, $p = 0.15$; $p = -0.09$, $p = 0.32$, respectively). This research supports the previous research on working memory (WM), as mathematical reasoning places a greater cognitive load on WM than numerical operations.

After the Wu et al. (2012) research, Wu and colleagues conducted two other studies assessing the relationship between math anxiety and achievement in primary-age children. Wu et al. (2014) found:

> Math achievement was not correlated with trait anxiety but was negatively correlated with math anxiety. Critically, math anxiety differed significantly between children classified as math learning disabled (MLD), low achieving (LA), and typically developing (TD), with math anxiety significantly higher in the MLD and LA groups compared to the TD group. (p. 503)

Specifically, after controlling for intelligence, math achievement was significantly correlated with attention problems (β = –.15, t(352) = –2.33, p = .02, R^2 = .06) and math anxiety, (β = –.25, t(340) = –4.24, p < .001, R^2 = .17), but not for other social or behaviors measured. Furthermore, after controlling for intelligence, math achievement predicted attention problems, (β = –.13, t(301) = –1.94, p = .05, R^2 = .05) and math anxiety (β = –.24, t(352) = –4.01, p < .001, R^2 = .16).

Wu et al. (2017) looked at affective and cognitive factors and their influence on verbal and non-verbal math abilities in second through fourth grade students. Their findings indicate mathematical reasoning and numerical operations had an indirect effect on achievement through working memory. Additionally, math anxiety had a direct negative effect on math reasoning but not on numerical operations. Their research further addressed attention, reading and working memory on both non-verbal numerical operations and verbal mathematical reasoning. Math anxiety had a pronounced influence on mathematical reasoning compared to numerical operations. Research conducted with the SEMA is listed in Table 2.

Table 2

Current research on math anxiety and math achievement in primary-age children using SEMA

Researchers	Cronbach's	Math Achievement Test	Results
Wu et al. (2012) *N* = 162 2nd and 3rd graders	α= .87	WASI (IQ test) WIAT- II scores (Numerical Operations and Math Reasoning) were combined: Math Composite score	Math anxiety significantly and negatively correlated with achievement (even in children with at or above grade level in math B= -0.26. $t(126)= -2.62$, p=.01, $R^2= .43$
Wu et al. (2014) *N* = 366 2nd and 3rd graders	Not reported	WASI (IQ test) WIAT- II scores (Numerical Operations and Math Reasoning) were combined: Math Composite score	Math achievement was significantly correlated with math anxiety, ($\beta = –.25$, $t(340) = –4.24$, $p < .001$, $R^2 = .17$) and a predictor or math anxiety ($\beta = –.24$, $t(352) = –4.01$, $p < .001$, $R^2 = .16$).
Cargnelutti et al. (2016) *N* = 80 2nd graders	α= 0.86,0.87	Computation and word problems (varied by grade level)	Increase in general and math anxiety from 2nd to 3rd Math anxiety impacted performance at 3rd grade only ($\beta =-.21$, $p < .01$), but not in second grade ($\beta =-.16$, $p = .12$). Math Anxiety in 2nd impacted future confidence in math

Cargnelutti et al. (2017) research looked at the relationship between general anxiety, math anxiety, and math proficiency, specifically to determine if math anxiety caused the poor math performance in math-anxious students. Results revealed that this link was significant in third grade ($\beta =-.21$, $p < .01$), but not in second grade ($\beta =-.16$, $p = .12$). Longitudinal analyses did show an indirect effect of math anxiety in second grade on subsequent math performance in third grade (Cargnelutti et al., 2017). Despite the non-significance found in second grade, the impact of anxiety on performance was greater in second than in third grade. Additionally, the effect size of math anxiety was higher than general anxiety by third grade. Cargnelutti et al.'s (2017) longitudinal research highlights the need for early detection and intervention for math anxiety and its 'snowball effect' on performance.

Additional research was conducted by Ramirez et al. (2013) with their math anxiety scale (Children's Math Anxiety Questionnaire: CMAQ) on 154 first and second-grade students. Ramirez et al. (2013) found a negative relationship between math anxiety and math achievement in high working memory (WM) students on more complex tasks (β = -0.770, t = -2.189, p = 0.03). Ramirez et al. (2016) revised their math anxiety scale (CMAQ-R) on 564 first and second-grade students. Again, a negative relationship was found between math anxiety and math achievement in students with higher WM (r = -.281, p < 0.01). An analysis of a two-way interaction between working memory and high math anxiety in first and second grade children negatively predicted their use of advanced problem-solving strategies and ultimately their achievement (β = -1.73, t = -2.28, p = .023) (Ramirez et al., 2016). Furthermore, their research indicated 26% of participants self-reported a medium to high level of math anxiety. Both studies analyzed math anxiety (as a unidimensional effect) on math achievement. Table 3 summarizes the research of the CMAQ and the CMAQ-R.

Other recent research on young children and math anxiety include the work of Harari et al. (2013), Vukovic et al. (2013), and Ganley and McGraw (2016). All three studies used the Mathematics Anxiety Scale for Young Children (MASYC) or its revised version, MASYC-R.

Harari et al. (2013) designed the MASYC to assess 106 first-grade students in a diverse, urban school setting. The research supported previous research (Hembree, 1990) indicating math anxiety scores were statistically significant and negatively correlated with three of the four math outcomes assessed:

Table 3

Current research on math anxiety and math achievement in primary-age children using CMAQ

Researchers	Cronbach's	Math Achievement Test	Results
Ramirez et al. (2013) *N* = 154 1^{st} and 2^{nd} graders	α = .55	Woodcock-Johnson III Applied Problems Subset WIAT-total digit span for WM	Negative relationship between math anxiety and math achievement in high WM students on more complex tasks β = -0.770, *t* = -2.189, *p* = .03
Ramirez et al. (2016) *N* = 564 1^{st} and 2^{nd} graders	α = .83	Woodcock-Johnson Applied Problems Wechsler Intelligence Scale for Children letter span task	~26% self-reported medium to high math anxiety in 2^{nd} graders ~correlation *r* = -.281, *p* < .01 Higher WM, greater negative relationship with math anxiety and achievement

- computation skills ($r = –.30$, $p = .002$)
- counting skills ($r = –.28$, $p = .004$)
- math concepts ($r = –.35$, $p < .001$)

However, mathematics anxiety scores were not correlated with number series ($r = –.15$, $p > .05$). Vukovic et al. (2013) continued research with the MASYC, adding the role of parental involvement, to determine if it had an impact on mathematical performance and math anxiety. Second-grade students in a diverse, urban school district were assessed on math anxiety, whole number arithmetic, word problems and pre-algebraic reasoning. Although their research focused mostly on parental involvement, the research indicated math anxiety had a statistically significant effect on word problems and algebraic reasoning, not whole number arithmetic.

Vukovic et al. (2013) stated, "The bootstrapped 95% confidence interval indicated that the indirect effect of home support and expectations on word problem and algebraic reasoning was statistically significant" (p. 457).

Most recently, Ganley and McGraw (2016) revised the MASYC in their research on 296 first to third-grade students. The research used three factors to assess math anxiety: negative reaction, worry, and numerical confidence. Each factor was assessed for general anxiety, math performance, math importance, math confidence, and math interest for each grade level in the study. Overall, Ganley and McGraw (2016) provided evidence of elevated levels of math anxiety in some students in primary grades, and reiterate the numerous, negative implications for future math development. Furthermore, all three grade levels indicated worry at a high level of anxiety (3.0-3.49): 9.6% of first-grades, 10.3% of second-graders, and 10.8% of third graders. Extremely worried students (3.5-4.0) accounted for 11.4% of the first-grade population, 4.0% of the second-grade population, and 12% of the third-grade population. This study found 33.1% (first grade), 25.5% (second grade), and 37.1% (third grade) worried about mathematics. Table 4 summarizes the research conducted using the MASYC or MASYC-R.

A great deal of current research on the prevalence of math anxiety and its negative effect on math performance has been conducted. The consequence of negative attitudes and feelings toward mathematics has been repeatedly addressed in cognitive and behavioral research. Remediation or intervention to help the estimated 25% of students suffering from math anxiety is needed.

Additionally, students who had greater success in mathematics increased their practice, which may improve their math performance. Concurrent research suggests high math anxiety (HMA) first graders are significantly impacted in their working memory, causing poor performance (MacKinnon-McQuarrie et al. 2014). The drop in performance is attributed to increased activity in the right amygdala, which is where negative emotions are processed. This is accompanied by a reduction in the region of the brain that supports working memory and numerical processing (Beilock & Willingham, 2014).

Table 4

Current research on math anxiety and math achievement in primary-age children using MASYC

Researchers	Cronbach's	Math Achievement Test	Results
Harari et al. (2013) *N* = 106 1st graders	α = .70	Stanford Diagnostic Mathematics Test-Fourth Edition for first grade Stanford Diagnostic Math Test α = .84	Math anxiety was significantly correlated with computation skills (r = –.30, p = .002) counting skills (r = –.28, p = .004) math concepts (r = –.35, p < .001)
Vukovic et al. (2013) *N* = 78 2nd graders	α = .81	Whole Number Arithmetic α = .85 Stanford Diagnostic Math Test α= .84 Key Math Diagnostic α = .83	~Math anxiety is detectable in 2nd grade ~Higher math anxiety in higher-order math (parent support was a main variable assessed in this study)
Ganley & McGraw (2016) *N* = 296 1st-3rd graders	α = .87	17 item math test created for 1st -3rd graders α = .83	25.5% of 2nd graders are above a mid-point level for worry ~Negative reactions and worry factors significantly correlated with math performance ($-0.19 < rs < -0.20$)

The importance of assessing young children and anxiety has become clear. The first years of formal mathematics instruction is the most profound time of cognitive developmental for young children (National Council of Teachers of Mathematics (NCTM), 2000). It has been established that math anxiety begins early, some suggesting it occurs as early as kindergarten (Arnold et al., 2002; Ashcraft & Moore, 2009). Of greater concern is the increasingly poor calculation performance of students from the beginning to the end of the primary grades even when their level of math anxiety did not increase (Krinzinger et al., 2009). Children who perform lower than average will fall behind, receive negative feedback, and will have a higher risk of developing math anxiety (Ashcraft & Moore, 2009). Recent research on elementary students found a reduction in math anxiety for all students who experience success in mathematics, regardless of their level of anxiety (Jansen et al., 2013). Early intervention is important for mathematics success in students with math anxiety.

The Importance of Early Mathematics Success

High-quality educational experiences are essential in mathematics, as it is the basis for all future mathematical concepts and experiences. The National Council for Teachers of Mathematics (2000) suggests a child's mathematics disposition is directly related to early experiences with math. Research supports the early engagement of mathematics for pre-school and kindergarten mathematics success (Arnold et al., 2002; Bodovski & Farkas, 2007; Geist, 1990). Many variables can contribute to mathematics achievement in young children. Motivation, task-avoidant behaviors, parental support, teacher attitude, and experiencing success all have a potential effect on mathematics achievement.

Student performance and task-avoidant behaviors have a direct correlation. Hirvonen, Tolvanen, Aunola, and Nurmi (2012) found a significant, negative covariance between level of math performance and level of task avoidance, leading Hirvonen et al. (2012) to surmise the lack of motivation, effort, and persistence are risk factors in skill development. Early engagement, exposure, and intervention in mathematics has shown an increase in student interest and achievement (Arnold et al., 2002), as math-anxiety and task-avoidant behaviors are both learned behaviors, not cognitive traits (Hembree, 1990). Increase in time for instruction has also shown an increase in achievement in all students, however, the effect of engagement was found to have a stronger impact on the lowest performing students (Bodovski & Farkas, 2007). Poor student performance and lack of engagement can be successfully remediated. Abilities in mathematics can be developed through effort, good teaching practices, and persistence (DiPerna et al., 2007; Fuson, Clements, & Sarama, 2015). Young students need to have positive, active engagement in mathematics to help their mathematical performance.

The long-term implications of early mathematical experiences and success are paramount. Several large-scale, longitudinal studies have researched the importance of math achievement in early elementary school (Cameron, Steele, Castro-Schilo, & Grissmer, 2015; Claessens & Engel, 2013; DiPerna et al., 2007; Duncan et al., 2007; Romano, Babchishin, Pagani, & Kohen, 2010). Duncan et al. (2007) utilized six longitudinal data sets in a meta-analysis which indicated early math skills as the strongest predictor of later academic achievement.

Romano et al. (2010) replicated the 2007 study of Duncan et al., which concluded kindergarten math also predicted socioemotional behaviors. Claessens and Engel (2013) conducted a secondary analysis of one of the national longitudinal studies utilized by Duncan et al. (2007). Their research aligns with Duncan et al. (2007), reinforcing early math skills as the strongest predictor of eighth-grade overall achievement. Additional research on the trajectory of mathematics achievement for children ages 5 to 14, over two, nine-year longitudinal studies (N = 9,032; N = 21,260) indicated the most rapid learning in math (and reading) are evident before the beginning of third grade (Cameron et al., 2015).

The results indicated students who learned more earlier, learned more overall. Their research found children to be in a position to have a rapid, critical period of growth and learning in early elementary school. Students who begin kindergarten with higher performance tend to make larger gains in achievement causing greater learning discrepancies over time (Bodovski & Farkas, 2007). Early childhood and elementary education in mathematics is essential to promoting future math achievement (Bodovski & Farkas, 2007; Claessens & Engel, 2013). Due to the early onset of math anxiety, remediating math anxiety in primary-age students is necessary to help them obtain strong math skills at the onset of formal schooling.

Early achievement in mathematics can have long-term implications. Claessens and Engel (2013) suggest a high-aptitude kindergartener may receive additional instruction, support, and potentially be placed in a higher-ability group, which can shape their development across domains throughout their entire school career. Early math achievement is one of the best predictors of late elementary math success, math grades in high school, high school graduation, and college entry (Duncan et al., 2007; Fuson, Clements, & Sarama, 2015). Claessens & Engel (2013) found early math skills to be crucial to future success, stating:

> The fact that early mathematics knowledge and skills are the most important predictors not only for later math achievement but also for achievement in other content areas and grade retention indicates that math should be a primary area of academic focus during the kindergarten year. (p.23)

It is evident that mathematical skills are essential for academic success across the curriculum and have a potential to impact college entrance, and ultimately, career choices (Bodovski & Farkas, 2007; Claessen & Engle, 2013; Duncan et al., 2007; Fuson et al., 2015). It is imperative to provide a strong academic focus on early math skills in order to capitalize on the rapid growth that young elementary students' experience (Claessen & Engel, 2013).

Math anxiety and its effect on achievement have been clearly documented (Ashcraft & Moore, 2009; Ramirez et al., 2016; Tobias, 1978). Its impact on working memory, independent of intelligence or ability requires attention (Hembree, 1990; Ramirez et al., 2016; Tobias; 1978), and early intervention through active engagement and exposure are essential in preventing long-term consequences of math anxiety (Alsup, 2005; Arnold et al., 2002; Bodovski & Farkas, 2007; Jansen et al., 2013).

Many strategies have been found to minimize math anxiety and improve student performance (Alsup, 2005; Bodovski & Farkas, 2007; Maloney & Beilock, 2012; Ramirez et al 2013) although few, if any are being utilized within most elementary schools currently. Dowker et al. (2016) suggested several strategies that are starting to be utilized to treat math anxiety. They include systematic desensitization, cognitive behavior therapy, and non-invasive brain stimulation. Most of these techniques require individualized counseling, therapy, or training, all of which are required outside of the typical school day, take an extended period of time, and require financial support. However, Dowker et al. (2016) suggest recent research on math anxiety and achievement provides promising for remediating math anxiety through expressive writing.

Expressive writing is one strategy found to alleviate anxiety, clear working memory, improve feelings towards mathematics and increase performance (Park et al., 2014; Rule & Harrell, 2006; Salinas, 2004; Sgoutas-Emch & Johnson, 1998). Moreover, expressive writing is free, relatively-quick, and can be successfully implemented within a classroom setting to a large number of students. Providing students with an early intervention of this strategy is key to helping improve student perceptions and anxieties about math, increasing achievement, and helping prepare our youngest learners for continued success in mathematics throughout adulthood (Claessens & Engel, 2013; DiPerna et al., 2007; Duncan et al., 2007; Maloney & Beilock, 2012).

Expressive Writing and its Effect on Anxiety

James Pennebaker has spent 30 years researching the use of expressive writing in various therapeutic environments, such as: job loss, depression, the military and PTSD, and even after the attacks on September 11, 2001 (Bond & Pennebaker, 2012; Fernández Sedano, I., Páez Rovira, D., & Pennebaker, J. W., 2009; Sayer et al. 2015, Spera, Buhrfeind, & Pennebaker, 1994). His work with expressive writing as a technique to reduce stress and anxiety has been well documented in various fields of psychology (Fernandez Sedano et al., 2009; Pennebaker & Francis, 1996; Spera et al., 1994). Spera et al. (1994) suggests that writing about stressful events allows the individual to work through their negative feelings.

Expressive writing refers to writing for approximately 10 minutes about a stressful or traumatic event over a period of approximately three to five days (Pennebaker & Francis, 1996; Ramirez & Beilock, 1996). However, some research has found improvement in academic performance after just one expressive writing episode (Ramirez & Beilock, 2011). Chung and Pennebaker (2008) researched the differences in the timing of expressive writing sessions. They determined that no significant differences occurred in participant engagement or short or long-term reactions to the intervention, indicating one session can be just as beneficial as three sessions in college-age students. The benefits of expressive writing in educational environments, specifically mathematics, have begun to be explored.

Pennebaker and Chung (2007) contend the writing paradigm is a powerful tool for children up to the elderly, and the overwhelming majority of participants over the past three decades of research indicated expressive writing was a valuable and meaningful experience in their lives. As of 2009, over 200 studies in English language journals have researched or were in the process of publishing research on the benefits of expressive writing (Pennebaker & Chung, 2007).

Expressive writing in education. Expressive writing in education has also traditionally been utilized with college-age students (Pennebaker & Francis, 1996; Ramirez & Beilock, 2011; Park et al., 2014). Pennebaker & Francis (1996) found that college-age students who wrote expressively regarding their concerns regarding college for 20 minutes improved in physical health compared to the control group ($d = 0.52$, $N = 72$). Subjects in the experimental group were asked to write specifically about their thoughts, feelings, and concerns about college, as opposed to the control group, which were instructed to write for 20 minutes about an object or an event in an objective way. Physical health was measured by the number of subject visits to the student health center. A 2 x 3 repeated-measure ANOVA computed the means of number of health care visits on subjects, showing a drop in the number of visits by experimental subjects in the two months following the experiment [$F(2, 140) = 2.83$, $p = 0.06$].

