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The effectiveness of creative writing on lowering mathematics anxiety and increasing standardized test scores in middle school

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The Effectiveness of Creative Writing on Lowering Mathematics Anxiety and Increasing Standardized Test Scores in Middle School

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Abstract

This study was designed to determine whether or not creative writing prior to "high-stakes" mathematics examinations was affective in reducing mathematics stress, anxiety, and/or worry. The participants chosen for the study were 26 sixth grade students in a middle school mathematics class. All participants were assigned to either a High Anxiety or Low Anxiety distinction based on an anxiety survey requiring students to rank the level of math anxiety they felt in various mathematics scenarios. Participants were then screened for mathematics ability by scores on standardized and district mathematics exams, and assigned to experimental and control conditions. Results were comprised of individual test scores on two high stakes exams, and analyzed specifically for growth across two installments of each exam. Analysis of growth scores showed that exposure to the experimental creative writing condition was successful for some groups.

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Chapter 1

Introduction

The action research described in this summary focuses on 26 sixth grade students who attended a Christian choice school in a large Midwestern city. The majority of the students who participated in this research had attended the same school for at least two years, and were in the fourth quarter of their sixth grade math class at the outset of data collection. Students were primarily African American (24), with very small sub-set of Hispanic students (2). All students were qualified for the free and reduced lunch program upon enrollment for their sixth grade year. In accordance with IDEA provisions requiring students with learning disabilities to be educated with the general learning population and other students who are not disabled, all students participating in this action research were in the least restrictive environment possible. More specifically, there were no identified or reported IEPs to make note of throughout the entire sample, and only one student who was knowingly taking medication for an attention deficit disorder. There were no identified math deficits or disabilities, which provided every student in the sample to be present for "regular classes" in accordance to the IDEA provisions.

With a sample containing such staggering varieties of math "levels" and capabilities based on standardized tests, benchmark examinations, and Common Core State Standard (Common Core State Standards Initiative, 2012) unit quizzes and assessments, this action research focused on a specific intervention to address mathematics stress, worry, and anxiety. There was, and still is, an overwhelming amount of natural "stress" placed on middle school students' academic performance, specifically derived from the level of mathematic rigor required in the Common Core State Standards in tandem with the high demand of proving mastery and growth on standardized tests such as the MAP (Measures of Academic Progress, Northwest Evaluation Association, 2000) test. This study explored a creative writing intervention to allow students to express any worry, stress or anxiety they were feeling prior to a “high-stakes” school-wide examination, and ideally help them to free up more working memory space to complete the tasks on the examination.

At the time of data collection, the students in the sample were truly excelling at full-class and partner math discussion, describing problem-solving thought processes, justifying and “bashing” multiple choice answer options, agreeing and disagreeing with classmates’ opinions based on mathematics reasoning, recalling and implementing basic math facts embedded in multi-step problems, and accurately following steps outlining correct methodology in solving multi-step problems. A major need scholars experienced at the time of data collection were tools aiding extension and application of mathematics knowledge, specifically for components of multi-step problems that were not explicitly modelled in a full-class setting. The domains within the Common Core State Standards (CCSSs) specifically shift between fifth and sixth grade, providing two new focuses that students would not have experienced in their previous year: Ratios and Proportional Relationships, and Statistics and Probability. Additionally, the domain of “Expressions and Equations” is more strictly connected to algebraic concepts at the sixth grade level than is apparent in the corresponding fifth grade domain. Because of these shifts in the CCSSs at the sixth grade level, students demonstrated difficulty in extending basic recall to application problems and applied theory. For example, many students in the sample excelled at fraction computations, but struggled to apply the concept to computing unit rates and determining ratios in real-world contexts. Due to these mathematics needs, the benchmark examination referenced in the procedures of this study proved to be one that elicited stress, worry, and anxiety in students who struggled with the sixth grade CCSSs in class.

In summary, this study addresses the question: Does creative writing about specific stress, worry or anxiety prior to high-stakes standardized mathematics tests affect scores on those tests?

The next chapter summarizes the extensive amount of research focusing on the origins of math stress, worry, and anxiety, and even explores possible interventions and coping mechanisms to help students identify their feelings about math. Many of the coping mechanisms and interventions explore how freeing up attention and memory is a result of identifying and coping with math stress and anxiety.

Chapter 2

Review of Literature

The presence of mathematics stress and anxiety is widespread across students of various ages and levels. The origin of stress and anxiety in the presence of mathematics tasks and situations is widespread, and differs according to each individual student. Studies outlined in this chapter attribute the origin of mathematical anxiety to self-esteem issues, social comparison to high-performing peers, achievement motivation, gender, math disability, working memory deficits, low emotional control, automatization and recall issues, and attention deficits and disorders. Additional studies in this chapter provide ideas and strategies for coping with and expressing math fears and anxieties, including creative writing, expressive writing, and journaling about worries before completing mathematics tasks. Further, analysis of proposed interventions suggest that tutoring programs and intensive step-by-step problem solving curriculum prove effective for high anxiety and math disabled students.