Academically, subjects' GPAs, hours attempted, and SATs were collected for two semesters. Multiple regressions were calculated for each semester's GPA while controlling for hours attempted and SAT scores. A 2 x 2 repeated-measure ANOVA was conducted on corrected GPAs, showing an increase for the expressive writing group compared to the control group from first to second semester [$F(1, 59) = 3.39$, $p = 0.07$]. This research supports the use of expressive writing as a relatively simple and effective technique for not only improving grades, but it also supports improved health.

Ramirez and Beilock (2011) assessed the benefits of pre-writing prior to testing to enhance performance in four different studies. The first study showed the expressive writing group (students who spent 10 minutes writing about their thoughts and feelings regarding math problems in their exam) outperformed the control group (who was asked to sit quietly) (N = 20, d = 2.48), although limited in subjects, the initial research provided support for continued research in the benefits of expressive writing on anxiety. To extend their previous research, Ramirez and Beilock (2011) compared an unrelated writing group with an expressive writing group and increased their sample size (N = 47). Although no difference in performance was found prior to writing, posttest results indicate a 7% drop in accuracy from pretest to posttest in the control group [($t(30) = 3.35$, $p < 0.01$, $d = 1.17$], which did not occur in the experimental group [$t(29) = 1.07$, $p = 0.29$]. It should be noted the last two studies conducted by Ramirez and Beilock (2011) involved testing in biology and not mathematics. Regardless, the results suggest that expressive writing about worries decrease anxiety and increase performance in high-stakes testing situations.

Two additional studies examined if expressive writing benefits test performance by reducing anxiety for students who are the most anxious (N =51 and N = 55, respectively). An inverse correlation between test anxiety and final exam scores (the higher the anxiety, the lower the exam score) was found for the control group [combined 2 studies, $r(56) = -0.51$, $p < 0.01$] but not for the expressive writing group [combined 2 studies, $r(50) = -0.14$, $p = 0.33$]. These findings indicated final exam scores from the expressive writing group significantly outperformed the control group.

In their final analysis, Ramirez and Beilock (2011) separated high-anxious from low-anxious students using a median split. No significant difference was found in high anxious students prior to writing intervention [all p values > 0.60]. However, after writing intervention, expressive writing students outperformed the controls by 6% [$t(52) = 2.08$, $p < 0.05$, $d = 0.57$] and performed similarly to low-anxious students regardless of writing condition [$t(78) = 0.66$, p

= 0.52]. Ramirez & Beilock (2011) found short expressive writing prior to testing reduces math test anxiety and increases performance that general writing does not. Expressive writing is a quick, inexpensive tool for remediating students with math and/or test anxiety.

Expressive writing in math education. Current educational trends advocate for the use of writing in mathematics (NCTM, 2000). However, writing in math education has been used predominantly in communication of mathematical ideas, as highlighted in the current Common Core State Standards for Mathematics (Cohen et al., 2014, NCTM, 2000). Furthermore, educators have used writing to assess students' metacognition in problem solving, construction of viable arguments, and reasoning-based writing (Cohen et al., 2014; Park et al., 2014). Recently, however, studies have focused on expressive writing in the reduction of math anxiety (Furner & Duffy, 2002; Park et al., 2014; Salinas, 2004).

Writing and symbolic drawing have been found to be effective strategies for reducing anxiety in math anxious college students (Rule & Harrell, 2006; Salinas, 2004; Sgoutas-Emch & Johnson, 1998), although none of the aforementioned defined the writing as "expressive writing." It was determined that statistics students who kept a journal recording their performance, attitudes, and anxieties toward the course showed improvement in their grades, self-reported lower anxiety prior to exams, and had a lower physiological reaction based on salivary cortisol levels (Sgoutas-Emch & Johnson, 1998). Although not statistically significant, exam scores for the journal group increased 7.5 points compared to the control group, which maintained the same performance level. Furthermore, salivary levels confirmed the journal group became more physically relaxed during the exam than the control group [$F(1, 32) = 11.30$, $p < .03$).

It should be noted that this research is dated, and there has been limited replication of this type of study in the field of math education. Lack of statistical significance, extraneous variables in salivary collection, and self-reported measures may be factors limiting this study. However, the research concluded journal writing to be most effective with highly math anxious individuals, which supports Salinas' (2004) research on the use of notebooks on perceived math anxiety (Sgoutas-Emch & Johnson, 2004).

Salinas' (2004) research analyzed 'reflective notebooks' to assess student perception of learning and math anxiety. Students (*N* = 24) were asked to record thoughts, respond to assignments or questions, or comment on math material after each class for a semester. Notebooks were collected weekly by the instructor, who offered comments and encouragement in the notebook. Data were collected in four separate ways: notebook content and frequency of content, instructor notebook indicating in-class discussions that pertained to the notebooks, semester-end surveys regarding the use of notebooks, and a random sample of subject interviews.

Early reflections from subjects indicated fear, dread, and negative thoughts regarding the mathematics content. Frustration was found to be a common theme among survey responses and journal entries. Students shared thoughts of how their own fears and attitudes impacted their learning. Additionally, students reported positive comments on the use of notebooks to help share their own feelings and monitor their learning. It should be noted this writing was conducted after the mathematics class, not prior, as most research has utilized and recommended. The purpose was to create a dialogue among teacher and student, assist in self-understanding of their own mathematics and the fears and feelings associated with it. It should be noted that subject writing may be compromised as a result of the teacher's collection and response to the notebook. Regardless of the timing of writing intervention and possible effect of teacher interaction, self-reported math anxious students found writing to be an effective tool in decreasing their anxiety and enhancing their learning (Salinas, 2004).

Similarly, pre-service teachers (N = 52) indicated a decrease in math anxiety after using symbolic drawings in a math methods course (Rule & Harrell, 2006). Using a triangulation mixed-method study, Rule and Harrell analyzed images and the interpretations of those images created by pre-service teachers. At the beginning of the course, subjects' creations depicted negative images (such as crying or sad faces, poor grades, or clocks indicating time pressures) 63.2% of the time. Subjects were asked to associate the pictures with feelings or words. Of these word associations, 60.4% of all the statements or phrases associated with the pictures were negative. At the posttest, however, only 27.9% of the images drawn were negative, and subjects' statements and phrases related to the images were only 29.5% negative.

This research focused specifically on using discourse, sketch ideas for math manipulatives, and use instructor feedback prior to performance. While this study does not specifically look at the use of expressive writing or drawing as an intervention for math anxiety, it does show the importance of drawing and writing as a way to express anxiety regarding mathematics. This is significant to the proposed study, as the early elementary subjects may utilize more symbolic drawings, as opposed to written words due to the young age of the students. More recent research, however, has assessed expressive writing specifically.

Although expressive writing has been shown to increase performance in previous math-anxious individuals (Furner & Berman, 2003; Maloney & Beilock, 2012; Park et al., 2014), the research is limited. Park et al. (2014) is the only current research located that has assessed expressive writing as an intervention strategy for math anxiety. Subjects (N = 76) were prescreened for math anxiety using the SMARS (Short Math Anxiety Rating Scale), which asked subjects to rate how anxious they feel during math situations (e.g., “Receiving a math textbook;” 0, not at all; 1, a little; 2, a fair amount; 3, much; 4, very much).

Subjects scoring below 20 were identified as Low Math Anxious (LMA), and students scoring above 40 were identified as High Math Anxious (HMA). Additionally, subjects were given a test-anxiety questionnaire, which indicated HMA individuals (M = 74.34, SD = 13.00) reported higher test-anxiety than LMA individuals (M = 52.19, SD = 11.20). After performing six high-demand math and six-high demand word problems, subjects were divided into an expressive writing group and a control group. The expressive writing group wrote for 7 minutes about their thoughts and feelings, while the other group was asked to sit quietly. After, both groups began a 60 math problem and 60 word problem exam.

Several differences were found between HMA and LMA subjects. HMA subjects in the control group spent significantly more time on high-demand problems than the LMA control subjects [$F(1, 37) = 4.67$, $p < .05$]. However, no significant difference was found between the HMA and LMA subjects in the expressive writing group [$F(1, 37) = 1.15$, $p > .20$]. Similarly, a marginally significant math anxiety and writing group interaction was found for high-demand word problems [$F(1, 75) = 3.66$, $p = .06$]. No significant difference occurred for low-demand math problems or word problems. This supports research suggesting expressive writing removes negative thoughts and feelings from working memory, providing individuals more cognitive space for high-demand mathematics (Maloney & Beilock, 2012; Park et al., 2014).

Furthermore, a high math anxiety (HMA), expressive writing interaction occurred on high-demand math problems. After expressive writing, HMA students performed as well as the LMA peers [$F(1, 37) = 2.64$, $p > .10$], in comparison to the HMA subjects in the control group who performed significantly worse than the LMA control subjects [$F(1, 37) = 15.88$, $p < .001$]. The research by Park et al. (2014) shows promising results for the use of expressive writing for math anxious students. Additional research utilizing expressive writing as an intervention for math anxious students is needed.

Most recently, Hines, Brown, and Myran (2016) examined the effects of expressive writing about a neutral topic to expressive writing about math concerns in 93 high school geometry students. An analysis of covariance (ANCOVA) was conducted to determine if there were significant differences between the two groups on their posttest, when using their pretests as a covariant. This was the only statistically significant difference found between the groups on anxiety [$F(1,93) = 3.8$, $p = .05$, $\eta^2 = .04$]. A one-way analysis of variance (ANOVA) determined there was no statistically significant difference between groups on their pretest scores, although the experimental group had a higher mean anxiety score (experimental: $M = 232.7$, $SD = 74.5$; control: $M = 209.3$, $SD = 71.9$). Lastly, an ANCOVA compare the effect of expressive writing between groups using the pretest scores as a covariate. Although it did not show a statistically significant difference [$F(1, 93) = 1.9$, $p > .05$, $\eta^2 = .02$], both groups had a decrease in math anxiety. Cognitive processing on writing was measured, but not specifically math achievement. Therefore, a correlation between math anxiety and achievement was not measured. Research on the effects of expressive writing on math anxiety and math achievement is needed.

With the overwhelming amount of research on working memory and its effect on performance (Ashcraft & Krause, 2007; Ashcraft & Moore, 2009; Legg & Locker, 2009; MacKinnon-McQuarrie et al., 2014), further research is needed to determine if expressive writing is a beneficial tool for primary-age, math-anxious children to utilize in decreasing their anxiety and improving their math performance. To date, there does not seem to be research on expressive writing and its effects on the performance of early elementary children. Therefore, the current study utilized expressive writing as an intervention strategy for primary-age students to determine if expressive writing helped lower math anxiety and increase performance in highly-math anxious, second-grade children.

Chapter 3

Methodology

The purpose of this quasi-experimental design study was to examine the effect of expressive writing on math anxiety and math achievement for second-grade students with self-reported, high math anxiety (HMA). Specifically, students were assessed for math anxiety using the Math Anxiety Scale for Young Children-Revised (MASYC-R) to determine which students were HMA, moderately math-anxious, or low math-anxious. A math achievement assessment (an i-Ready computational fluency assessment) was used to assess their baseline computation skills. Students were asked to write expressively about mathematics concerns (treatment) or write expressively about a free-choice topic (control). Following five 10-minute sessions of writing, students were reassessed on math achievement and self-reported math anxiety. This research has potential positive implications for students with HMA, teachers, principals, and the school district.

Research Questions

The purpose of this study was to examine the impact of expressive writing on math anxiety and math achievement in primary-age, math-anxious children in a second-grade classroom in a suburban public school. Specifically, this research sought to answer:

1. Did expressively writing about mathematical worries decrease self-reported math anxiety in second-grade students who are highly math-anxious (HMA)?

2. Did expressively writing about mathematical worries increase math achievement in second-grade students who are highly math-anxious (HMA)?

3. Was there a statistically significant difference in math achievement between self-reported math-anxious students who wrote expressively about mathematics compared to students who wrote expressively about a free-choice topic?

Sample Demographics

The participants of interest were second-grade students. The entire second-grade from a suburban, predominantly Caucasian, elementary school was selected, as the second-grade teachers had agreed to commit to the study. The principal was also in support of the program and had issued a letter of support (See Appendix C). This study was a quasi-experimental design utilizing a convenience sample.

Variables

Dependent variable. The dependent variable was math achievement. Math achievement was assessed prior to treatment. Students were given the i-Ready computation fluency assessment prior to the intervention and again after five days of expressive writing. Students were familiar with the i-Ready format, which had been adopted district-wide. Additionally, the school uses the i-Ready diagnostic to assess student aptitude three times during the school year. Research conducted by the Educational Research Institute of America (2016) identified statistically significant correlations between the i-Ready diagnostics test and the New York State English and Mathematics assessments ($\leq .0001$ ranging from .74 to .86) for all categories and ages. Despite this, the i-Ready diagnostic was not an appropriate measure for assessing math ability in this research study due to the length of the exam, the content it covers, and the inability to control for when the diagnostic is administered to the students within the school year. Therefore, a computational fluency worksheet from the i-Ready program was used to assess only addition and subtraction computation.

Due to student comfort with the paper-pencil format, the simplicity of the worksheet, and the lack of additional mathematical content within this worksheet, it was chosen as an appropriate assessment of student computational achievement. The paper-pencil test assessed addition and subtraction facts with one- and two-digit numbers, with and without regrouping. This assessment was not announced as a timed test. However, students were given 15 minutes to complete the assessment. Those who did not complete it during the time frame were asked to hand it in unfinished. The assessment had 22 questions and each question was scored as either correct or incorrect, creating a 22-point scale. It was determined that a paper-pencil test would be the better assessment choice, as the students had less experience on the computers, and the paper assessment was a quicker, more convenient approach for the teachers and students.

As this was a district-required program, permission was not required to use the assessment, as the school had a site license for the program. However, the researcher did contact the creators, Curriculum Associates, and received permission to use this assessment within the study.

Independent variables. The independent variables were expressive writing and math anxiety.

Expressive writing. The first two research questions used expressive writing as the independent variable. The first research question determined if expressively writing about mathematical worries decreased math anxiety in second-grade students who were highly math-anxious (HMA). The second research question used expressive writing to determine if there was an increase in highly-anxious, second-grade students' math achievement following a week of writing intervention. The third research question assessed if there was an interaction between both independent variables (expressive writing and anxiety) on math achievement.

Two classes were randomly placed into the treatment or control groups for expressive writing. The treatment was defined as being asked to write expressively about math worries for 10 minutes prior to performing mathematical tasks. Two entire classrooms were randomly selected to write about mathematical worries for the duration of the study. Mathematical tasks included, but were not limited to, taking a timed test, participating in their math lesson, or working on a math assignment. The control was operationalized as expressively writing about a topic of choice for 10 minutes prior to performing a mathematical task. Two separate classrooms were randomly selected to be the control group classrooms for this study.

Writing, as suggested by Lepore, Greenberg, & Smyth (2002), can vary greatly depending on the purpose for writing. For expressive writing in this research, the writing was structured in the directions provided to students. However, the student writing was unrestricted and could include sentences, phrases, or pictures. In order to help keep the process consistent and streamlined, teachers used scripted prompts and conducted a brief (2-5 minutes depending on the day) brainstorming session with the class. The teachers read the script and made a list of words and thoughts that students shared in the brainstorming session. The scripts and prompts for both groups are provided in Appendix E.

Due to the benefits associated with expressive writing, it would have been unethical to deny students these benefits. Therefore, there was not a true control, as it was presumed expressive writing alone may have had benefit (See Table 1: Hines, Brown, & Myran, 2016).

Writing was collected in individual writing books for the students. No writing was assessed, however, teachers ensured that students were writing for a minimum of five minutes during the designated time. After the first five minutes, students were invited to continue writing or draw pictures to express their feelings about their topic.

Math anxiety. The third research question used math anxiety as the independent variable to assess if an interaction between writing expressively and math anxiety existed. Math anxiety was measured using the 13-question Math Anxiety Scale for Young Children-Revised (MASYC-R) (See Appendix A). As the MASYC-R was rated on a 4-point scale on 13 questions, HMA students needed to score to 31-52 points. Thirty-one was used as the cutoff for HMA, as this would indicate if the student had at least half of their responses be "kind of" or "yes." Additionally, the data indicated an appropriate split from moderately anxious students to highly anxious students at an anxiety score of 31. LMA students were considered to be students who scored between 13-19, with the majority of their responses as "no" or "not really" for negative reactions or worry, and "yes" for numerical confidence. It was expected only 25% of the students fall into the HMA category, as this percentage is supported by previous research (Eden et al., 2013; Ganley & McGraw, 2016; Ramirez et al., 2013). Consistent with previous research, 22.5% of the population in this study identified as highly math-anxious.

Design

Students were sent home with a letter informing parents of the upcoming research (See Appendix D). Parents were given the option of removing their child's data from the research. Seven students were removed from the data due to parents choosing to not participate. Regardless of student permission and to prevent students from feeling excluded, all students were given both assessments and received a writing booklet, with the exception of one student. This student's parent did not want their child to participate in any aspect of the research. The scores of the children whose parents refused to participate or students who had missing data were removed from the research. The research occurred for one full week of school at the end of

October. A week was chosen to minimize classroom disruption, maximize a full week of instruction, and to accommodate the research assistant's schedule.

Prior to the first day of research, the researcher pulled teacher names out of a bag to determine which classes would be the treatment groups and the control groups. The first two names were the treatment group. The second two names were the control group. Both groups contained HMA and LMA students, however, the control group had 42 participants; 11 of which were considered HMA, 17 LMA, and 14 considered moderately math-anxious (MMA). In contrast, the treatment group had 38 participants, but only had 7 HMA students, 17 LMA students, and 14 MMA. The number of participants with completed, usable data totaled 80.

On Monday, the students were given the math anxiety assessment by the research assistant. The math assessment was given immediately afterwards by the classroom teacher. The students were instructed using the math assessment script (see Appendix F) to use their hundreds charts if they chose. Students were asked to complete the assessment to the best of their ability. Students were given 15 minutes to work on the math assessment, but the students were unaware they were being given a time limit to prevent any possible anxiety. Immediately after the assessments, the classroom teacher brainstormed words, ideas, and phrases to correspond with the classes' expressive writing topic using the expressive writing script (Appendix E). Students were then asked to write for five minutes. After five minutes, students were asked to either continue writing or add pictures to their writing, depending on their preference. After 10 minutes of writing, writing books were collected and stored in the classroom by the teacher.