Self-concept, Self-efficacy, and Comparison in Mathematics

This section summarizes three studies addressing students' emotions and responses to mathematics and mathematics anxiety. The evaluation of self-esteem, motivation, comparison, and self-concept as a contributing factor to increasing mathematics anxiety levels serves as a common thread through current research on mathematics anxiety. Research has also been conducted on self-efficacy towards mathematics and science tasks as varying by gender, which is highlighted as a contributing factor to mathematics anxiety and worry. As a coping mechanism to identify thoughts and feelings towards mathematics using mathematical writing, students exhibited greater social awareness and recognition of their personal fears and anxieties in relation to mathematics.

In Kesici and Erdogan's (2010) study, researchers examined the relationship between math anxiety, achievement motivation, self-esteem, and social comparison in eighth grade students. Specifically, the study focused on determining if a student with low achievement motivation significantly differed from a student with high achievement motivation in terms of math anxiety. Researchers also sought to determine how varying levels of self-esteem contributed to mathematics anxiety. The broad aim of the study was to explore how students' self-concept and subjective self-evaluative measures and perceptions influenced math anxiety, as opposed to actual mathematic criteria.

Researchers used a random sample of 156 eighth grade students attending a private tutoring center in Turkey, 86 of whom were male, and 70 were female. Participants were included in the study on a voluntary basis, and remained confidential. Researchers used three different evaluative measures to address the independent variables: Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972), Achievement Motivation Scale (Umay, 2002), and Social Comparison Scale (Gilbert, Allan, & Trend, 1991). All data collected on the three aforementioned scales sought to connect student self-evaluation measures directly to math anxiety.

The Mathematics Anxiety Rating Scale included 98 items in which students rated their own degree of anxiety caused by each outlined situation. The score produced from this scale was the accumulated total of all points, anywhere from 98 to 490 points total. Researchers attributed high accumulated totals to signs of higher math anxiety, and low accumulated totals to low math anxiety. The Achievement Motivation Scale included 14 items to measure motivation of students "who are expected to have high achievement motivations" (p. 58). Finally, the Social

Comparison Scale was a self-evaluative scale consisting of 18 items analyzing how students perceive themselves when they compare themselves to others.

The results on the Achievement Motivation Scale were classified according to the mean score (23.52). Students who scored below the mean were said to have low achievement motivation, whereas students who scored above the mean were said to have high achievement motivation. Based on the sample, the results showed the math anxiety of students possessing high achievement motivation is significantly higher than those students possessing low achievement motivation. The overall effect of achievement motivation on math anxiety was "medium" according to researchers, indicating achievement motivation may not have extreme effects on math anxiety. Alternatively, the results of the Social Comparison Scale showed students possessing negative self-esteem had significantly higher levels of math anxiety than students possessing positive self-esteem.

Researchers concluded possible reasons for the results stated above. They suggested social comparison is a critical contributor to math anxiety because low self-esteem leads to greater anxiety levels. Students who experience low self-esteem evaluate their own personal potential negatively, and thus tend to rely on upward comparisons rather than own individual self-efficacy. The study showed that a student's self efficacy was not based on actual mathematical criteria (based on outcome of actual math tasks), but rather personal perceptions of mastery and comparison with other individuals who may have obtained said mastery. The researchers concluded students would not be able to decrease math anxiety by comparing themselves to other individuals based on mathematical performance, but rather by evaluating their successes and failures on objective mathematic criteria.

In the last study, Kesici and Erdogan (2010) found that students who compared their mathematic performance with others tended to develop higher levels of mathematics anxiety. In the next study, Griggs, Rimm-Kaufman, Merritt and Patton (2013) studied gender as an influencing factor on anxiety in math and science situations. Their findings seem to provide a prospective reasoning for the low math self-efficacy discussed in Kesici and Erdogan's study.

In Griggs, Rimm-Kaufman, Merritt and Patton's (2013) study, researchers sought to determine what links, if any, there are between student anxiety, gender, and self-efficacy in math and science. Specifically, they wanted to collect data to determine the extent to which anxiety is associated with poorer math and science self-efficacy in early middle school students. Additionally, researchers wanted to determine if Social and Emotional Learning (SEL) practices had any role in shaping students' self-perceptions. Researchers sought to do this by collecting self-reported data from students attending schools implementing Responsive Classroom (RC) practices, and determining whether or not these students reported greater self-efficacy in math and science than schools not using these practices.