On Tuesday, Wednesday, and Thursday, students were reminded of the brainstorming from the previous day and asked if they had any other words to add to the brainstorm poster (which was posted in the classroom). Wednesday and Thursday, the brainstorming time was decreased, as students had a wide range of words to use in their writing. The writing prompt was read to the students, and again students were given five minutes of writing, followed by an invitation to either continue writing or to add illustrations to their writing.

On Friday, students began the day by being reminded of the brainstorm, but on this day, students were asked to begin writing for the last time. After the five minutes of writing, and the additional five minutes of writing or drawing, student writing books were collected. Students were then asked to complete the math anxiety assessment as a class (with the research assistant reading the directions and statements again). The same math assessment was then given to students by their homeroom teacher to complete at the culmination of the study. The schedule for these data collection events is present in Table 5.

To minimize researcher bias, the researcher utilized a certified, substitute teacher (research assistant) who was familiar with the school, the students, and licensed to work with children. She was provided with directions and scripts for instruction and implementation of the treatment, as well as, the pretest and posttest measures. The research assistant refused compensation for her time.

Table 5

Schedule for administration of assessments and expressive writing

Day	MAYSC Assessment	i-Ready Computation Fluency Assessment	Expressive Writing
Monday	x	x	x
Tuesday			x
Wednesday			x
Thursday			x
Friday	x	x	x

The math anxiety measure (MASYC-R) was given prior to the math achievement in order to avoid the assessment having an influence on the results of the math anxiety measure. The

MASYC-R was administered in a whole-group format, as the research assistant read the 13 questions using the script provided (See Appendix A). The students circled their response to each question. This took approximately 15 minutes per class. Following the MASYC-R, students completed a 22-problem assessment called the i-Ready computational fluency practice. The research assistant asked students to complete the worksheet and return it to their teacher upon completion. This assessment was a math worksheet that would typically be given to these students during a regular math lesson and was not announced as a test or an assessment. This paper test took 15 minutes as well, however, less capable students who could not complete the task were asked to complete as much as they could (See Appendix B). The research assistant collected the math assessments and math anxiety measures when they were completed.

The researcher used Excel to input the scores of the math anxiety scale and matched the math assessment score to the appropriate identification code. Students were ordered alphabetically be teacher last name to receive an identification code number. These numbers were kept and printed in Excel to verify any discrepancies.

The classroom teachers used scripts for the next four days to read the directions for the expressive writing component and help students brainstorm ideas for their writing. The researcher provided each participant with a small, age-appropriate writing journal for the purpose of expressive writing throughout the study. Additional journals were needed after Tuesday, and most students filled several books with writing.

The expressive writing script was read to two entire second-grade classes who consisted of the treatment group, to do expressive writing about math worries (See Appendix E). This procedure was repeated with two different classrooms, known as the control group, where the expressive writing script invited them to write expressively on any topic of choice. The classroom teacher notified the students after five minutes to allow for students to add drawings to their writing and stopped the class after 10 minutes, collected the books, and placed them in a container for the subsequent day.

This procedure was repeated in four different classes, at the beginning of each day to maximize consistency amongst the classes. Containers held each classroom's writing materials to avoid confusion or lost materials. These were stored securely in each teacher's room throughout the study.

On the final day of the study, the students wrote expressively as they had done the previous four days. Following the expressive writing, the entire class retook the math anxiety scale, given by the research assistant, and the math assessment, using the same procedures and scripts provided at the pre-assessment. The research assistant collected all materials from students who received permission to participate. The research assistant delivered all research materials (post-assessments and writing books) to the researcher for analysis.

These procedures were consistent with a two-group, quasi-experimental design. Utilization of script, random assignment of classrooms, manipulation of the treatment variable, the ability to have a control group, and no researcher interaction with the participants made this research plan and sample of second-grade students appropriate choices for this quasi-experimental research.

Data Clean

The pretest and posttest data from the math anxiety assessment and math achievement measure were cleaned prior to running analytical procedures. The classroom teacher provided a list of the student identification codes for each student. Student identification codes were entered into Excel for the pretest. Following the posttests, the researcher matched the student identification code from the pretest with the code from the posttest. Three students did not do the pretest and therefore, their data was removed. Seven students were not permitted to take part, and their data were also removed.

Additionally, six students did not have a signed permission slips at the end of the research. Teachers sent out the permission slip to families on four separate occasions. After the fourth attempt, the remaining six students who still did not have permission slips had their data removed from the Excel file. The remaining 80 participants' data was transferred to SPSS for data analysis.

Data Analysis

Exploratory data analysis was conducted on the descriptive statistics for this experiment. A three-way mixed analysis of variance (ANOVA) was used to determine the following:

1. Was there a difference between students' math achievement between the mathematical expressive writing group and the free-choice writing group?

2. Was there a difference in HMA students' self-reported math anxiety after mathematical expressive writing?

3. Was there a difference in HMA students' math achievement after mathematical expressive writing?

Interpretation and reporting of results. Following the analysis of data, the researcher determined if a statistically significant three-way interaction existed. If a statistically significant three-way interaction existed, the researcher looked for statistically significant two-way interactions and simple, simple main effects and simple, simple comparison in the data. If no statistically significant three-way interaction existed, the researcher determined if there were any statistically significant two-way interactions. (Laerd Statistics, 2015). Table 6 contains the null hypotheses assumed regarding this research.

Table 6

Null hypotheses assumed

There is no statistically significant difference in math achievement between the two types of expressive writing groups (mathematical and free-choice).
There is no statistically significant difference in math achievement scores for HMA students who write expressively about mathematics.
There is no statistically significant difference in self-reported math anxiety for HMA students who write expressively about mathematics.

Both statistically significant and not statistically significant main effects were reported. The hypotheses were accepted with the descriptive statistics as justification for the acceptance of the initial null hypotheses.

Assessing Data Assumptions

The following assumptions are required to conduct a three-way mixed ANOVA. The assumptions are listed in Table 7. These assumptions make the three-way mixed ANOVA an appropriate measurement for this research.

Research Ethics

All students performed expressive writing to prevent withholding of treatment to any participants. The treatment manipulation was the type of expressive writing performed. Random assignment of groups prevented research bias. Identification codes ensured confidentiality. Teachers were the only one able to identify each student. This minimized any potential researcher bias.

Table 7

Assumptions required for a three-way mixed ANOVA (Laerd Statistics, 2015)

1. The research measured one continuous dependent variable (post math achievement) on a scale from 0-22.

2. There was one, categorical between-group independent variable (expressive writing about math or non-math). There was a second, categorical between-group independent variable (math anxiety).

3. There was one, within-subject, categorical factor (time) that was used to measure pretest and posttest measures of math achievement.

4. Boxplot data analysis detected any significant outliers in this research. There were no significant outliers that needed to be removed.

5. Shapiro-Wilk test for normality determined normal distribution of dependent variable (math achievement).

6. Levene's test for equality of variance determined equality on between-groups (type of expressive writing) variance of the dependent variable (math achievement).

7. The variances of the differences between groups in this research should be equal.

An IRB was obtained from the school district in order to conduct research within the school. A letter was sent to all parents or guardians of the second-grade students in the school informing them of the research study and allowing parents to refuse participation if desired. No compensation was offered to participants; however, the research assistant was offered compensation, which was refused. The cooperating teachers were provided gift cards as a thank you for their assistance.

Threats to validity. A threat to internal validity was lack of a covariate of mathematical aptitude. Although it was considered as a potential variable in the experiment, the pretest established a baseline score for each individual, and therefore, math aptitude was not utilized. Individual differences could also be a threat to internal validity. The researcher chose not to match individuals between groups to reduce this threat, as the focus was on a particular group of individuals (HMA) and their scores on anxiety and achievement after treatment.

Lack of a true control was a threat to internal validity. It is unethical to keep a beneficial treatment from participants, therefore, all students participated in a type of expressive writing. Furthermore, it would be unethical and impractical for the researcher to request the control participants to sit quietly for 10 minutes, as this would be a waste of time and educational opportunity for the participants. Testing effect could be a potential threat to internal validity due to the short time span between pre and post measures.

Pilot tests were not needed, as MASYC-R has been found to have strong validity and reliability (Ganley & McGraw, 2016). Additionally, participants were familiar with i-Ready content and paper-pencil fluency worksheets. Writing in mathematics was a familiar occurrence in the elementary school (NCTM, 2000), therefore, a pilot test of expressive writing was unnecessary.

Role of researcher. I am a graduate student conducting this study as the culminating project toward a doctoral degree completion (Ed.D). I do not work at the school or the district in which I am conducting research, but I have worked in conjunction with several schools within the district as a supervisor for student teachers. Additionally, my sons attend or have attended the elementary school in which the research was conducted. I had a vested interest in this research as a member of the community, a parent of students within the district, and a supervisor of student teachers who work within the district. Therefore, I was not directly involved in the collection of the data with students.

The researcher was responsible for securing a research assistant that committed to two days of the research. The researcher provided paper copies of the pretests and posttests, instructions for the administration of the assessments, as well as directions for the expressive writing groups. Furthermore, the researcher provided expressive writing journals to every student in the second grade, regardless of their ability to participate in the study.

The collected data were delivered to the researcher. The analysis of the pretest measures was conducted by the researcher. The assignment of treatment and control group participants was randomly assigned by the researcher before the pretest measures. After the treatment sessions ended, the researcher received the posttest measures from the research assistant. The researcher analyzed the posttest measures, input the data into an Excel spreadsheet and used SPSS to analyze the pre/post measures for math achievement, math anxiety, and between groups for math achievement and anxiety. The researcher agreed to share any relevant findings with the school, principal, or district per their request.

Implications of Study

The greatest possible implication to this study is the fact that, at present, there is no known research being conducted on primary-age students and the remediation of math anxiety through expressive writing. This is significant for the community of researchers working in the area of math anxiety, as well as researchers in the area of expressive writing as a remediation strategy.

Furthermore, the results of this research could help students of all academic levels in finding a strategy for reducing math anxiety. The specific school within the study is also interested in the results, as the principal encourages mathematical writing within the classrooms in this school.

Lastly, this research will provide insight into math anxiety measures for primary-age students. The research will facilitate future research in the areas of expressive writing and math anxiety in primary-age students.

Chapter 4

Results

This research study was a quasi-experimental design which attempted to assess if expressive writing about mathematical concerns would increase student math achievement and decrease math anxiety in highly-math anxious (HMA) second-grade students. Additionally, the research assessed if expressive writing about mathematical concerns yielded greater mathematical achievement over students who wrote expressively about a topic of choice.

The following chapter examines the results of this one-week study on expressive writing, including the procedures for data cleaning and exportation, the design assumptions for the three-way mixed ANOVA, and the interpretation of those results. Furthermore, an item-analysis of the i-Ready computation assessment was conducted to assess the reliability of the assessment.

The data were first entered into an Excel file. After incomplete data were removed, and pre and post data were matched, the 80 participants' data were transferred to SPSS. This included setting all appropriate levels of measurement for each variable and recoding the string values to numerical values when appropriate for categorical data such as gender, anxiety level, and achievement level. Additionally, categorical data were transformed to meet the necessary assumptions required for the three-way mixed ANOVA.

Although this design was utilized in the study, there are weaknesses inherit within the design for this research. First, there was no allowance for looking at the interaction of anxiety as a within-group moderator. Since participants could not experience each level of anxiety and each expressive writing group, anxiety was only able to be analyzed as a change over time. It was also not possible to determine whether the changes in anxiety over time had an interaction effect with the other independent variables.

Descriptive Statistics

The study began by assessing students on a self-survey of mathematical anxiety. Eighty students took a pre-assessment regarding their level of math anxiety based off of a 13-question anxiety scale for young children called the Math Anxiety Scale for Young Children-Revised (MASYC-R). After scoring the MASYC-R on a scale of 13-52, students were identified as being highly math anxious (HMA), moderately math anxious (MMA), or low math anxious (LMA). Students who scored from 13-19 were identified as low anxiety. Students who scored 20-30 were labeled moderately math anxious. Students who scored above 30 were considered highly math anxious.

Two second-grade classes were randomly selected to be the treatment group for this research, and two second-grade classrooms were randomly assigned to the control group. Forty-two students were in the free-choice writing, control group. Of the 42 students in the control group, 17 students were identified as LMA, 14 were MMA, and 11 were HMA. Thirty-eight students were in the treatment group for expressive writing. Seventeen were considered LMA, 14 were considered MMA, and 7 were identified as HMA (See Table 8). The difference between the number of highly and moderately math-anxious students was consistent with previous research, which suggests 25% of second-grade students typically identify as highly-math anxious (McGraw, 2016; Ramirez et al., 2016).

Table 8

Student Post-Anxiety Category x Expressive Writing Treatment

		LOW	MED	HIGH	Total
Expressive Writing	Control	17	14	11	42
	Treatment	17	14	7	38
Total		34	28	18	80

Analysis of the students by gender indicated a difference in the ratio of girls and boys in both the low anxiety group and the high anxiety group. Although there was an even number of boys and girls in the moderate math-anxious category, there were more males with low math anxiety than females. Twenty boys self-assessed their math anxiety as low compared to 14 girls. Additionally, 7 boys identified as highly math-anxious compared to 11 girls. These numbers were consistent with research regarding math anxiety and gender for older students (Hembree, 1990; Wigfield & Meece; 1988). However, previous research has not found significant differences in gender and math anxiety among primary-age students (Harari et al., 2013; Ma, 1999; Wu et al., 2012). Table 9 highlights the gender-specific data.

Table 9

Student Post-Anxiety Category x Gender

		LOW	MED	HIGH	Total
Gender	Male	20	14	7	41
	Female	14	14	11	39
Total		34	28	18	80

Following the MASYC-R self-survey, all students were given a 22-question math computational worksheet. Students were given 15 minutes to complete the work to the best of their ability. After a week of writing expressively (about math worries or a free-choice topic), students were retested on the 22-question computational assessment to determine if writing expressively about math worries had an impact on their assessment score.

The results of the pre and post assessment are listed in Table 10. Data are mean ± standard deviations unless otherwise stated (Laerd, 2015). Students who were identified as having low levels of math anxiety in the both the control, free-choice topic group and the expressive writing group had an increase from their pre-achievement mean (*M* =16.41, *SD* =

4.85; *M* = 16.71, *SD* = 4.07, respectively) to their post-achievement mean (*M* = 17.94, *SD* = 2.38; *M* = 17.71, *SD* = 3.74). Both low anxiety groups had a mean increase of approximately one point.

Table 10

Descriptive Statistics on Math Achievement by Anxiety Level and Treatment Group

Expressive Writing Treatment			Mean	Std. Deviation	N
PRE Achieve.	Control	LOW	16.41	4.85	17
		MED	14.93	5.45	14
		HIGH	13.27	4.88	11
		Total	15.10	5.09	42
	Treatment	LOW	16.71	4.07	17
		MED	14.36	3.13	14
		HIGH	13.00	7.85	7
		Total	15.16	4.78	38
	Total	LOW	16.56	4.41	34
		MED	14.64	4.36	28
		HIGH	13.17	5.98	18
		Total	15.13	4.92	80
POST Achieve.	Control	LOW	17.94	2.38	17
		MED	15.79	5.12	14
		HIGH	15.18	4.62	11
		Total	16.50	4.15	42
	Treatment	LOW	17.71	3.74	17
		MED	15.29	3.54	14
		HIGH	12.14	8.19	7
		Total	15.79	5.06	38
	Total	LOW	17.82	3.09	34
		MED	15.54	4.33	28
		HIGH	14.00	6.21	18
		Total	16.16	4.59	80

Both moderately-anxious groups also had an increase from their pretest measure to their posttest measure for achievement. The control group (*M* = 14.93, *SD* = 5.43; *M* = 15.79 *SD* = 5.12, respectively) had nearly identical scores and variations compared to the treatment group for moderately, math-anxious students (*M* = 14.36, *SD* = 3.13; *M* = 15.29, *SD* = 3.54). The differences between the group means were not significant.

The highly math-anxious participants in the control group also had an increase from pretest to posttest (*M* = 13.27, *SD* = 4.88; *M* = 15.18, *SD* = 4.62). However, the treatment group of highly math-anxious participants had the only decrease in mean test scores from pretest to posttest (*M* = 13.00; *SD* = 7.85; *M* = 12.14, *SD* = 8.19). This difference was not statistically significant.

Most groups had a small standard deviation on pretest and posttest measures with the exception of the moderately math-anxious treatment group and both the control group and treatment group for the HMA students. The HMA treatment group had a standard deviation that was much greater than all the other groups within the study.

Item Analysis

Reliability measures and item analyses were run on both the MASYC-R (*N* = 80) and the i-Ready assessment (*N* = 78). The item statistics and inter-item correlation matrices can be found in Appendix G for each scale of the MASYC-R, as well as the i-Ready computational assessment. The MASYC-R assessed three different areas of math anxiety: negative reaction, numerical confidence, and worry. Each area was measured separately for reliability.

Negative reactions. The four items measuring negative reaction had a fair level of reliability ($\alpha = 0.64$) for the pretest. There was a slightly higher posttest measure ($\alpha = 0.71$). Table 11 provides item-total statistics for negative reactions.

Table 11

Item-Total Statistics: Scale for Negative Reactions

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Pre MASYC-R 1	4.46	4.05	0.45	0.21	0.54
Pre MASYC-R 2	4.63	4.74	0.36	0.20	0.60
Pre MASYC-R 7	4.68	5.03	0.35	0.18	0.61
Pre MASYC-R 10	4.31	3.36	0.53	0.30	0.48
Post MASYC-R 1	4.38	4.11	0.51	0.28	0.64
Post MASYC-R 2	4.49	4.35	0.56	0.40	0.61
Post MASYC-R 7	4.58	5.31	0.35	0.17	0.73
Post MASYC-R 10	4.34	3.70	0.59	0.39	0.59

Numerical confidence. The second scale of math anxiety was numerical confidence. The reliability measure was fair (α = 0.63) for the pretest measure and slightly higher for the posttest measure (α = 0.69). This scale contained three items and was reverse coded. Table 12 provides the data analysis for the pretest and posttest item-total statistics for numerical confidence.

Table 12

Item-Total Statistics: Scale for Numerical Confidence

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Pre MASYC-R 3	4.03	4.28	0.36	0.14	0.63
Pre MASYC-R 4	3.58	3.01	0.47	0.23	0.51
Pre MASYC-R 6	3.85	3.27	0.51	0.27	0.43
Post MASYC-R 3	4.15	3.50	0.70	0.50	0.38
Post MASYC-R 4	3.73	3.47	0.47	0.36	0.67
Post MASYC-R 6	4.00	4.10	0.40	0.27	0.74

Although the third question on the MASYC-R has a slightly higher reliability measure, the two-hundredths difference in the pretest is not significant. However, in the posttest for numerical confidence, the sixth question has a significantly higher Cronbach's alpha (α = 0.74). If this item were to be deleted from the posttest, the reliability for this scale would have increased.