The sample used was quite large, and very intricate. Research was conducted on a subset of schools in a randomized controlled trial of the RC approach. The RC approach includes seven principles about teaching, and ten practices derived from those principles (i.e., Morning Meeting, Guided Discovery, Academic Choice, Rule Creating, Logical Consequences, etc.). Twenty four socioeconomically diverse elementary schools in a mid-Atlantic state were randomly assigned to a control trial of the RC approach for a three-year time frame. In the last year, the study schools were invited to participate in intensive student data collection specifically of 5^{th} grade students. Twenty of the invited schools enrolled, which resulted in 12 schools being assigned to the intervention group, and eight assigned to the control group. Fifth grade math teachers from the

20 schools were invited to participate, and a total of 62 teachers participated (34 intervention, 28 control). Fifth grade students were also invited to complete the questionnaires; 1,561 students comprised the sample (797 intervention, 764 control).

Fifth grade teachers in the RC condition went to two-week institutes to learn the RC method in detail, and received intensive coaching and follow up meetings. The schools/teachers in the control group used “normal” social and emotional learning strategies, often taught/provided by the guidance counselor on site. In the third year of the study, fifth grade students were given a 20-item Self Efficacy and Anxiety Questionnaire survey, which was adapted from the Patterns of Adaptive Learning Scales (PALS; Midgley et al., 2000) to highlight feelings specifically related to math and science. Teachers reported the use of RC practices on the 47-item self-survey, Classroom Practices Teacher Survey (CPTS). Data on the comparative levels of anxiety and self-efficacy in math and science across intervention and control schools came from three domains: school district regarding student demographics, teachers regarding use of RC practices, and students self-reporting on self efficacy, anxiety, gender, and age.

Results showed boys and girls reported similar self-efficacy in math, but boys reported greater self-efficacy towards science than girls. Boys reported less math and science anxiety overall than girls reported. In terms of effectiveness of RC practices on math and science self-efficacy and anxiety, researches found there was no main effect of these practices on math self-efficacy, but there was as significant effect of RC practices in regards to science. Students reported a greater self-efficacy in science when data were controlled for gender and anxiety levels. Further, researches found there was a negative association between anxiety and self-efficacy in schools where teachers reported more RC practices, suggesting students who were in a RC school experienced higher self-efficacy as the their anxiety decreased.

The researchers concluded that students who felt more anxious about math and science also reported fewer efficacies towards these subjects, but students experiencing greater math and science anxiety were less likely to experience poor self-efficacy when they were exposed to more RC practices. Although the results showed no significant difference between genders, researchers concluded RC strategies might result in interactions that increase self-efficacy in science, but not necessarily math. This may be due to the differences in fifth grade math and science curriculum insomuch as science curriculum for this age level allows for more inquiry and exploration of individualized interests than math does. Overall, there is a lack of association between RC practices and math self-efficacy.

In the last study, Griggs, M. S., Rimm-Kaufman, S. E., Merritt, E. G., and Patton, C. L. (2013) found that students tended to have lower levels of anxiety if they believed they had the ability to solve math and science related questions. In the next study, Tracie, M. S. (2004) sought to determine if the use of creative writing in a journal had any effect on the level of comparison a student had in a mathematics course.

In Tracie's (2004) study, the researcher sought to investigate the effectiveness of writing on students' perceptions of mathematics. She highlighted that writing has an abundance of advantages for students, even in the field of mathematics. Writing about math helps clarify and deepen mathematical understanding, as well as heighten conceptual understanding of principles and strategies. Further, writing—not only about concepts, but about feelings towards math itself—provides reinforcement to the student, and feedback to the teacher. The discussion highlights that there is currently a lack of proof that writing improves mathematical learning, but the researcher attempts to determine the non-quantifiable benefits of writing in mathematics in this research.

The sample consisted of 24 college students, four male and 20 female. All but one of the participants was a traditional undergraduate student, and all were enrolled in a math course designed to meet the needs of pre-service elementary teachers. The structure of each class involved an introduction to a math problem, a brief lecture, and then a discovery of knowledge in which small groups work together to find a solution. Groups were expected to share methods, critique one another, and evaluate multiple strategies in order to solve the given problems.

The course instructor asked students to keep a journal for the course, and to record thoughts each day after class. The journal was collected from each student weekly, and was not marked down for grammar or given any grade at all. There were also no length requirements. The instructor read all the journal entries, and simply wrote comments of encouragement to the student.

The researcher collected data in four different ways: content and frequency of writings in student notebooks, instructor notebook in which records were kept of discussions or events that related to the use of the student notebook, end of class survey on students' thoughts about the use of the notebook, and end of semester interviews used to gauge previous math experience, thoughts on writing in a math class, and personal observations from journal writing.