Worry. The MASYC-R contained six items that were used to measure the concept of worry in relation to math anxiety. Worry had the highest reliability measure of the three scales for the MASYC-R, showing strong reliability on both the pretest and posttest (α = 0.79 and 0.83 respectively). Table 13 shows the pretest and posttest measures for worry.

Table 13

Item-Total Statistics: Scale for Measures of Worry

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Pre MASYC-R 5	9.35	16.00	0.48	0.26	0.78
Pre MASYC-R 8	9.44	15.70	0.52	0.34	0.77
Pre MASYC-R 9	9.40	15.20	0.59	0.37	0.75
Pre MASYC-R 11	9.46	14.90	0.6	0.43	0.75
Pre MASYC-R 12	9.08	15.60	0.47	0.28	0.78
Pre MASYC-R 13	9.84	15.90	0.63	0.45	0.75
Post MASYC-R5	9.81	18.80	0.54	0.44	0.81
Post MASYC-R 8	9.89	18.00	0.63	0.45	0.79
Post MASYC-R 9	9.74	17.50	0.73	0.65	0.77
Post MASYC-R 11	9.81	17.30	0.68	0.57	0.78
Post MASYC-R 12	9.56	19.70	0.42	0.28	0.83
Post MASYC-R 13	10.10	18.60	0.58	0.45	0.80

i-Ready. The mathematics computational assessment had strong reliability on both the pretest (α = 0.89) and posttest (α = 0.87) measures. As with the MASYC-R, the pretest measures were slightly lower in reliability than the posttest measures. Table 14 and 15 document the item-total statistics for the 22-question i-Ready computational assessment for both the pre and post measure. The item statistics and inter-item correlation matrices (both pre and post) can be found in Appendix H.

Table 14

Item-Total Statistics for Pretest Measures for the i-Ready Assessment

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
i-Ready Pre 1 Recoded	14.01	23.00	0.54	0.88
i-Ready Pre 2 Recoded	14.09	22.54	0.49	0.88
i-Ready Pre 3 Recoded	14.08	22.80	0.42	0.88
i-Ready Pre 4 Recoded	14.01	23.13	0.48	0.88
i-Ready Pre 5 Recoded	14.11	22.20	0.55	0.88
i-Ready Pre 6 Recoded	14.13	22.19	0.53	0.88
i-Ready Pre 7 Recoded	14.16	22.24	0.47	0.88
i-Ready Pre 8 Recoded	14.15	21.47	0.70	0.87
i-Ready Pre 9 Recoded	14.19	21.72	0.58	0.88
i-Ready Pre 10 Recoded	14.18	22.27	0.45	0.88
i-Ready Pre 11 Recoded	14.15	22.03	0.54	0.88
i-Ready Pre 12 Recoded	14.31	21.71	0.50	0.88
i-Ready Pre 13 Recoded	14.18	21.72	0.60	0.88
i-Ready Pre 14 Recoded	14.39	21.81	0.46	0.88
i-Ready Pre 15 Recoded	14.24	21.93	0.49	0.88
i-Ready Pre 16 Recoded	14.59	21.64	0.51	0.88
i-Ready Pre 17 Recoded	14.28	22.20	0.40	0.88
i-Ready Pre 18 Recoded	14.41	21.54	0.52	0.88
i-Ready Pre 19 Recoded	14.65	22.38	0.36	0.89
i-Ready Pre 20 Recoded	14.44	21.41	0.54	0.88
i-Ready Pre 21 Recoded	14.84	23.33	0.23	0.89
i-Ready Pre 22 Recoded	14.65	22.26	0.39	0.88

Assumptions Required for a Three-way Mixed ANOVA

The three-way mixed, between-between-within, ANOVA was chosen as an appropriate measure for this research as it satisfied the following seven assumptions (Laerd Statistics, 2015):

1. There was one continuous, dependent variable. This was math achievement and it was measured on a scale of 0-22 with each question being either correct or incorrect.

2. There were at least two independent variables which were measured categorically. The first was the between-group measure of expressive writing. Students were assigned to either the treatment group of writing about mathematical worries or the control group of writing about a topic of choice. Secondly, there was another between-group measure of math anxiety. Students were categorized as high, moderate, or low anxiety based off of the pretest of the MASYC-R self-survey.

3. One, within-subject, categorical variable was utilized. Time was operationalized as the difference between pre and post measures of the achievement test.

The remaining assumptions required the analysis of the cells of this design. The data was split and the output was organized by the type of expressive writing group (writing about math anxieties or writing about a choice topic) and the pre-anxiety level taken from the MASYC-R self-survey. Assumptions 4-7 utilized this format to confirm the assumptions for the three-way mixed ANOVA.

4. To assess significant outliers, box plots were utilized. The data contained a few outliers. The extreme outliers detected throughout the six combinations of the between-between independent variable (when using the box plots and criteria for 1.5 and 3 box lengths) were kept in the data set. There was no category where it was necessary to consider removing or transforming any of the data, as there was not an extreme number of outliers that would be expected more than by chance. Box plots and outliers are available in Appendix I.

5. The Shapiro-Wilk test for normality determined some pre-achievement and one post-achievement scores were not normally distributed (See Appendix I). As suggested by Laerd

Table 15

Item-Total Statistics for Posttest Measures for the i-Ready Assessment

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
i-Ready Post 1 Recoded	15.17	20.82	0.32	0.87
i-Ready Post 2 Recoded	15.22	20.12	0.47	0.87
i-Ready Post 3 Recoded	15.23	20.44	0.32	0.87
i-Ready Post 4 Recoded	15.17	20.58	0.45	0.87
i-Ready Post 5 Recoded	15.27	20.07	0.39	0.87
i-Ready Post 6 Recoded	15.27	20.07	0.39	0.87
i-Ready Post 7 Recoded	15.31	19.44	0.54	0.87
i-Ready Post 8 Recoded	15.23	19.84	0.54	0.87
i-Ready Post 9 Recoded	15.28	19.32	0.61	0.86
i-Ready Post 10 Recoded	15.31	19.39	0.55	0.87
i-Ready Post 11 Recoded	15.26	20.06	0.41	0.87
i-Ready Post 12 Recoded	15.40	19.72	0.38	0.87
i-Ready Post 13 Recoded	15.29	19.95	0.39	0.87
i-Ready Pre 14 Recoded	15.54	18.93	0.52	0.87
i-Ready Post 15 Recoded	15.33	19.37	0.53	0.87
i-Ready Post 16 Recoded	15.58	18.59	0.60	0.86
i-Ready Post 17 Recoded	15.44	18.90	0.57	0.87
i-Ready Post 18 Recoded	15.55	18.87	0.53	0.87
i-Ready Post 19 Recoded	15.73	19.71	0.34	0.87
i-Ready Post 20 Recoded	15.59	19.36	0.41	0.87
i-Ready Post 21 Recoded	15.81	19.07	0.52	0.87
i-Ready Post 22 Recoded	15.73	19.19	0.46	0.87

Statistics (2015), transformations did not occur since ANOVA is considered to be fairly robust to normality violations. Therefore, only "approximately normally distributed data" was required.

Normal Q-Q plots and Box's test of equality of covariance matrices are available in the Appendix J.

6. Levene's test for homogeneity of variance assumes the population variances for the dependent variable of math achievement is equal across the groups (See Table 16). There was homogeneity of variance for the pre-achievement scores (*p* = .17), however, there was not homogeneity of variance for the post-achievement scores (*p* < .001). Transformations were not run for math achievement, since the overall group sample sizes were approximately similar (See Appendix I).

The ratio of largest group variance (high anxiety) was more than three times as large as the smallest group variance (low anxiety) as was expected based on previous research (Ganley & McGraw, 2016; Ramirez et al., 2016).

Table 16

Levene's Test of Equality of Error Variance

Levene's Test of Equality of Error Variances[a]				
	F	df1	df2	Sig.
PRE Achieve Scale	1.59	5	74	0.17
POST Achieve Scale	6.11	5	74	0.00

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Design: Intercept + EWControlTreat + PRE_MASYC_Recoded + EWControlTreat * PRE_MASYC_Recoded Within Subjects Design: time

7. The Mauchly's test for sphericity (See Table 17) showed no significance, as two-time points (pre and post) were used. However, there is discrepancy among researchers regarding the use of Mauchly's test. Weinfurt 2000 (as cited by Laerd Statistics, 2015) suggested the test for sphericity is difficult not to violate. Furthermore, Maxwell and Delaney (2004) (as cited by Laeard Statistics, 2015) recommend using an epsilon-corrected *F* test due to the extreme

sensitivity of Mauchly's *F* test of sphericity. They suggest using Greenhouse-Geisser correction, while others recommend using Huynh-Feldt correction depending on whether the epsilon value is above or below 0.75. This study had an epsilon value of 1, and therefore, the assumption was satisfied.

Table 17

Mauchly's Test of Sphericity[a] on Achievement

					Epsilon[b]		
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.00	0.00	0		1.00	1.00	1.00

a. Design: Intercept + EWControlTreat + PRE_MASYC_Recoded + EWControlTreat * PRE_MASYC_Recoded Within Subjects Design: time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Inferential Statistics

A three-way mixed ANOVA was run to understand the effects of anxiety, writing treatment, and time on math achievement (See Table 18). Specifically, this researched asked:

1. Did expressively writing about mathematical worries decrease self-reported math anxiety in second-grade students who are highly math-anxious (HMA)?

2. Did expressively writing about mathematical worries increase math achievement in second-grade students who are highly math-anxious (HMA)?

3. Was there a statistically significant difference in math achievement between self-reported math-anxious students who write expressively about mathematics compared to students who write expressively about a free-choice topic?

Using the three-way mixed (BBW) ANOVA, it was determined a three-way interaction between expressive writing, pre-anxiety level, and time on math achievement was not statistically significant, [$F(2, 74) = 1.04$, $p = .36$, $\eta^2 = .03$], as illustrated in Figure 1 and on Table 18. Additionally, there were no statistically significant two-way interactions between time and writing treatment [$F(1, 74) = 1.95$, $p = .17$, $\eta^2 = .026$], or time and anxiety [$F(2, 74) = .30$, $p = .74$, $\eta^2 = .01$]. Therefore, although achievement scores did increase, and math anxiety did decrease, these scores were not statistically significant in students who were HMA.

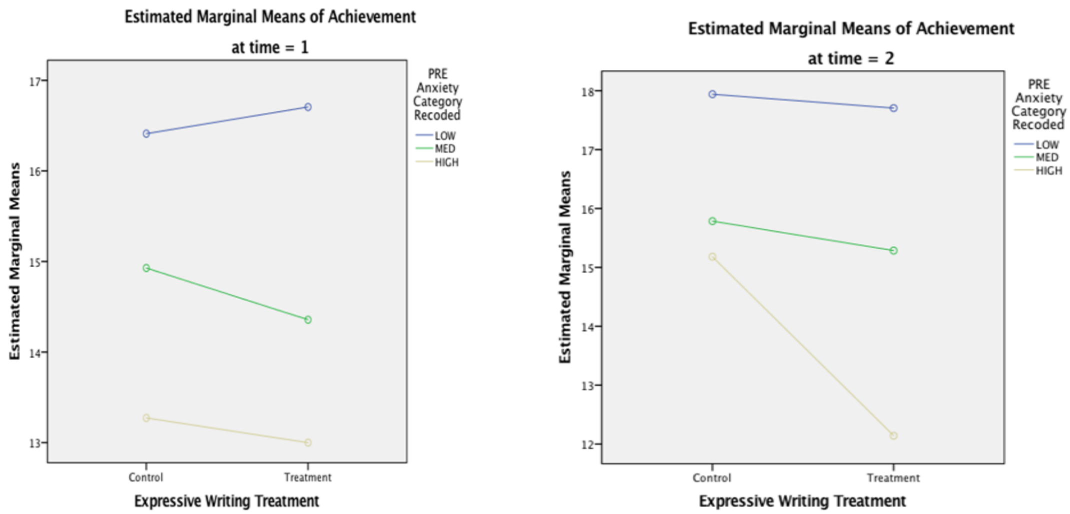
Table 18

Tests of Within-Subjects Effects on Achievement

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
time	Sphericity Assumed	29.14	1.00	29.14	5.40	0.02	0.07
	Greenhouse-Geisser	29.14	1.00	29.14	5.40	0.02	0.07
	Huynh-Feldt	29.14	1.00	29.14	5.40	0.02	0.07
	Lower-bound	29.14	1.00	29.14	5.40	0.02	0.07
time * EWControlTreat	Sphericity Assumed	10.52	1.00	10.52	1.95	0.17	0.03
	Greenhouse-Geisser	10.52	1.00	10.52	1.95	0.17	0.03
	Huynh-Feldt	10.52	1.00	10.52	1.95	0.17	0.03
	Lower-bound	10.52	1.00	10.52	1.95	0.17	0.03
time * PRE_MASYC_Recoded	Sphericity Assumed	3.25	2.00	1.62	0.30	0.74	0.01
	Greenhouse-Geisser	3.25	2.00	1.62	0.30	0.74	0.01
	Huynh-Feldt	3.25	2.00	1.62	0.30	0.74	0.01
	Lower-bound	3.25	2.00	1.62	0.30	0.74	0.01
time * EWControlTreat * PRE_MASYC_Recoded	Sphericity Assumed	11.24	2.00	5.62	1.04	0.36	0.03
	Greenhouse-Geisser	11.24	2.00	5.62	1.04	0.36	0.03
	Huynh-Feldt	11.24	2.00	5.62	1.04	0.36	0.03
	Lower-bound	11.24	2.00	5.62	1.04	0.36	0.03
Error(time)	Sphericity Assumed	399.32	74.00	5.40			
	Greenhouse-Geisser	399.32	74.00	5.40			
	Huynh-Feldt	399.32	74.00	5.40			
	Lower-bound	399.32	74.00	5.40			

Figure 1

Estimated Marginal Means of Achievement on Pre and Post Achievement Measures



Furthermore, there was not a statistically significant difference between the groups of students who wrote expressively about mathematical worries than students who wrote expressively about a topic of choice. Table 19 reports data from the between group analysis.

The current research assessed if highly-math anxious students would show an increase in computational mathematics achievement while indicating a decrease in self-reported math anxiety. As reported, there were no statistically significant findings to support an increase in math achievement or a decrease in math anxiety for HMA students. Furthermore, there was not a statistically significant difference in HMA students who wrote expressively about mathematical worries compared to HMA students who wrote expressively about a topic of choice. The discussion section that follows will further address possible causes for the aforementioned results, as well as limitations to this study, and future research considerations in the area of math anxiety in primary-age children.

Table 19

Between Group Analysis of Interaction of Time, Treatment, and Anxiety

Effect		Value	F	Hyp	Error df	Sig.	Partial Eta Squared
time	Pillai's Trace	0.07	5.400[b]	1.00	74.00	0.02	0.07
	Wilks' Lambda	0.93	5.400[b]	1.00	74.00	0.02	0.07
	Hotelling's Trace	0.07	5.400[b]	1.00	74.00	0.02	0.07
	Roy's Largest Root	0.07	5.400[b]	1.00	74.00	0.02	0.07
time * EWControl Treat	Pillai's Trace	0.03	1.949[b]	1.00	74.00	0.17	0.03
	Wilks' Lambda	0.97	1.949[b]	1.00	74.00	0.17	0.03
	Hotelling's Trace	0.03	1.949[b]	1.00	74.00	0.17	0.03
	Roy's Largest Root	0.03	1.949[b]	1.00	74.00	0.17	0.03
time * PRE_MASYC_Recoded	Pillai's Trace	0.01	.301[b]	2.00	74.00	0.74	0.01
	Wilks' Lambda	0.99	.301[b]	2.00	74.00	0.74	0.01
	Hotelling's Trace	0.01	.301[b]	2.00	74.00	0.74	0.01
	Roy's Largest Root	0.01	.301[b]	2.00	74.00	0.74	0.01
time * EWControl Treat * PRE_MASYC_Recoded	Pillai's Trace	0.03	1.041[b]	2.00	74.00	0.36	0.03
	Wilks' Lambda	0.97	1.041[b]	2.00	74.00	0.36	0.03
	Hotelling's Trace	0.03	1.041[b]	2.00	74.00	0.36	0.03
	Roy's Largest Root	0.03	1.041[b]	2.00	74.00	0.36	0.03

a. Design: Intercept + EWControlTreat + PRE_MASYC_Recoded + EWControlTreat * PRE_MASYC_Recoded Within Subjects Design: time
b. Exact statistic

Chapter 5

Discussion

This quasi-experimental design used a three-way mixed ANOVA intended to investigate the potential benefits of expressively writing about mathematical concerns for second-grade, highly math-anxious students. Specifically, this research attempted to determine if mathematical anxiety would decrease and mathematical achievement would increase with an expressive writing treatment. Furthermore, the study assessed if there was a difference in math computational achievement between students who wrote expressively about mathematics or on a topic of their choosing. In this chapter, the findings will be discussed with respect to each research question followed by perceived limitations and suggestions for future research on math-anxious children.

Summary of Findings

The following research questions guided the present study. As indicated, there was no statistically significant three-way or two-way effect found. However, discussion and limitations of each question are worth noting.

Q1: Did expressively writing about mathematical worries decrease self-reported math anxiety in second-grade students who are highly math-anxious (HMA)?

Although there was no statistically significant difference between pre and post measures of HMA students' self-reported anxiety, half of the HMA students who wrote about mathematical worries showed a decrease in math anxiety. Several factors could have contributed to the decrease in self-reported math anxiety accompanied by a lack of statistical significance in this group of students.

First, there were only seven HMA students who wrote about math anxieties. Although this number is proportional to the sample size for this study and consistent with previous research on the prevalence of highly math-anxious students (McGraw & Ganley, 2016; Ramirez et al., 2016), the size of the sample is very small. Having a larger sample size would have been more beneficial to this research and possibly would have allowed for a more normal distribution in the data. For example, many students stayed consistent with their MASYC-R score, differing between a few points from pre to post. However, at least half of the HMA students in the expressive writing treatment group increased or decreased their MASYC-R score by five to ten points. These decreases and increases are likely due to extraneous variables outside the control of the study. Having a larger sample of HMA students would have allowed for a more accurate account of a typical HMA student from pretest to posttest measure.

Secondly, treatment fidelity may have had an effect on the assessments given. Previous research (Chung & Pennebaker, 2008) suggested the duration of expressive writing was not significant in college-aged individuals. Nevertheless, timing mattered for the participants in this study, therefore, the current research utilized the successive implementation of writing over a five-day period (Pennebaker & Francis, 1996). However, since no current known research had been conducted on young children, it was unclear if this time frame had an effect on the posttest measures of anxiety. Furthermore, the short time frame between pre and post tests could have created a testing effect, causing students to appear less anxious than they were initially, solely based on familiarity of the test. Hence, the lack of a significant difference would be justified.

Finally, on the final day of the research, one of the four teachers participating in the study was absent from school. This teacher was one of the teachers assigned to the math treatment group. Her students' results were considerably different than the other math treatment teacher, as well as the other control group teachers. All teachers had some students who had an increase in anxiety from their pretest to posttest measure. However, three teachers had 31.8%, 36%, and 33% of their students show an increase in anxiety following the research. The students of the teacher that was absent had 71% of the class report an increase in anxiety following the posttest survey. It can be surmised the absence of the teacher on the last day of the study had a negative effect on their level of anxiety, although this cannot be verified.

Q2: Did expressively writing about mathematical worries increase math achievement in second-grade students who are highly math-anxious (HMA)?

Although the math achievement of HMA students who wrote expressively about mathematics were not statistically significant, it is relevant to discuss the results as they pertain to individual classes and students within the study. Of the HMA students who wrote about mathematical worries, half of the students increased their math achievement score from pre to post measure. Additionally, of all HMA students, nearly 60% showed an improvement in math achievement over the week-long study. Although it cannot be determined if expressive writing was the contributing factor in the increase in their math performance, further research should be conducted to determine if these results are consistently achieved.

These achievements could be the result of a testing effect, as there were only four days between pre and post measure. The familiarity with the test could have lowered anxiety and allowed students more time to complete the assessment. The additional practice from the pretest could be another unintended factor increasing the posttest measure on these students. However, as this assessment was taken from curriculum currently used within the classroom, and the assessment was not presented as a test, it is not assumed that a testing effect alone is responsible for the increase in achievement.

Interestingly, the absence of the one teacher had little effect on the achievement or lack thereof, of her HMA students. It should be noted that one student in the absent teacher's classroom was able to correctly answer 17 questions on the pretest but only completed 6 correct problems on his/her posttest. It is plausible to conclude this child did not lose the ability to answer 11 questions within a week and assume other factors contributed to this decline in achievement score.

Q3: Was there a statistically significant difference in math achievement between self-reported math-anxious students who write expressively about mathematics compared to students who write expressively about a free-choice topic?

In comparing the two groups of students in this study, there was not a statistically significant difference between students who wrote expressively about math compared to students who wrote expressively on a topic of choice in relation to their math achievement. The current research utilized the work of Hines et al. (2016) which found a decrease in math anxiety in all students who expressively wrote despite the topic of math or a neutral topic. It is considered unethical to deny students the benefit of expressive writing based on previous research regarding expressive writing in educational settings (Hines et al., 2016; Park et al., 2014; Ramirez & Beilock, 2011). Therefore, a lack of a true control group for this study prevents the researcher from having more conclusive results regarding the benefits of expressively writing about mathematics.

Furthermore, all levels of anxiety in both the treatment and the control groups increased their mean score from pre- to post- measure on the achievement test with the exception of the HMA treatment group. All groups gained approximately one to nearly two points on the mean score. The HMA treatment group's mean score decreased by .84 of a point from pre to post.

Although none of these figures are considered significant, it should be noted that the standard deviation of the HMA treatment group was nearly doubled that of any other group within the study. This difference is worth noting, as it indicates a wide range of scores in the HMA treatment group (7.85 and 8.19 respectively) that was not present in the HMA control group (4.88 and 4.62 respectively). This could account for the lack of growth shown for the group overall. It also presents one of the limitations to this study, as the sample size was very small. Furthermore, one student's score was drastically different than the others, causing a large standard deviation.

Limitations

The greatest limitation to this research was the lack of research on young children with mathematics anxiety to support or refute the current research results. To date, the youngest participants in expressive writing research in the area of mathematics were ninth-grade students (Hines et al., 2016). There is a vast difference in cognition, development, and academia between eight-year-old children and fourteen-year-old adolescents. Furthermore, the bulk of the research on both math anxiety and expressive writing has been conducted on adults. The age of the subjects within this study created a great number of unknowns including length of study, terminology utilized, content covered, and possible, unintended repercussions of writing about anxiety over an extended period of time.

The assessments chosen, although found to be reliable measures, may have been a limitation to the study as well. The MASYC-R, a revised version of the anxiety survey, is already being revised again by Ganley (personal communication, August 2017). The newer version will contain three additional items reversely coded in the numerical confidence section. This section of the MASYC-R currently contains the least number of items, and the addition of these items will double the number of questions in the numerical confidence portion of this survey. Furthermore, there continues to be debate regarding the use and validity of self-surveys in research among children, terminology to be used, and the difficulty young children have in selecting responses (Cargnelutti et al., 2017; Jameson, 2013; Krinzinger et al., 2009).

The math assessment was chosen due to the familiar format for the students, ease of grading, and content covered on the assessment. Previous research indicated highly math-anxious students would perform less well than their peers due to an increase in cognitive load on more complex mathematical tasks being compromised by intrusive, negative thoughts (Ashcraft, 2002; Ashcraft & Krause, 2007; Ashcraft & Moore, 2009). The math assessment chosen had low-level, rote memorization facts for the first six problems. These six problems do not require working memory or advanced calculations, and therefore, could have been removed.

Originally, the researcher thought the addition of these items would support the claim regarding competency on low-level computation. However, in grading the assessments, it was clear some students could not perform these tasks at all, therefore making the entire assessment too difficult for them. Nine children, approximately 10%, were not capable of completing the basic math facts on the pre-assessment, and therefore, should have been excluded from the research altogether due to extraneous factors.

Previous research has suggested that HMA individuals with higher working memories would likely have greater performance issues than students with lower working memories (Mattarella-Micke et al., 2011; Ramirez et al., 2013). Five of these nine students were in the HMA category and had low achievement. Therefore, the anxiety may not have been the cause of their low performance, as a cognitive disability could have contributed to the low performance. This could also account for the large range of scores for the HMA students in some of the classes. The students who were unable to complete basic math facts may not have been good candidates for this research if they had a significant learning disability, and since working memory and aptitude were not assessed, it is unclear which participants would have had the potential to have the maximum benefit from this research. It is important to note, however, that eight of the nine lowest performing students had a decrease of two to nine points from their pretest to their posttest on the MASYC-R.

In lieu of these six problems, the assessment should have provided more advanced computation through regrouping of addition and subtraction facts to determine if HMA students could complete basic two-digit addition and subtraction without regrouping but were unable to complete the more advanced task of regrouping. This assessment did not exist in the school's curriculum, and therefore, a pre-existing format was used instead. The assessment used had two forms. A new assessment could have been created and used by merging those two forms so the assessment contained more advanced mathematics throughout the assessment.

Another limitation in this study was the small sample size. Although the entire second grade of one elementary school participated, after parental consent and data clean, only 80 participants were included. After dividing the participants into treatment (*N* = 38) and control (*N* = 42) groups, and further dividing them into high, medium, and low anxiety, the sample size was simply not large enough to support the intended research, even though it did support previous research indicating 25% of the population would identify as HMA (Eden et al., 2013; Ganley & McGraw, 2016; Ramirez et al., 2013). Furthermore, if students who could not complete the first six assessment problems were removed (as previously stated), this would further decrease the already small sample size.

In hindsight, enlisting the third and fourth grade classrooms or expanding the research to other schools within the district would have been beneficial. However, due to the difficulty in securing research permission within the district and teacher buy-in, the researcher chose to keep the study smaller, in order to maintain good working relations with the district, teachers, and administrators.

An additional limitation of the study was the absence of the one treatment teacher on the day of posttest assessments. It was intended that all teachers were to be present throughout the study, and the study was conducted on a specific week to support that goal, however, the teacher became ill and her absence was unavoidable. Although the use of the research assistant was designed to create consistency, the unfamiliar substitute caused the posttest analysis to run less smoothly than anticipated, and it is believed to have caused many students within that classroom some additional anxiety. It cannot be predicted how the data would have differed if this absence did not occur.

Statistically, there were limitations as well. Some of the pre-achievement groups and one post-achievement group within the data analysis were non-normal using the Shapiro-Wilk test for normality. Although ANOVA is considered 'fairly robust' to violations of normality, and 'approximately normally distributed data' is acceptable (Laerd, 2015), it is a limitation of this study and the use of the three-way mixed ANOVA. Furthermore, there was a lack of homogeneity of variance in the data for this research.

Although treatment fidelity was upheld, it was difficult to determine if there was a testing effect due to the length of the study and the amount of time that had passed between pre and post measures. This is noted in regards to the differences between the post-assessments results compared to the pre-assessment results. There was greater consistency in the post-assessment results than in the pre-assessment. This suggests a possible testing effect from pre to post-assessment.

As was previously stated, it was difficult to determine what would be most appropriate for an eight-year-old's attention span and cognitive load, while still being developmentally appropriate. In addition, the researcher was cognizant and respectful of the time involved in implementation of the assessments and the treatment to the teachers, the school, and the students. In being mindful of the educational time of the participants involved and the volunteer teachers administering the assessments and treatments, it may have detracted from the potential benefit of the research had it been conducted more longitudinally.

Despite the limitations to this study, the research provided valuable information about math anxiety, highly-math anxious primary-age students, and research in an educational setting with young children. Most noteworthy is the potential for future research in the area of math anxiety in young children. Future research considerations are discussed below.

Future Research Consideration

There is a plethora of research regarding math anxiety that has spanned several decades (Geist, 2010; Krinzinger et al., 2009; Maloney & Beilock, 2012; Ramirez et al., 2013; Ramirez et al., 2016; Sgoutas-Emch & Johnson, 1998; Tobias, 1978), however the research on math anxiety and young children has only recently become an area of interest. The current research on math anxiety and children focus primarily on identification of math anxiety in young children and the creation of reliable assessments (Cargnelutti et al., 2017; Ganley & McGraw, 2016; Vukovic et al., 2013; Wu et al., 2012). These measures have become more sophisticated and tailored specifically to primary-age children. However, this area of research will need to continue to help support intervention-based or remediation research for math anxiety in young children.

Previous research has highlighted the problem of the early onset of math anxiety Krinzinger et al., 2009; Thomas & Dowker, 2000). Additional research has determined the effect of math anxiety on achievement in highly math-anxious (HMA) individuals (Park et al., 2014; Ramirez et al., 2013; Wu et al., 2012). There is a lack of research in interventions to reduce math anxiety in the greater population, however, interventions for math anxiety are virtually non-existent in primary-age children. There is a great need for continued research in childhood math anxiety, and specifically in remediation or interventions to support schools, teachers, parents, and students.

Math anxiety research has used expressive writing as a remediation tool for math anxiety in young adults, however, this is also limited. In the past seven years, only four known studies have utilized expressive writing as a technique to reduce math anxiety with the goal of increasing performance (See Table 1). More research in expressive writing and math anxiety are needed for adults, as well as for children in all grade levels.

Furthermore, there is a need for more research on gender and math anxiety. The current study indicated a greater number of female students in the HMA category compared to the male students. Similarly, male students were nearly twice as likely to self-report low levels of math anxiety. Previous research has not found gender difference in regards to math anxiety in primary-age students (Harari, Vukovic, & Bailey, 2013; Ma, 1999; Wu et al., 2012), however, the current research highlights the need for additional research in this area.

Most importantly, future research is needed in prevention of math anxiety. Educational institutions, administrators, and teachers need access to research that supports best practices in math education, reduction of timed-test and grade-based assessments, and the use of multiple strategies for teaching math content at all levels.

Conclusion

The current research investigated the potential benefits of using expressive writing as a tool to help reduce math anxiety and increase math achievement in primary-age students. As a math educator, teacher, and mother of a son with math anxiety, this research had great significance for me. Watching my son and my students struggle due to overwhelming fear of numbers made the reduction of math anxiety a personal and professional mission of mine. Completing this study has reignited my passion for research, specifically practical research that has potential benefits for teachers, school districts, parents, and students. I have learned a lot through this process; the things I should have done differently, the directions I will go in the future, and the need teachers have for the support that is just non-existent at this point.

I have been reminded of the compassion teachers have for their students and their willingness to learn and grow on their behalf. I have learned that red tape is never going to go away, but loopholes can always be found. I have been reminded that I love to work with teachers, and I am in awe of their dedication to their students. I am humbled by the support I have been given in the school, with the teachers, and with my committee at George Fox. I am hopeful that I can continue this work within my career. I know I am a stronger researcher from this process and a better writer than I was a decade ago.

Although my research did not yield the results that I had hoped for, I continue to believe in expressive writing as a valid intervention for anxiety, and I will continue to push for more writing within the mathematics classroom for both academic and emotional purposes. I am thankful for the opportunity to work with so many amazing people and will continue to work for the reduction of math anxiety in young children.

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Appendices

Appendix A

Math Anxiety Scale for Young Children-Revised

Instructions

First we are going to do the questions about what you think of math. I will go through instructions and read each question aloud and we will all go through them together as a class. It is important that you don't go ahead and you stay with me. If you ever have any questions just raise your hand.

Reader hold up the worksheet and point to the choices while talking.

(2) Math Attitudes Measures

First put your number and teacher letter on your first page in the corner. (Reader models this.)

We will go through some instructions and practice. You can read along with me. We are interested in how you think and feel about math. We are going to read some sentences about math. For each one you will choose what you think about that sentence. The choices will be "yes" "kind of" "not really" and 'no". You will circle one of these four choices.
For example, if the statement was "I like pizza" If you love pizza, then you should circle "Yes", if you kinda like pizza you should circle "Kind of", if you don't really like pizza that much you should circle "Not really". If you really don't like pizza you should circle "No" because you don't like pizza.

Go ahead and circle your answer for the sentence about pizza **(pause until they have all circled an option).** Does anyone have any questions?

Ok, now we are going to try another practice. "I like broccoli" please circle which of the choices shows what you think about broccoli. You can go ahead and do it on the page. **(pause until they have all circled an option).**

Now we will go through each one together. After I say a sentence, choose the option that best shows what you think for that sentence.

Also, sometimes it will seem like I keep asking the same question, but they are all a little bit different.

ID NUMBER: _________________

MASYC-R Self-survey

We are interested in how you think and feel about math. We are going to read some sentences about math. For each one you will choose what you think about that sentence. The choices will be "yes" "kind of" "not really" and 'no". You will circle one of these four choices.

Sample:

I like pizza.

Yes Kind of Not really No

If you love pizza, you should circle "Yes"
If you kinda like pizza you should circle "Kind of"
If you don't really like pizza that much you should circle "Not really"
If you hate pizza, you should circle "No"

Practice:

I like broccoli.

Yes Kind of Not really No

MASYC-R

1. When it is time for math my head hurts.
Yes Kind of Not really No

2. I am scared in math class.
Yes Kind of Not really No

3. I like being called on in math class.
Yes Kind of Not really No

4. I like doing math problems on the board in front of the class.
Yes Kind of Not really No

5. I get nervous about making a mistake in math.
Yes Kind of Not really No

6. I like to raise my hand in math class.
Yes Kind of Not really No

7. Math gives me a stomachache.
Yes Kind of Not really No

8. When the teacher calls on me to tell my answer to the class, I get nervous.
Yes Kind of Not really No

9. I get worried before I take a math test.
Yes Kind of Not really No

10. My heart starts to beat fast if I have to do math in my head.
Yes Kind of Not really No

11. I get nervous when my teacher is about to teach something new in math.
Yes Kind of Not really No

12. I get worried when I don't understand something in math.
Yes Kind of Not really No

13. I feel nervous when I am doing math.
Yes Kind of Not really No

Appendix B

Addition and Subtraction Within 100— Skills Practice

Name: ______________________

Add or subtract. **Form B**

1. 6 + 3 = ________
2. 7 + 7 = ________
3. 9 + 8 = ________
4. 5 − 4 = ________
5. 13 − 9 = ________
6. 16 − 8 = ________
7. 45 + 6
8. 23 + 4
9. 74 + 5
10. 59 + 3
11. 87 − 3
12. 62 − 6
13. 56 − 5
14. 94 − 8
15. 36 + 60
16. 29 + 39
17. 43 + 32
18. 67 + 24
19. 92 − 53
20. 78 − 25
21. 81 − 64
22. 97 − 18

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Fluency Practice 337

Appendix C

August 11, 2017

Dr. Scot Headley
Dean of the College of Education
George Fox University
414 NE Meridian Street
Newberg, OR 97132

Dear Dr. Headley,
This letter is to inform you of Hope Walter's doctoral research project at your school. The school district is not open to outside research studies on it students or staff due to interruption with academic instruction, however after speaking with Mrs. Walter and the scope of her work, we agree to provide support to her research this one time. We support her research with willing participants given the following stipulations:

- The scope of the research in the classrooms will be limited to 4 weeks.
- An informational letter explaining the research will be provided to the principal, staff involved, and parents of involved students.
- Written permission from parents of students in the research project will be necessary with the option of opting out at any time during the research study.
- A copy of the IRB permission from George Fox University will be forward to principal of the school.
- Personal, identifiable information of students will not be used in the course of the research or in reporting results. Confidentiality of the students involved must be maintained.
- Mrs. Walter will maintain open communication with principal and classroom teachers involved through the research project.
- Results of the research will be shared with principal at the conclusion of the research study.

We welcome Mrs. Walter to our elementary and look forward to working with her during her research study. Please do not hesitate to contact me should you have any further questions or concerns at 503-565-4802.

Sincerely,

Principal

Appendix D

Dear Parent or Guardian,

The elementary school has accepted an invitation to participate in a 2nd grade research study about math anxiety in young children. 1 in 5 people describe themselves as math anxious. Math anxiety has been found in children as young as 6.

The purpose of the study is to determine if writing about math worries will help students feel less anxious about math. Studies have shown that adults who write about their worries become less worried and do better on math tests. This research will determine if it is beneficial for children as well.

The study will occur within the typical school day, does not require your student to be removed from his/her classroom, and is appropriate for the age of your child and their learning needs. This letter is requesting permission to include your child in the study. Student names will not be on any of the papers. Your child's identity in this study will be confidential. The results of the study may be published for scientific purposes but will not give your child's name or include any identifiable references to your child.