The results surfaced into three themes: student development of new understanding of the meaning of math; student awareness of their place in a learning community; and self-evaluation of motivation, feelings, and learning mathematics. For the first theme, results mainly came from interviews and reflection on journal entries. Many (if not most) of the students involved had strong dislike and discomfort with math because they believed it was prescribed, "black and white," and methodical. After engaging in writing in their notebook and self-discovery learning, many had a widened view of what problem solving could encapsulate, and how there was much creative freedom in approaching mathematical problems. For the second theme, results showed many students recorded thoughts of comparison in their journal in regards to their learning community. They began the course feeling inadequate and lacking confidence in their math ability, but switched to having an "I'm not the only one" mentality through their journal writing. Because the course relied heavily on group work, many students began to record increasingly more positive thoughts about group roles, learning from peers, and asking mathematical explanations from "stronger" math students. Finally, for the third theme, results tied in very closely with the researcher's prediction. Students' writing began to reflect recognition for their fears and anxieties towards math. As the journal entries continued, students expressed how valuable it was to have an understanding for the way they approached math, and to see that they were not always correct in their presumptions. Many students had overwhelmingly positive responses to math problems, experiences, and tests, especially those who began the course feeling the exact opposite.

In the first study, Kesici and Erdogan (2010) found that achievement motivation resulted in higher levels of mathematics anxiety, as did social comparison in mathematics situations. Many of these emotions were discussed as being a result of person perception rather than empirical data. In the second study, Griggs, M. S., Rimm-Kaufman, S. E., Merritt, E. G., and Patton, C. L. (2013) discussed levels of math and science anxiety in terms of gender. They found that students who had greater levels of anxiety also believed they had fewer efficacies towards mathematics, but these emotions and perceptions did not actually differ by gender. In the last study, Tracie M. S. (2004) found that expressing emotions regarding mathematics tasks widened students' views about how they could approach math problems, and how they viewed their role amongst peers in math group work. All three studies discussed how self-perception influenced the way math students view their mathematic abilities, and thus influence the anxiety they feel towards math.

Working Memory

The research on the connection between math anxiety and working memory capacity is extensive. The research summaries included in this section concentrate primarily on the lowering of working memory capacity as a result of math worry and/or stress. Problem solving is highlighted as a great difficulty for students with lower working memory capacity due to the limited resources available to reason through multiple steps and components of mathematics word problems. Further, gender, math disabilities, attention deficits, and lowered emotional control are all contributors or results of lowered working memory capacity.

In Ganley and Vasilyeva's (2014) study, researchers sought to determine how gender, math anxiety, and working memory contribute to math performance in college-aged students. Interest in this study came from the notion that women tend to have higher anxiety about a math test, which causes them to utilize much of their working memory resources needed to solve the task, which leads to poorer performance on the task. Although research has shown the types of tasks females perform better on includes computation and tasks involving procedures and information, male students consistently outscore females on the SAT and AP tests, thus affecting academic futures based on gender. The researchers sought to determine what, if any, connections exist between verbal and visuospatial working memory, gender, and math anxiety.

The participants involved were 87 college students attending a private university in the northeast. All participants were volunteers who were recruited in their undergraduate psychology classes and informed they would be given extra credit for participating. Of those who signed up to participate, 63 were female and 24 were male.

The researchers used four different measures to determine the relationship between gender, working memory, and math anxiety. Math anxiety was measured specifically as a worry, using a four-item self report scale about personal level of worry in given mathematics situations. Verbal and visuospatial working memories were measured by dual-task measures on a computer. To measure verbal working memory, students were given a word recall task in which they made true or false judgments about sentence meaning, and then asked to recall the last word given in each sentence. To measure visuospatial working memory, students were asked to determine if a shape was the same or opposite shape as one provided, as well as choose the location of a dot matching the placement of a dot on one of the shapes. Finally, math performance was measured by a 12-item math multiple-choice math test, with items taken from widely-used standardized tests. Six items covered algebra topics, and six items covered geometry/measurement problems.

Students were given a booklet with all four measures described above. They were told the main component of the booklet was the math test, and then immediately given a math "example" problem. Once the example was completed, they were then asked to complete the worry scale. Students then completed the dual computer tasks testing working memory, and ended by completing the math test.

The results showed gender differences were found in worry, visuospatial working memory, and math performance—not verbal working memory. Gender was significantly related to math test score and worry, and further, gender and worry were predictors of visuospatial working memory. The researchers found that gender was no longer a predictor of math test performance, but worry and visuospatial working memory were predictors of math test performance. Although the findings do not prove there is a casual link between the three, the researchers theory seemed to be substantiated: one possible reason for gender differences in math performance is the increased worry of females causes a decrease in visuospatial working memory, and thus decreases math performance.

In the last study, Ganley and Vasilyeva (2014) found that women tended to have higher levels of worry about math performance, which results in lower working memory capacity. In the next study, McQuarrie, Siegel, Perry and Weinberg (2014) studied cortisol reactivity in response to high-stakes math situations. Findings for both studies support lowered working memory capacity in the presence of stress, worry, and anxiety.