Students will be asked to take a short survey about math situations. Students will also be given a short math assignment that is part of their regular class assignments. Students will write about their feelings for about 10 minutes a day, over a week. At the end of the week students will retake the survey and the math assignment to see if their scores differ.

You are free to choose whether or not your child is to participate in this study. Please notify your child's teacher if you decide to not participate at any time. Any further questions you have about this study will be answered by the principal researcher, Hope Walter, at **hwalter14@georgefox.edu**.

I have read and understand this consent form, and I allow my child to participate in this research study. I understand that I will receive a copy of this form if I request one. I voluntarily choose to participate, but I understand that my consent does not take away any legal rights in the case of negligence or other legal fault of anyone who is involved in this study. I further understand that nothing in this consent form is intended to replace any applicable Federal, state, or local laws.

Parent or Guardian Name (Printed or Typed): ___________________________________

Date: ___________________

Parent or Guardian Signature:____

Date: ___________________

Appendix E

Expressive Writing Scripts

(modified with permission from James W. Pennebaker, Sept 2017)

<u>Expressive Writing Group Instructions</u>

I am working on learning about 2^{nd} graders writing. I am going to ask you to write for the next 10 minutes about the worries or fears you have when you hear the word math or think about doing math. The only rule I have about your writing is that you write the whole time until I say to stop. If you run out of things to say, just repeat what you have already written. Don't worry your spelling. Just write. Are there any questions about what you are going to write about right now? (if asked, children may draw pictures after they have written something to explain or show what they have written)

On the second day of writing

Do you remember writing the other day about your worries or fears about math? Today, I want you to continue writing about any worries you have about math. It could be the same topic that you wrote about yesterday or it could be something different. But today, I really want you to think about a time you might have been worried or concerned when doing math or being asked to do math. Remember, if you can't think of anything to more to write, you can repeat what you have already written, but try to write for the entire time. If you can't write words to explain it, you may draw a picture with your writing.

On the third day of writing

You have written now for two days about your worries or fears. You will have three more chances to write about whatever worries you about math or doing math. I want you to really think about what worries you about math. Remember you can repeat words or sentences or put a draw with your words.

On the fourth day of writing

You have written now for three days about your worries or fears. You will have two more chances to write about whatever worries you about math or doing math. I want you to really think about what worries you about math. Remember you can repeat words or sentences or put a draw with your words.

On the last day of writing

Today is the last day of writing about math worries! Try to get all your worries about math out of your mind. Remember you can rewrite sentences or draw pictures to go with your words.

Control Condition Instructions

I am working on learning about 2nd graders writing. I am going to ask you to write for the next 10 minutes about anything you like. The only rule I have about your writing is that you write the whole time until I say to stop. If you run out of things to say, just repeat what you have already written. Don't worry your spelling. Just write. Are there any questions about what you are going to write about right now? (if asked, children may draw pictures after they have written something to explain or show what they have written)

On the second day of writing

Do you remember writing the other day I asked you to write until I said stop? Today, I want you to continue writing about anything you would like in your writing journal. It could be the same topic that you wrote about yesterday or it could be something different. Remember, if you can't think of anything to more to write, you can repeat what you have already written, but try to write for the entire time. If you can't write words to explain it, you may draw a picture with your writing.

On the third day of writing

You have written now for two days in your writing journal. You will have three more chances to write about whatever you want. Remember you can repeat words or sentences or put a draw with your words.

On the fourth day of writing

You have written now for three days. You will have two more chances to write about whatever you wish. Remember you can repeat words or sentences or put a draw with your words.

On the last day of writing

Today is the last day of writing in your writing journals for me! Write until I say stop. Remember, you can rewrite sentences or draw pictures to go with your words.

Appendix F

Math Assessment Script for Teachers

<u>Math Assessment Instructions (Given AFTER MASYC-R): 15 minute time limit</u>

TEACHER INSTRUCTIONS: Now we are going to work on this addition and subtraction worksheet. It is important that you try to do your best and do as many problems as you can on your own. You can use your 100s chart to help you if you need it. Please pull out your 100s chart and begin.

At 12 minutes state, please finish up the last few problems you have. If you do not finish, it is ok, but I want you to do as many as you think you can. We will do this again in a few days and I want to see how much you have improved.

At 15 minutes, please collect math assessments and make sure all students have their ID code.

Appendix G

MASYC-R Reliability Measures

Pretest: Negative Reactions

Item Statistics

	Mean	Std. Deviation	N
Pre MASYC-R 1	1.56	0.99	80
Pre MASYC-R 2	1.40	0.85	80
Pre MASYC-R 7	1.35	0.77	80
Pre MASYC-R 10	1.71	1.13	80

Inter-Item Correlation Matrix

	Pre MASYC-R 1	Pre MASYC-R 2	Pre MASYC-R 7	Pre MASYC-R 10
Pre MASYC-R 1	1.00	0.26	0.36	0.36
Pre MASYC-R 2	0.26	1.00	0.07	0.43
Pre MASYC-R 7	0.36	0.07	1.00	0.32
Pre MASYC-R 10	0.36	0.43	0.32	1.00

Posttest: Negative Reactions

Item Statistics

	Mean	Std. Deviation	N
Post MASYC-R 1	1.55	0.98	80
Post MASYC-R 2	1.44	0.86	80
Post MASYC-R 7	1.35	0.75	80
Post MASYC-R 10	1.59	1.03	80

Inter-Item Correlation Matrix

	Post MASYC-R 1	Post MASYC-R 2	Post MASYC-R 7	Post MASYC-R 10
Post MASYC-R 1	1.00	0.48	0.29	0.39
Post MASYC-R 2	0.48	1.00	0.17	0.55
Post MASYC-R 7	0.29	0.17	1.00	0.37
Post MASYC-R 10	0.39	0.55	0.37	1.00

Pretest: Numerical Confidence

Item Statistic

	Mean	Std. Deviation	N
Pre MASYC-R 3	1.70	0.97	80
Pre MASYC-R 4	2.15	1.27	80
Pre MASYC-R 6	1.88	1.14	80

Inter-Item Correlation Matrix

	Pre MASYC-R 3	Pre MASYC-R 4	Pre MASYC-R 6
Pre MASYC-R 3	1.00	0.28	0.34
Pre MASYC-R 4	0.28	1.00	0.47
Pre MASYC-R 6	0.34	0.47	1.00

Posttest: Numerical Confidence

Item Statistics

	Mean	Std. Deviation	N
Post MASYC-R 3	1.79	1.02	80
Post MASYC-R 4	2.21	1.25	80
Post MASYC-R 6	1.94	1.13	80

Inter-Item Correlation Matrix

	Post MASYC-R 3	Post MASYC-R 4	Post MASYC-R 6
Post MASYC-R 3	1.00	0.60	0.51
Post MASYC-R 4	0.60	1.00	0.23
Post MASYC-R 6	0.51	0.23	1.00

Pretest: Worry

Item Statistics

	Mean	Std. Deviation	N
Pre MASYC-R 5	1.96	1.11	80
Pre MASYC-R 8	1.88	1.11	80
Pre MASYC-R 9	1.91	1.11	80
Pre MASYC-R 11	1.85	1.14	80
Pre MASYC-R 12	2.24	1.19	80
Pre MASYC-R 13	1.48	0.94	80

Inter-Item Correlation Matrix

	Pre MASYC-R 5	Pre MASYC-R 8	Pre MASYC-R 9	Pre MASYC-R 11	Pre MASYC-R 12	Pre MASYC-R 13
Pre MASYC-R 5	1.00	0.35	0.39	0.31	0.39	0.32
Pre MASYC-R 8	0.35	1.00	0.50	0.40	0.21	0.46
Pre MASYC-R 9	0.39	0.50	1.00	0.43	0.33	0.46
Pre MASYC-R 11	0.31	0.40	0.43	1.00	0.43	0.60
Pre MASYC-R 12	0.39	0.21	0.33	0.43	1.00	0.37
Pre MASYC-R 13	0.32	0.46	0.46	0.60	0.37	1.00

Posttest: Worry

Item Statistics

	Mean	Std. Deviation	N
Post MASYC-R5	1.96	1.15	80
Post MASYC-R 8	1.89	1.15	80
Post MASYC-R 9	2.04	1.12	80
Post MASYC-R 11	1.96	1.20	80
Post MASYC-R 12	2.21	1.17	80
Post MASYC-R 13	1.71	1.13	80

Inter-Item Correlation Matrix

	Post MASYC-R5	Post MASYC-R 8	Post MASYC-R 9	Post MASYC-R 11	Post MASYC-R 12	Post MASYC-R 13
Post MASYC-R5	1.00	0.44	0.56	0.29	0.39	0.34
Post MASYC-R 8	0.44	1.00	0.56	0.59	0.37	0.39
Post MASYC-R 9	0.56	0.56	1.00	0.64	0.24	0.63
Post MASYC-R 11	0.29	0.59	0.64	1.00	0.39	0.57
Post MASYC-R 12	0.39	0.37	0.24	0.39	1.00	0.25
Post MASYC-R 13	0.34	0.39	0.63	0.57	0.25	1.00

Appendix H

i-Ready Computational Assessment Pretest Statistics

Item Statistics

	Mean	Std. Deviation	N
i-Ready Pre 1 Recoded	0.95	0.22	80
i-Ready Pre 2 Recoded	0.88	0.33	80
i-Ready Pre 3 Recoded	0.89	0.32	80
i-Ready Pre 4 Recoded	0.95	0.22	80
i-Ready Pre 5 Recoded	0.85	0.36	80
i-Ready Pre 6 Recoded	0.84	0.37	80
i-Ready Pre 7 Recoded	0.80	0.40	80
i-Ready Pre 8 Recoded	0.81	0.39	80
i-Ready Pre 9 Recoded	0.78	0.42	80
i-Ready Pre 10 Recoded	0.79	0.41	80
i-Ready Pre 11 Recoded	0.81	0.39	80
i-Ready Pre 12 Recoded	0.65	0.48	80
i-Ready Pre 13 Recoded	0.79	0.41	80
i-Ready Pre 14 Recoded	0.58	0.50	80
i-Ready Pre 15 Recoded	0.73	0.45	80
i-Ready Pre 16 Recoded	0.38	0.49	80
i-Ready Pre 17 Recoded	0.69	0.47	80
i-Ready Pre 18 Recoded	0.55	0.50	80
i-Ready Pre 19 Recoded	0.31	0.47	80
i-Ready Pre 20 Recoded	0.53	0.50	80
i-Ready Pre 21 Recoded	0.13	0.33	80
i-Ready Pre 22 Recoded	0.31	0.47	80

Inter-Item Correlation Matrix Questions 1-8

	i-Ready Pre 1 Recoded	i-Ready Pre 2 Recoded	i-Ready Pre 3 Recoded	i-Ready Pre 4 Recoded	i-Ready Pre 5 Recoded	i-Ready Pre 6 Recoded	i-Ready Pre 7 Recoded	i-Ready Pre 8 Recoded
i-Ready Pre 1Recoded	1.00	0.26	0.28	0.47	0.55	0.52	0.32	0.48
i-Ready Pre 2 Recoded	0.26	1.00	0.22	0.43	0.27	0.24	0.57	0.30
i-Ready Pre 3 Recoded	0.28	0.22	1.00	0.28	0.40	0.27	0.22	0.44
i-Ready Pre 4 Recoded	0.47	0.43	0.28	1.00	0.39	0.37	0.32	0.33
i-Ready Pre 5 Recoded	0.55	0.27	0.40	0.39	1.00	0.38	0.23	0.43
i-Ready Pre 6 Recoded	0.52	0.24	0.27	0.37	0.38	1.00	0.29	0.40
i-Ready Pre 7 Recoded	0.32	0.57	0.22	0.32	0.23	0.29	1.00	0.40
i-Ready Pre 8 Recoded	0.48	0.30	0.44	0.33	0.43	0.40	0.40	1.00
i-Ready Pre 9 Recoded	0.43	0.25	0.38	0.29	0.44	0.33	0.33	0.74
i-Ready Pre 10 Recoded	0.44	0.17	0.40	0.30	0.47	0.52	0.20	0.46
i-Ready Pre 11 Recoded	0.18	0.40	0.34	0.33	0.43	0.31	0.32	0.43
i-Ready Pre 12 Recoded	0.31	0.36	0.15	0.19	0.35	0.46	0.29	0.45
i-Ready Pre 13 Recoded	0.44	0.36	0.30	0.16	0.47	0.27	0.35	0.53
i-Ready Pre 14 Recoded	0.27	0.21	0.17	0.27	0.35	0.31	0.20	0.36

i-Ready Pre 15 Recoded	0.24	0.28	0.22	0.24	0.21	0.34	0.18	0.42
i-Ready Pre 16 Recoded	0.18	0.29	0.11	0.18	0.25	0.34	0.19	0.31
i-Ready Pre 17 Recoded	0.34	0.15	0.19	0.34	0.17	0.22	0.14	0.37
i-Ready Pre 18 Recoded	0.25	0.27	0.16	0.25	0.25	0.28	0.30	0.34
i-Ready Pre 19 Recoded	0.03	0.26	0.16	0.16	0.06	0.01	0.20	0.19
i-Ready Pre 20 Recoded	0.24	0.25	0.22	0.24	0.30	0.26	0.34	0.38
i-Ready Pre 21 Recoded	0.09	0.14	-0.11	0.09	0.05	0.06	0.19	0.09
i-Ready Pre 22 Recoded	0.16	0.09	0.24	0.16	0.13	0.15	0.07	0.26

Inter-Item Correlation Matrix Questions 9-15

	i-Ready Pre 9 Recoded	i-Ready Pre 10 Recoded	i-Ready Pre 11 Recoded	i-Ready Pre 12 Recoded	i-Ready Pre 13 Recoded	i-Ready Pre 14 Recoded	i-Ready Pre 15 Recoded
i-Ready Pre 1 Recoded	0.43	0.44	0.18	0.31	0.44	0.27	0.24
i-Ready Pre 2 Recoded	0.25	0.17	0.40	0.36	0.36	0.21	0.28
i-Ready Pre 3 Recoded	0.38	0.40	0.34	0.15	0.30	0.17	0.22
i-Ready Pre 4 Recoded	0.29	0.30	0.33	0.19	0.16	0.27	0.24
i-Ready Pre 5 Recoded	0.44	0.47	0.43	0.35	0.47	0.35	0.21
i-Ready Pre 6 Recoded	0.33	0.52	0.31	0.46	0.27	0.31	0.34
i-Ready Pre 7 Recoded	0.33	0.20	0.32	0.29	0.35	0.20	0.18
i-Ready Pre 8 Recoded	0.74	0.46	0.43	0.45	0.53	0.36	0.42
i-Ready Pre 9 Recoded	1.00	0.38	0.43	0.42	0.45	0.26	0.41
i-Ready Pre 10 Recoded	0.38	1.00	0.30	0.20	0.25	0.17	0.43
i-Ready Pre 11 Recoded	0.43	0.30	1.00	0.45	0.53	0.49	0.35
i-Ready Pre 12 Recoded	0.42	0.20	0.45	1.00	0.64	0.54	0.19
i-Ready Pre 13 Recoded	0.45	0.25	0.53	0.64	1.00	0.48	0.30

i-Ready Pre 14 Recoded	0.26	0.17	0.49	0.54	0.48	1.00	0.15
i-Ready Pre 15 Recoded	0.41	0.43	0.35	0.19	0.30	0.15	1.00
i-Ready Pre 16 Recoded	0.23	0.21	0.24	0.24	0.28	0.25	0.36
i-Ready Pre 17 Recoded	0.35	0.24	0.09	-0.04	0.11	0.08	0.25
i-Ready Pre 18 Recoded	0.30	0.27	0.15	0.18	0.14	0.04	0.34
i-Ready Pre 19 Recoded	0.11	-0.24	0.19	0.16	0.22	0.25	0.17
i-Ready Pre 20 Recoded	0.21	0.24	0.12	0.19	0.36	0.20	0.14
i-Ready Pre 21 Recoded	-0.07	0.01	-0.01	0.04	0.10	0.17	0.15
i-Ready Pre 22 Recoded	0.17	0.09	0.26	0.10	0.15	0.20	0.29

Inter-Item Correlation Matrix Questions 16-22

	i-Ready Pre 16 Recoded	i-Ready Pre 17 Recoded	i-Ready Pre 18 Recoded	i-Ready Pre 19 Recoded	i-Ready Pre 20 Recoded	i-Ready Pre 21 Recoded	i-Ready Pre 22 Recoded
i-Ready Pre 1 Recoded	0.18	0.34	0.25	0.03	0.24	0.09	0.16
i-Ready Pre 2 Recoded	0.29	0.15	0.27	0.26	0.25	0.14	0.09
i-Ready Pre 3 Recoded	0.11	0.19	0.16	0.16	0.22	-0.11	0.24
i-Ready Pre 4 Recoded	0.18	0.34	0.25	0.16	0.24	0.09	0.16
i-Ready Pre 5 Recoded	0.25	0.17	0.25	0.06	0.30	0.05	0.13
i-Ready Pre 6 Recoded	0.34	0.22	0.28	0.01	0.26	0.06	0.15
i-Ready Pre 7 Recoded	0.19	0.14	0.30	0.20	0.34	0.19	0.07
i-Ready Pre 8 Recoded	0.31	0.37	0.34	0.19	0.38	0.09	0.26
i-Ready Pre 9 Recoded	0.23	0.35	0.30	0.11	0.21	-0.07	0.17
i-Ready Pre 10 Recoded	0.21	0.24	0.27	-0.24	0.24	0.01	0.09
i-Ready Pre 11 Recoded	0.24	0.09	0.15	0.19	0.12	-0.01	0.26
i-Ready Pre 12 Recoded	0.24	-0.04	0.18	0.16	0.19	0.04	0.10
i-Ready Pre 13 Recoded	0.28	0.11	0.14	0.22	0.36	0.10	0.15
i-Ready Pre 14 Recoded	0.25	0.08	0.04	0.25	0.20	0.17	0.20

i-Ready Pre 15 Recoded	0.36	0.25	0.34	0.17	0.14	0.15	0.29
i-Ready Pre 16 Recoded	1.00	0.30	0.44	0.31	0.38	0.33	0.31
i-Ready Pre 17 Recoded	0.30	1.00	0.53	0.22	0.39	0.09	0.22
i-Ready Pre 18 Recoded	0.44	0.53	1.00	0.29	0.55	0.27	0.29
i-Ready Pre 19 Recoded	0.31	0.22	0.29	1.00	0.43	0.40	0.48
i-Ready Pre 20 Recoded	0.38	0.39	0.55	0.43	1.00	0.28	0.43
i-Ready Pre 21 Recoded	0.33	0.09	0.27	0.40	0.28	1.00	0.15
i-Ready Pre 22 Recoded	0.31	0.22	0.29	0.48	0.43	0.15	1.00

i-Ready Computational Assessment Posttest Statistics

Item Statistics

	Mean	Std. Deviation	N
i-Ready Post 1 Recoded	0.96	0.19	78
i-Ready Post 2 Recoded	0.91	0.29	78
i-Ready Post 3 Recoded	0.90	0.31	78
i-Ready Post 4 Recoded	0.96	0.19	78
i-Ready Post 5 Recoded	0.86	0.35	78
i-Ready Post 6 Recoded	0.86	0.35	78
i-Ready Post 7 Recoded	0.82	0.39	78
i-Ready Post 8 Recoded	0.90	0.31	78
i-Ready Post 9 Recoded	0.85	0.36	78
i-Ready Post 10 Recoded	0.82	0.39	78
i-Ready Post 11 Recoded	0.87	0.34	78
i-Ready Post 12 Recoded	0.73	0.45	78
i-Ready Post 13 Recoded	0.83	0.38	78
i-Ready Post 14 Recoded	0.59	0.50	78
i-Ready Post 15 Recoded	0.79	0.41	78
i-Ready Post 16 Recoded	0.55	0.50	78
i-Ready Post 17 Recoded	0.69	0.47	78
i-Ready Post 18 Recoded	0.58	0.50	78
i-Ready Post 19 Recoded	0.40	0.49	78
i-Ready Post 20 Recoded	0.54	0.50	78
i-Ready Post 21 Recoded	0.32	0.47	78
i-Ready Post 22 Recoded	0.40	0.49	78