In McQuarrie, Siegel, Perry and Weinberg's (2014). study, the researchers wanted to further investigate how students with math disability (MD) were affected when exposed to "high-stakes" math situations. Research has shown that MD students have a deficit in their working memory system, and thus have great difficulty retrieving basic math facts, executing mathematical functions, and processing mathematical information quickly. The researchers were specifically interested in determining how math anxiety/reactivity, measured by salivary cortisol levels, affected students with MD. They wanted to determine if children with MD differ from their typically achieving (TA) peers in terms of stress levels when they were exposed to mathematical situations. Finally, they wanted to observe whether or not the varying reactivity levels of MD and TA students affected the math performance of these students, and how the two groups differed in performance.

The participants for this study were 83 first grade students from a school district in western Canada. The Woodcock-Johnson Tests of Achievement Third edition (WJ-III ACH; Woodcock, McGrew, & Mather, 2001) was used to determine which students would be in the

MD and TA groups. Students specifically were tested on applied mathematics, math calculation, letter-word identification, and word attack problems. Students who scores at or below the 25th percentile on the mathematical components of the test and above the 30th percentile on the language components of the test were placed in the MD group. The remaining students were placed in the TA group.

In order to elicit stress from those involved, the participants were told they would be working with numbers on an upcoming task. They were assigned to one of two testing sessions, and were given nine different cognitive tasks believed to contribute to MD: working memory for words, digit span backward, digit span forward, letter number sequence, rapid picture naming, rapid number naming, block rotation, number series, and quantitative concepts. Four samples were taken to measure salivary cortisol levels: prior to the test session to establish a baseline level for the participants, 30 minutes after the beginning of the test, the morning of a later day without any testing, and the afternoon of the later day. Reactivity was considered "high" if it was at or above the 75th percentile, "low" if it was at or below the 25th percentile, and "moderate" if it was in between.

The results were consistent with the researchers' predictions. Students who tested as MD performed lower than their TA peers on the letter number sequence and quantitative concept tasks. Cortisol levels showed that overall, reactivity was a significant predictor of performance on these tasks: students with high reactivity according to their cortisol levels had lower scores than students with low reactivity in working memory number and word tasks, as well as the quantitative concepts task. The MD students did not perform differently than the TA students on all nine tasks due to reactivity, however. But, the scores for the highly reactive MD students were lower than the low reactive MD students in comparison. Overall, the MD students as a group had more difficulty with number sense than their TA peers, which was consistent with what the researchers predicted at the outset of the study. The response to stress related to both working memory and math tasks in MD students.

In the last study, McQuarrie, Siegel, Perry and Weinberg, J. (2014) found that higher levels of reactivity to stress resulted in greater difficulty in math tasks for both math disability and typically achieving students. In the next study, Trezise and Reeve (2014) study the working memory capacity of students in terms of average speed in problem solving abilities. Their findings support those in McQuarrie, Siegel, Perry, and Weinberg's study.

In Trezise and Reeve's (2014) study, the researchers sought to investigate the connection between emotional states and working memory. Previous research has highlighted that individuals who have limited working memory capabilities have lower ability to regulate and/or control their emotional states, which often leads to worry or anxiety. This creates a cyclical difficulty for the individual because worry requires a greater use of working memory, and thus decreases the individual's capacity for other tasks. Because this cycle has been said to affect reasoning abilities (such as those common in mathematics), the researchers wanted to investigate the cognition-emotion relationships associated with algebraic problem solving. Specifically, the study wanted to address whether or not working memory and worry relationships could be identified in individuals. Next, whether or not the membership in a working memory and stress related group would remain the same over time. Finally, to determine whether or not the working memory and worry relationships in an individual would predict problem solving ability.

The sample included 126 teenage students who attended an urban high school in Australia. The students were asked to complete three different algebraic tasks, including algebraic working memory, algebraic judgment/worry, and an algebraic problem-solving test. In addition, they completed two general tasks measuring visuospacial working memory and response inhibition. Students completed these tasks in two different sessions on a single day using laptop computers.

The algebraic working memory task asked students to determine the accuracy of algebraic statements without solving the given equation. The algebraic worry task intended to measure the level of worry a student experience while making judgments. Specifically, this task gave the student a set of equations and asked whether or not the equations were equivalent based on the value of the variable. Immediately following the question, students had to rate the level of worry they experienced while answering the problem by selecting a picture of a face that accurately described their feelings. The algebra problem-solving task required students to solve linear equations of varied difficult levels. The visuospatial task required the student pay attention to the order in which nine cubes were highlighted on the screen. Once the sequence of light had finished, the student had to reproduce the same order by clicking the blocks. Finally, the response inhibition task required students to press a key on as soon as a red dot appeared amongst a series of colored dots and crosses on the screen.