Inter-Item Correlation Matrix Questions 1-8

	i-ready Post 1 Recoded	i-ready Post 2 Recoded	i-ready Post 3 Recoded	i-ready Post 4 Recoded	i-ready Post 5 Recoded	i-ready Post 6 Recoded	i-ready Post 7 Recoded	i-ready Post 8 Recoded
i-ready Post 1 Recoded	1.00	0.40	0.15	0.65	0.11	0.30	0.25	0.15
i-ready Post 2 Recoded	0.40	1.00	0.04	0.40	0.39	0.39	0.44	0.19
i-ready Post 3 Recoded	0.15	0.04	1.00	0.15	0.23	0.35	0.28	0.16
i-ready Post 4 Recoded	0.65	0.40	0.15	1.00	0.11	0.30	0.43	0.37
i-ready Post 5 Recoded	0.11	0.39	0.23	0.11	1.00	0.47	0.39	0.35
i-ready Post 6 Recoded	0.30	0.39	0.35	0.30	0.47	1.00	0.29	0.23
i-ready Post 7 Recoded	0.25	0.44	0.28	0.43	0.39	0.29	1.00	0.50
i-ready Post 8 Recoded	0.15	0.19	0.16	0.37	0.35	0.23	0.50	1.00
i-ready Post 9 Recoded	0.28	0.24	0.32	0.28	0.44	0.34	0.54	0.68
i-ready Post 10 Recoded	0.25	0.32	0.06	0.43	0.19	0.19	0.57	0.61
i-ready Post 11 Recoded	0.12	0.28	0.25	0.32	0.40	0.18	0.32	0.38
i-ready Post 12 Recoded	0.03	0.32	0.08	0.18	0.34	0.09	0.24	0.27
i-ready Post 13 Recoded	0.09	0.22	0.08	0.27	0.31	0.12	0.33	0.30

i-ready Pre 14 Recoded	0.10	0.38	0.23	0.24	0.19	0.26	0.29	0.23
i-ready Post 15 Recoded	0.06	0.29	0.35	0.06	0.25	0.25	0.34	0.25
i-ready Post 16 Recoded	0.22	0.26	0.12	0.22	0.15	0.08	0.32	0.29
i-ready Post 17 Recoded	0.16	0.28	0.23	0.30	0.21	0.13	0.20	0.23
i-ready Post 18 Recoded	0.23	0.19	0.14	0.23	0.18	0.18	0.34	0.31
i-ready Post 19 Recoded	0.03	0.07	0.02	0.03	0.03	0.18	-0.03	0.10
i-ready Post 20 Recoded	0.08	0.16	0.20	0.22	-0.01	0.14	0.04	0.20
i-ready Post 21 Recoded	0.14	0.12	0.14	0.14	0.04	0.20	0.18	0.14
i-ready Post 22 Recoded	0.16	0.16	0.10	0.16	-0.05	0.10	0.18	0.28

Inter-Item Correlation Matrix Questions 9-15

	i-ready Post 9 Recoded	i-ready Post 10 Recoded	i-ready Post 11 Recoded	i-ready Post 12 Recoded	i-ready Post 13 Recoded	i-ready Pre 14 Recoded	i-ready Post 15 Recoded
i-ready Post 1 Recoded	0.28	0.25	0.12	0.03	0.09	0.10	0.06
i-ready Post 2 Recoded	0.24	0.32	0.28	0.32	0.22	0.38	0.29
i-ready Post 3 Recoded	0.32	0.06	0.25	0.08	0.08	0.23	0.35
i-ready Post 4 Recoded	0.28	0.43	0.32	0.18	0.27	0.24	0.06
i-ready Post 5 Recoded	0.44	0.19	0.40	0.34	0.31	0.19	0.25
i-ready Post 6 Recoded	0.34	0.19	0.18	0.09	0.12	0.26	0.25
i-ready Post 7 Recoded	0.54	0.57	0.32	0.24	0.33	0.29	0.34
i-ready Post 8 Recoded	0.68	0.61	0.38	0.27	0.30	0.23	0.25
i-ready Post 9 Recoded	1.00	0.54	0.37	0.30	0.29	0.22	0.31
i-ready Post 10 Recoded	0.54	1.00	0.22	0.24	0.33	0.29	0.34
i-ready Post 11 Recoded	0.37	0.22	1.00	0.46	0.45	0.23	0.09

i-ready Post 12 Recoded	0.30	0.24	0.46	1.00	0.27	0.20	0.12
i-ready Post 13 Recoded	0.29	0.33	0.45	0.27	1.00	0.26	0.28
i-ready Pre 14 Recoded	0.22	0.29	0.23	0.20	0.26	1.00	0.42
I-ready Post 15 Recoded	0.31	0.34	0.09	0.12	0.28	0.42	1.00
i-ready Post 16 Recoded	0.40	0.32	0.19	0.32	0.15	0.35	0.24
i-ready Post 17 Recoded	0.33	0.34	0.16	0.16	0.22	0.40	0.49
i-ready Post 18 Recoded	0.35	0.34	0.06	0.07	0.38	0.34	0.34
i-ready Post 19 Recoded	0.13	0.04	0.08	0.08	0.01	0.20	0.22
i-ready Post 20 Recoded	0.25	0.24	0.11	0.25	0.07	0.22	0.42
i-ready Post 21 Recoded	0.22	0.25	0.10	0.23	0.09	0.29	0.28
i-ready Post 22 Recoded	0.20	0.24	0.16	0.08	0.08	0.36	0.22

Inter-Item Correlation Matrix Questions 16-22

	i-ready Post 16 Recoded	i-ready Post 17 Recoded	i-ready Post 18 Recoded	i-ready Post 19 Recoded	i-ready Post 20 Recoded	i-ready Post 21 Recoded	i-ready Post 22 Recoded
i-ready Post 1 Recoded	0.22	0.16	0.23	0.03	0.08	0.14	0.16
i-ready Post 2 Recoded	0.26	0.28	0.19	0.07	0.16	0.12	0.16
i-ready Post 3 Recoded	0.12	0.23	0.14	0.02	0.20	0.14	0.10
i-ready Post 4 Recoded	0.22	0.30	0.23	0.03	0.22	0.14	0.16
i-ready Post 5 Recoded	0.15	0.21	0.18	0.03	-0.01	0.04	-0.05
i-ready Post 6 Recoded	0.08	0.13	0.18	0.18	0.14	0.20	0.10
i-ready Post 7 Recoded	0.32	0.20	0.34	-0.03	0.04	0.18	0.18
i-ready Post 8 Recoded	0.29	0.23	0.31	0.10	0.20	0.14	0.28
i-ready Post 9 Recoded	0.40	0.33	0.35	0.13	0.25	0.22	0.20
i-ready Post 10 Recoded	0.32	0.34	0.34	0.04	0.24	0.25	0.24
i-ready Post 11 Recoded	0.19	0.16	0.06	0.08	0.11	0.10	0.16
i-ready Post 12 Recoded	0.32	0.16	0.07	0.08	0.25	0.23	0.08
i-ready Post 13 Recoded	0.15	0.22	0.38	0.01	0.07	0.09	0.08
i-ready Pre 14 Recoded	0.35	0.40	0.34	0.20	0.22	0.29	0.36
i-ready Post 15 Recoded	0.24	0.49	0.34	0.22	0.42	0.28	0.22
i-ready Post 16 Recoded	1.00	0.52	0.58	0.36	0.30	0.51	0.36
i-ready Post 17 Recoded	0.52	1.00	0.50	0.14	0.39	0.40	0.31
i-ready Post 18 Recoded	0.58	0.50	1.00	0.22	0.20	0.31	0.27
i-ready Post 19 Recoded	0.36	0.14	0.22	1.00	0.33	0.57	0.52

i-ready Post 20 Recoded	0.30	0.39	0.20	0.33	1.00	0.31	0.28
i-ready Post 21 Recoded	0.51	0.40	0.31	0.57	0.31	1.00	0.62
i-ready Post 22 Recoded	0.36	0.31	0.27	0.52	0.28	0.62	1.00

Appendix I

Tests of Normality

Control Group

Tests of Normality for Low Anxiety Control Group

Tests of Normality[a]

	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRE Achievement Scale	0.28	17	0.00	0.71	17	0.00
POST Achievement Scale	0.14	17	0.20*	0.96	17	0.59

*. This is a lower bound of the true significance.
a. Expressive Writing Treatment = Control, PRE Anxiety Category Recoded = LOW
b. Lilliefors Significance Correction

Tests of Normality for Moderate Anxiety Control Group

Tests of Normality[a]

	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRE Achievement Scale	0.29	14	0.00	0.82	14	0.01
POST Achievement Scale	0.17	14	0.20*	0.91	14	0.14

*. This is a lower bound of the true significance.
a. Expressive Writing Treatment = Control, PRE Anxiety Category Recoded = MED
b. Lilliefors Significance Correction

Tests of Normality of High Anxiety Control Group

Tests of Normality[a]

	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRE Achievement Scale	0.21	11	.20*	0.92	11	0.36
POST Achievement Scale	0.16	11	.20*	0.88	11	0.09

*. This is a lower bound of the true significance.
a. Expressive Writing Treatment = Control, PRE Anxiety Category Recoded = HIGH

b. Lilliefors Significance Correction

Treatment Group

Tests of Normality for Low Anxiety Treatment Group

Tests of Normality[a]

	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRE Achievement Scale	0.18	17	0.13	0.92	17	0.16
POST Achievement Scale	0.28	17	0.00	0.82	17	0.00

a. Expressive Writing Treatment = Treatment, PRE Anxiety Category Recoded = LOW

b. Lilliefors Significance Correction

Tests of Normality for Moderate Anxiety Treatment Group

Tests of Normality[a]

	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRE Achievement Scale	0.13	14	0.20*	0.97	14	0.84
POST Achievement Scale	0.19	14	0.20*	0.94	14	0.44

*. This is a lower bound of the true significance.

a. Expressive Writing Treatment = Treatment, PRE Anxiety Category Recoded = MED

b. Lilliefors Significance Correction

Tests of Normality for High Anxiety Treatment Group

Tests of Normality[a]

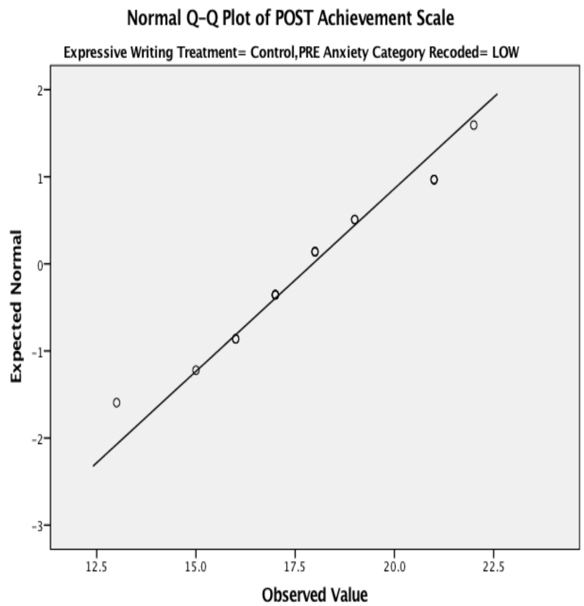
	Kolmogorov-Smirnov[b]			Shapiro- Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRE Achievement Scale	0.27	7	0.14	0.82	7	0.06
POST Achievement Scale	0.30	7	0.07	0.84	7	0.10

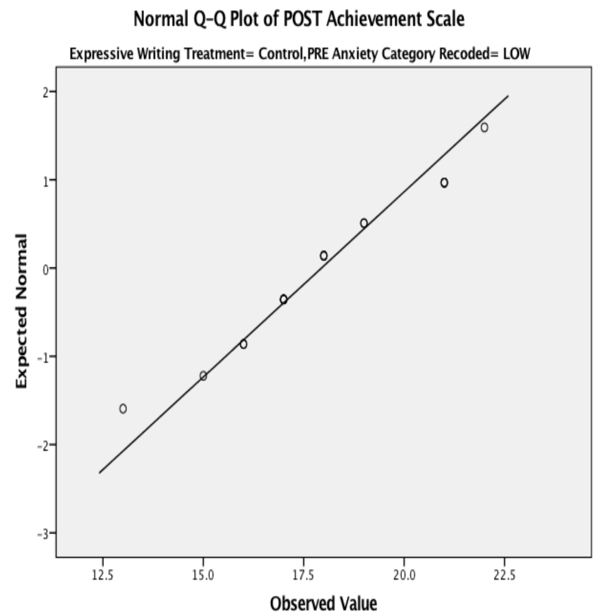
a. Expressive Writing Treatment = Treatment, PRE Anxiety Category Recoded = HIGH

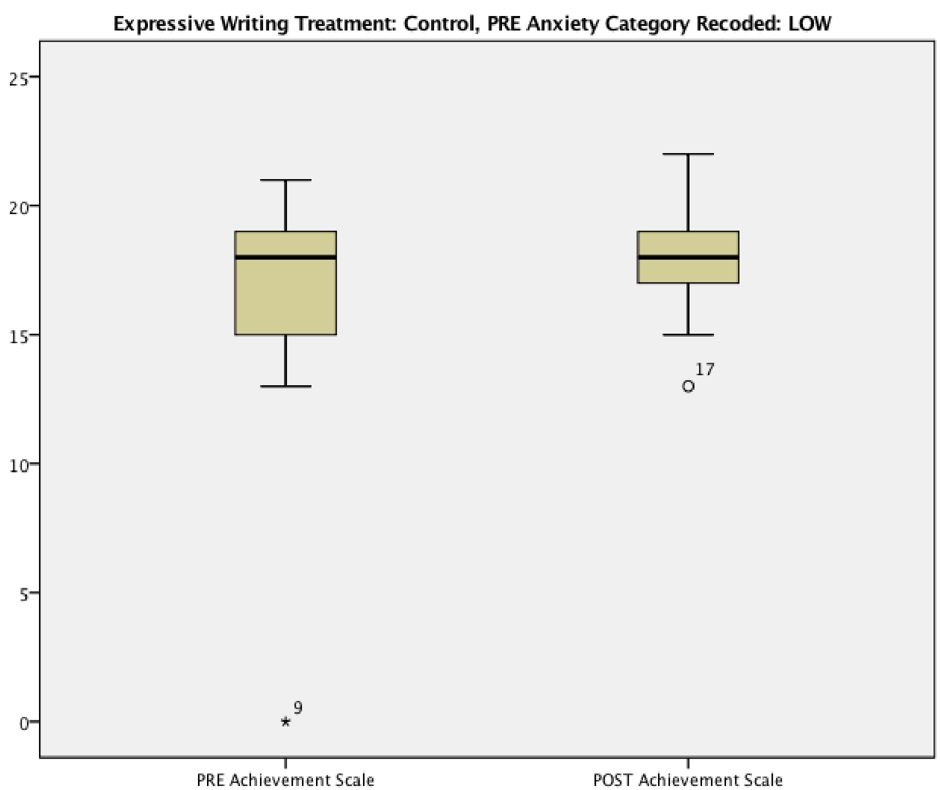
b. Lilliefors Significance Correction

Appendix J

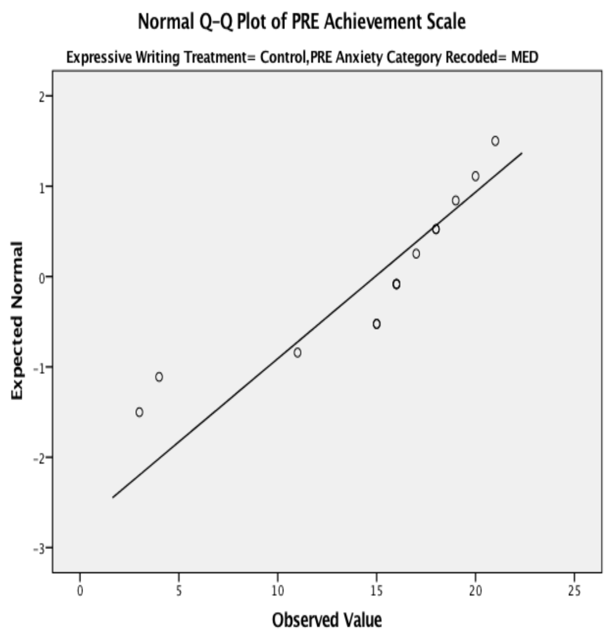
Normal Q-Q Plots Pre and Post for Low Anxiety for Control Group