Results showed that students with high working memory and low math worry showed the highest accuracy rates for all problem solving, average speed for easy problems, and slower responses for hard problems. The high working memory and high anxiety/worry students had a low average speed, but demonstrated high accuracy for easy problems, and average accuracy for difficult problems. Alternatively, the low working memory and low worry students showed average levels of accuracy and response time for the easy problems, but low quick responses with low levels of accuracy for the difficult problems. Therefore, the individuals who experience high levels of worry in mathematically-related situations will have varied response times (speed) depending on their working memory. The findings also supported the original assumption regarding worry and reduction of working memory capacity: students who originally showed high working memory capacity were likely to change to low working memory capacity in the presence of worry, suggesting that worry about the mathematical situation reduces working memory capacity.

In the last study, Trezise and Reeve (2014) found that math stress, worry, and anxiety lowered working memory capacity. In the next study, Swanson, H. L. (2014) studied the effects of problem solving strategy training for students with math difficulties.

In Swanson's, H. L. (2014) study, he sought to investigate the problem-solving abilities of students who experience math difficulties (MD). Lee discussed the use of cognitive strategies, including verbal strategy instruction and visual-spatial strategies, as being key contributors in improving mathematical problem-solving accuracy. However, he hypothesized that these strategies prove ineffective on children with MD if they also have low working memory capacities (WMC) because they would be "over-taxed" by the lack of working memory resources crucial to benefit from the cognitive strategies. If a student had a low working memory capacity, they would experience difficulty in committing the strategy information into long-term memory, and thus not experience improvement in problem-solving capabilities. Lee designed this study to determine exactly what role working memory capacity plays in strategy training outcomes for children with MD, and hypothesized that children with lower WMC would benefit less from the strategy conditions than children with higher WMC.

In order to test this hypothesis, Lee identified children at risk for difficulties in math problem solving by using a cutoff score on standardized math achievement tests: 25^{th} percentile on norm-referenced word problem solving math tests over a two-year period. Children were randomly assigned within each classroom to a control group or to one of the three treatment conditions: verbal strategies, verbal and visual strategies, and visual strategies only. All participants remained in their normal classrooms, interacting with the normal math curriculum which included the math problem solving steps of understand, plan, solve, and look back. Each of the experimental conditions contained 20 scripted lessons given over an 8 week period. The lessons were given three times per week in small groups of children by trained tutors. The five-minute instruction phase of the small group lesson was when students were exposed to the specific treatment condition. For the verbal strategy approach, students needed to find the question, underline it, circle the numbers, put a square around the key words, cross out information not needed, decide on what operation needs to be done, and then solve. For the visual strategy approach, students were taught how to use two separate diagrams to show how parts made up a whole, and how quantities are compared. Finally, for the verbal and visual (combined) strategy, students were given a diagramming of the given information, as well as the six verbal steps above. After exposure to the treatment strategy, students were given support by the tutor in utilizing the strategy during a "guided practice," and then worked independently without support on an "independent practice."

At the conclusion of the lesson, students would receive points for the correct usage of the components of the visual, verbal, or visual and verbal strategies. Two measures were used to determine participants' word problem solving abilities: subtests from the Test of Math Ability (TOMA-2; Brown et al., 1994) and KeyMath (KEYM; Connolly, 1998). Additionally, the Comprehensive Mathematical Abilities test (CMAT; Hresko, Schlieve, Herron, Swain, & Sher-benou, 2003) was given as a pre and posttest measure of word problem accuracy. Working Memory Capacity was measured by an average of three measures: conceptual span task to assess the child's ability to organize words into abstract categories, sentence/digit span to assess the child's ability to remember numerical information embedded in a short sentence, and "updating" which required children to recall the last three digits in an unknown series while keeping the order of previously presented digits.

The sample included 147 third-grade children from public schools in the southwestern region on the United States. Of the 147 children, 74 were female students and 73 were male. Data on socioeconomic status (SES) were based on free and reduced lunch participation, parent education, and parent occupation. The mean SES was low to middle, with relatively large discrepancies across classrooms. However, due to the random assignment of treatments across classrooms, Lee determined SES was not a contributing factor to the outcomes of each individual treatment group.

The results showed that for children with MD and relatively high WMC, an advantage was found for the verbal only and visual only strategies, as compared to the control group. However, as hypothesized by Lee, when there was low WMC, none of the treatment conditions exceeded the outcomes of the control condition outcomes. Interestingly, for the "average achievers," there was no treatment condition that provided an advantage over the control condition. Lee does discuss that although treatment conditions and problem-solving strategies appear favorable over the control condition, these effects were non-significant for low, middle and high levels of WMC. In conclusion, Lee claims there is "weak support" for students with low WMC to benefit from cognitive mathematical problem-solving strategies.

In the last study, Swanson, H. L. (2014) found that students with low working memory capacity experience difficulty in mathematics problem solving. In the next study, Zentall, S. S.

(1990) studied the retrieval time of learning disabled and attention deficit students in computing basic math facts. His findings support those in Swanson's study.

In Zentall's, S. S. (1990) study, he sought to investigate the retrieval time and accuracy of mathematic calculations. Zentall discussed prior research that claims that if students could master skills at an automatic level, the freed up energy could be directed towards problem solving skills instead. Currently, there are high numbers of students reported as attention deficit or disordered who have not mastered basic content and thus cannot fully approach problems requiring problem solving skills. This study aimed to provide a better assessment of problem solving by controlling for IQ, reading ability, and exposure to different grade levels of math materials. Additionally, the study sought to use group comparison of fact retrieval speed for older students who should already have demonstrated mastery of lower level skills such as addition, subtraction, and multiplication facts. Lastly, the study sought to assess the relationship between retrieval time and problem solving.

The base population included 300 seventh and eighth grade students, of which 15 students, 8 Caucasian boys and 7 Caucasian girls, were identified as LD by the schools they attended. Of the 15 LD students, 10 were defined as having attention deficits. Of those 10, 80% were ADD without hyperactivity, and 20% were ADD with hyperactivity. With parental permission, an additional 33 students were identified as non-learning disabled with an attention deficit disorder, 70% with hyperactivity and 30% without hyperactivity. There were 18 normal control (NC) students selected from the same classes.

To conduct the study, subjects were seated at a table in an empty classroom. The subjects faced two screens, one of which had a panel containing a one-way mirror. The observer sat behind the screen so that the student was visible from the front. Students were given a random sequence of 40 word problems, 20 of which were at the student's grade level, and 20 of which were above their grade level. Problems were coded as action type (included action verbs), comparison type (two quantities), mixed type (combination of action and comparison), same operations (one type of operation), and different operation (at least two operations). Students solved problems in a notebook or on a post-it, proceeding until they completed all of the problems or until 25 minutes had elapsed. For a different session, students were given sets of 100 addition, subtraction, and multiplication facts written on cards. Problems were presented in three notebooks with the 50 easy problems presented first, followed by the 50 hard problems presented second. Students were told to proceed to the second notebook as soon as the first was completed in order to respond to the task of speed.

Students were randomly assigned to a task order (word problems then facts, or visa versa), word problem order, and difficulty order for their two observed sessions. Behavior was measured by 20 minute observations on three types of behaviors: bottom/torso movement (movement resulting in bottom being off the chair, out of one's seat, sitting on a foot, leaning forward and backward, titling seat); vocalization/noise (clearly audible, nonrespiratory noise such as tapping feet); and visual off-task attention (90 degree turn of the head away from the task). Performance was measured by mean fact-retrieval time, which was the average time required to read, solve, and write answers to the given problems.

The findings showed that fact-retrieval time differentiated the combined LD and ADD groups from the normal comparison group in each of the mathematical operations. Off task behaviors were only observed during multiplication facts, which shows that the retrieval speeds for addition and subtraction cannot be attributed to behavioral interference. When examining word problem solving scores, the ADD group did not differ from the control groups, but the LD students differed from the ADD and control groups. Zentall found that all children produced more correct answers in single operation problems, and that both of the experimental groups were also off task more than their normal classmates across any type of word problem given to them. Generally speaking, the ADD students not receiving special services appeared to be very similar to the LD students in retrieval time and problem solving. Zentall concluded that students with attention disorders and learning disabilities still face difficulties in basic math skills, and that retrieval speed is a significant predictor of higher-level problem solving. Further, that current methods to instruct students with attention disorders and learning disabilities fail to take into account the basic skill deficits and may result in long-term problems for basic and higher level mathematics.

In the first study, Ganley, C. M., and Vasilyeva, M. (2014) found that although gender was not a significant predictor of mathematics performance, women tend to have higher levels of worry in relation to mathematics. Higher levels of worry lead to lower levels of working memory capacity, which is supported by the second study. McQuarrie, M. M., Siegel, L. S., Perry, N. E., and Weinberg, J. (2014) studied cortisol reactivity to high-stakes math situations, finding that higher levels of reactivity resulted in lower scores on mathematics tasks. In the third study, Trezise, K., and Reeve, R. A. (2014) analyzed self-reported anxiety ratings after mathematics tasks. They found that high levels of working memory paired with low worry resulted in the highest levels of accuracy on mathematics tasks. In the fourth study, Swanson, H. L. (2014) studied the effect of problem solving strategies on students with varying levels of working memory capacity, including student with mathematics disabilities. His findings showed that problem solving strategies provided weak support in the presence of low working memory capacity. Finally, Zentall, S. S. (1990) studied basic fact retrieval time for students with attention deficits and learning disabilities, finding that basic skill deficits were predictors of problem-solving difficulties. All five studies supported the assertion that worries, stress, and anxiety contributed to lowered working memory capacity, and thus lower performance on mathematics tasks.