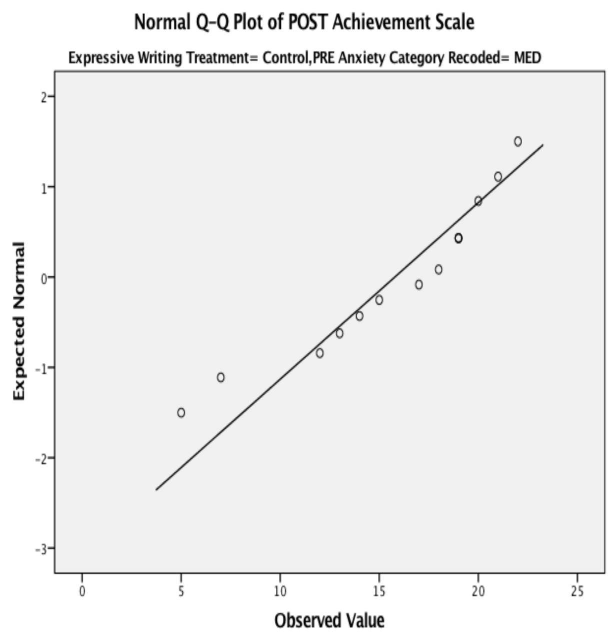


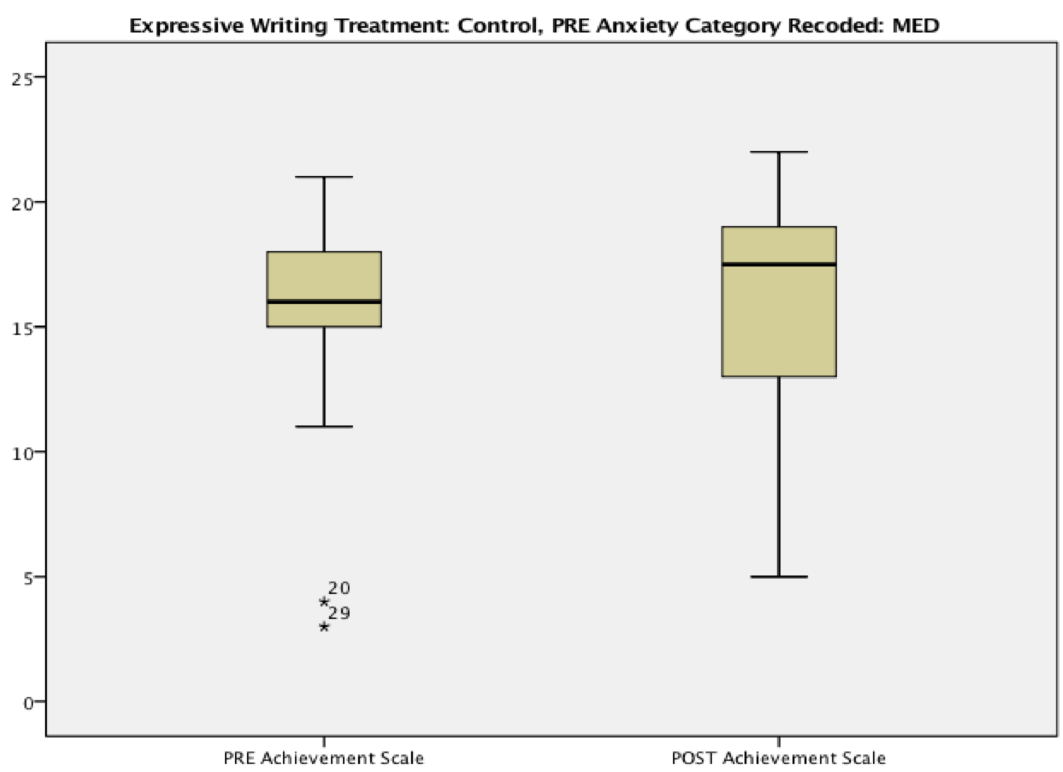




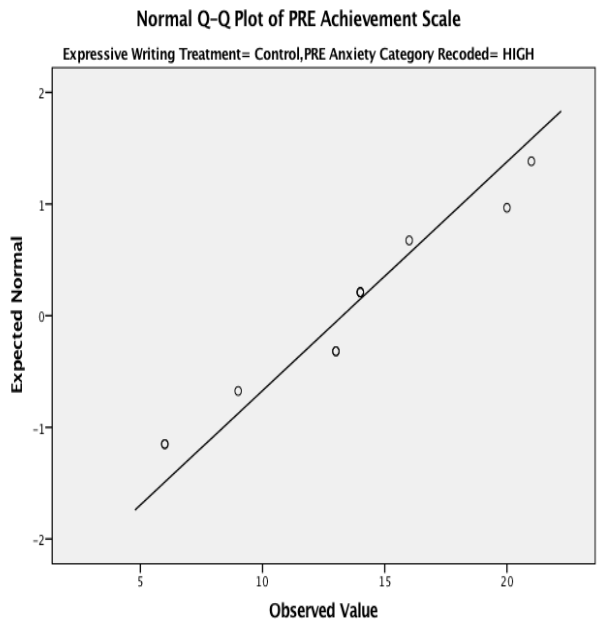
Normal Q-Q Plots Pre and Post for Moderate Anxiety for Control Group

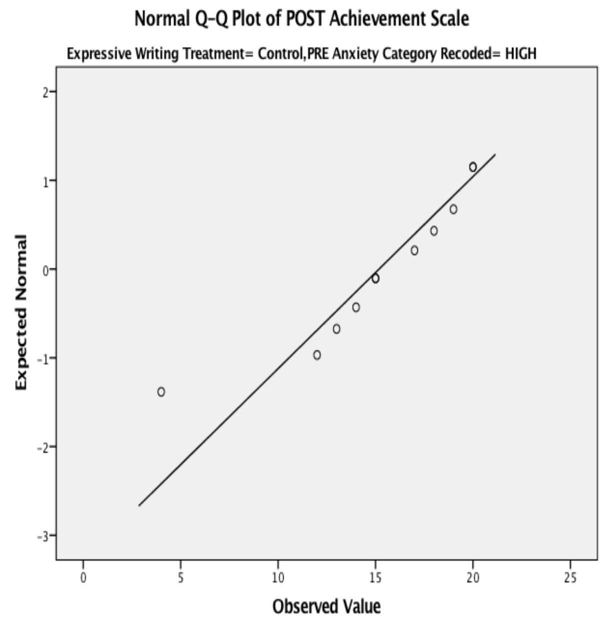


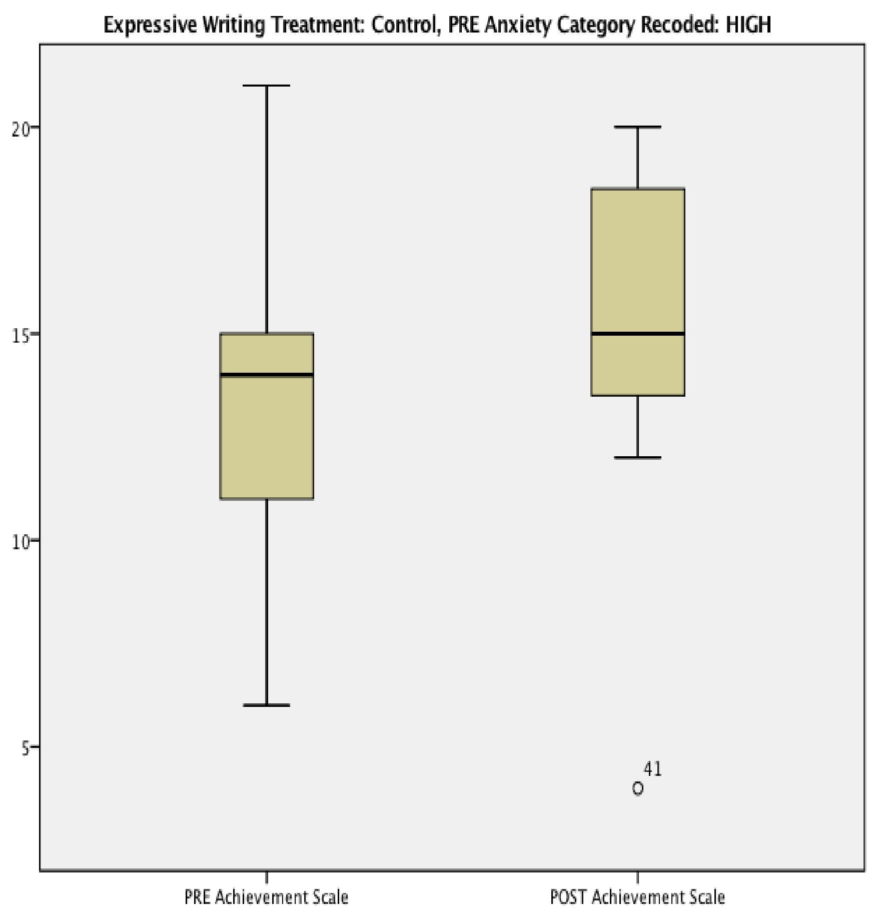




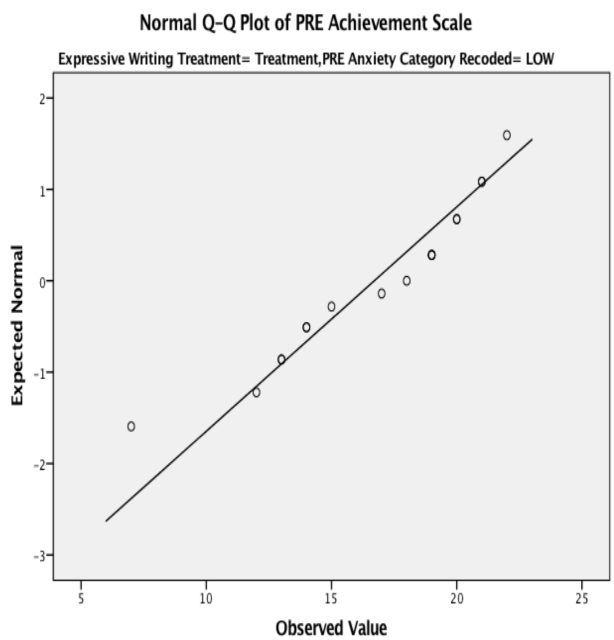
Normal Q-Q Plots Pre and Post for Moderate Anxiety for Control Group

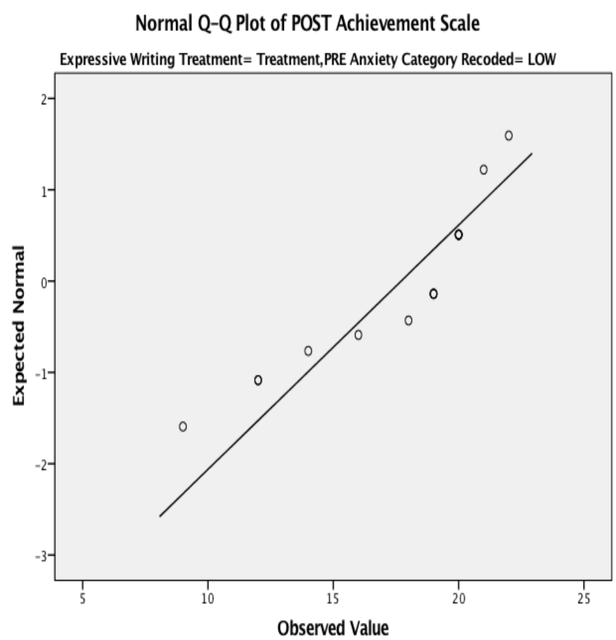


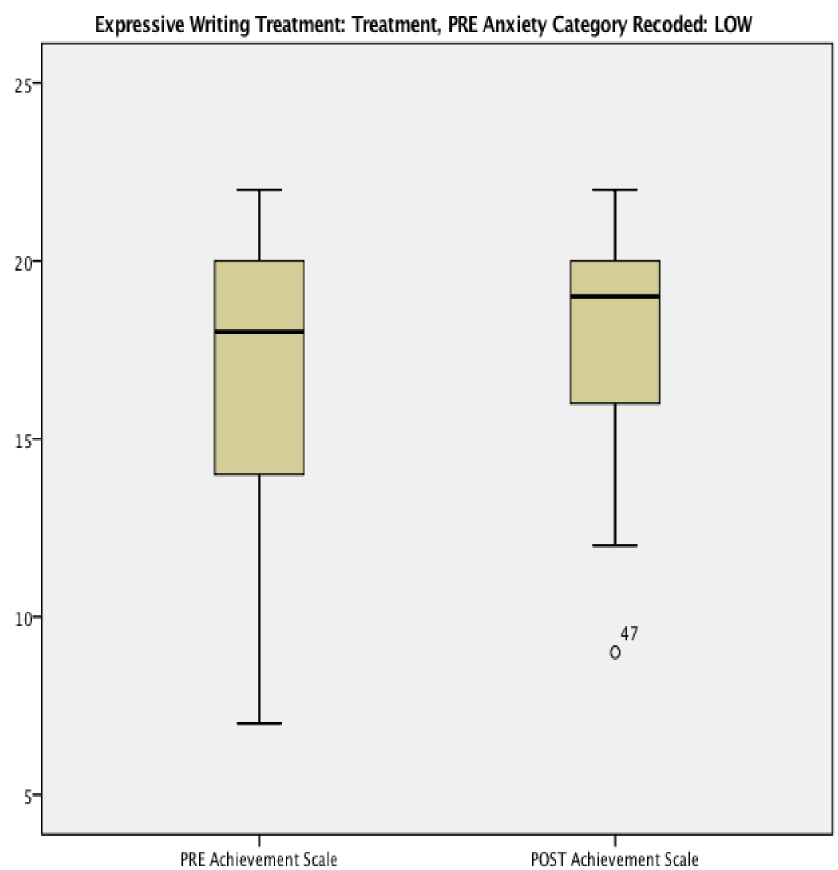




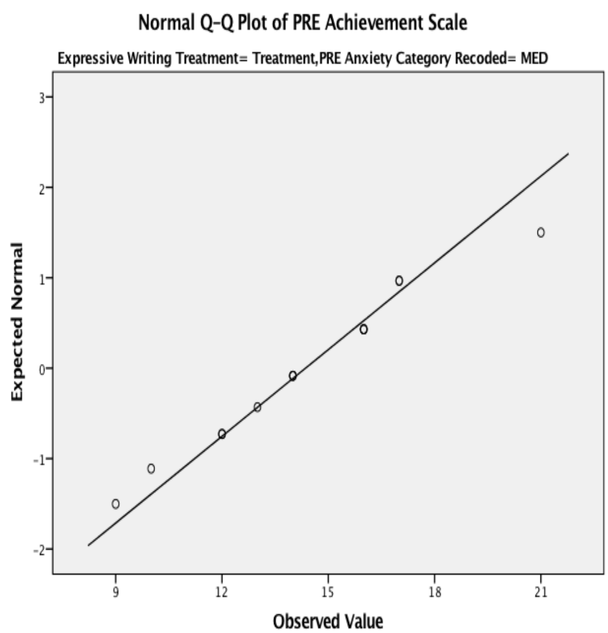
Normal Q-Q Plots Pre and Post for Low Anxiety for Treatment Group

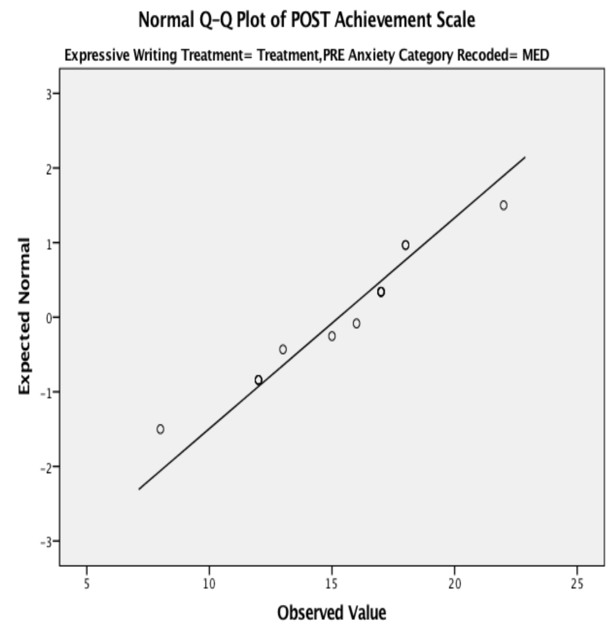


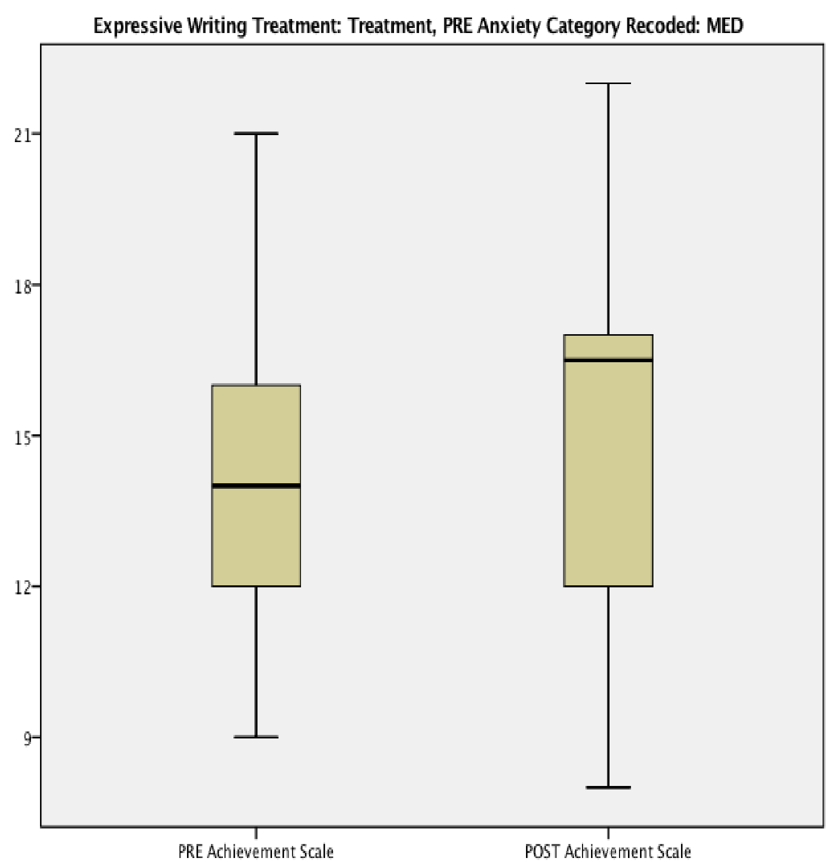




Normal Q-Q Plots Pre and Post for Moderate Anxiety for Treatment Group







Normal Q-Q Plots Pre and Post for High Anxiety for Treatment Group