Creativity and Creative Writing as Benefactors for Math Anxiety

Many studies have been conducted to focus on coping with and addressing the lowered working memory capacity and high anxiety levels of mathematic students. Creativity and the use of writing has not only come up in a study highlighted above, but has been used as a form of self-identification and reflection for students who experience anxiety in math situations. The studies in this section discuss the connection between fostering creativity in math problem solving and varying levels of anxiety, as well as students self-identifying their levels of anxiety towards mathematics situations. Both studies use methods in which students could potentially lower levels of anxiety through reflection and coping mechanisms.

In Park, D., Ramirez, G., and Beilock's, S. L. (2014) study, researchers sought to determine if expressive writing reduced the negative impact of math anxiety and worry on math performance. The motivation for this study was founded on the idea that worry and nervous thoughts about math situations take away a critical cognitive resource from high math-anxious (HMA) individuals: working memory. If a student lacks working memory, he/she experiences great difficulty in finding the appropriate steps to calculate a solution to a problem, as well as hold and manipulate task-related information. The researchers highlighted that high math anxiety does not automatically imply poor math skills in a student, and thus low math-anxious (LMA) individuals do not necessarily outperform HMAs on *basic* math problems. This study sought to isolate dual-task/difficult math problems for HMA individuals in order to address the worry component of anxiety that takes away the working memory components in their thinking. The researchers used expressive writing to "free-up" the working memory space in HMA individuals, and determine if this increased math performance.

The sample was composed of 88 Midwestern college students who were invited to participate in the study. Participants took a 25-item self-report survey, the Short Math Anxiety Rating Scales (SMARS; Alexander & Martray, 1989), which reported scores out of 100 points total. The researchers categorized HMAs by scores below 20 on the SMARS, and LMAs by scores above 40. Of the 88 students who responded to the survey, 44 were considered HMAs and 26 were considered LMAs. Researchers then used the Cognitive Test Anxiety Scale (Cassady & Johnson, 2002) in attempts to separate out general testing anxiety from specific math anxiety before assigning students to the experimental and control groups.

Based on the results of the SMARS, participants were prescreened based on levels of reported high or low math anxiety, and randomly assigned to the expressive writing group (experimental) or the quiet reflection group (control). Participants were then given 12-item practice exam (six items were high-demand problems and six were high-demand word problems) designed to elicit anxiety. Immediately following this practice exam, participants were sent to their control and experimental groups for seven minutes. The experimental group was given a detailed prompt encouraging them to write about their emotions and feelings in regards to the upcoming exam. They were explicitly told to discuss previous life situations in which they experienced the same emotions they were experiencing currently. The control group was told to sit still and quietly for the same amount of time (any activity, such as reading, would exclude them from the study). Researchers entered the room after the seven minutes elapsed, and gave all participants a 60-task exam. Half of the exam had high-working memory demands (higher numbers and borrowing operations), while the other half of the exam had low-working memory demands (lower numbers and no borrowing operations).

The results showed that within the control group, the HMAs spent more time on high-demand problems than the LMAs, and also performed worse on these problems than the LMAs. In the expressive/experimental group, the HMAs showed no significant difference form the LMAs in reaction time (time taken to solve). Researchers concluded that the time taken to solve high demand problems between the HMAs and LMAs depended only on exposure to the expressive writing condition. The researchers concluded that in a single exposure to an expressive writing experience, there was a significant reduction in the extent to which anxiety related to the individuals' math performance. Researchers found that the HMAs who used more anxiety words in their expressive writing sample showed better performance on demanding problems, which they attributed to the freeing up of memory resources through the writing activity. The conclusions provided suggested that this activity helped students identify the emotions/anxieties present in this high-stress situation, and allowed them time to utilize strategies to regulate those emotions in order to prevent worry from capturing their attention during the actual math task.

In the last study, Park, Ramirez and Beilock's (2014) found that students' performance on a math task was not affected by anxiety if they were able to expressively write about their feelings prior to the math task. In the next study, Sharma, Y. (2014) studied how integrating creativity into mathematics would affect anxiety levels in students. For students with high math anxiety, his findings conflict with those in Park, Ramirez, and Beilock's study.

In Sharma's, Y. (2014) study, he sought to determine how students with math anxiety were affected when exposed to and encouraged to develop mathematical creativity. The researcher discussed mathematical creativity as a point of interest by asserting that is would contribute to the growth of the field as a whole, and prepare students to solve unknown problems in their lives. He provided that mathematical creativity would be fostered by adjusting resources and strategies to incorporate all learning styles and backgrounds of students in the classroom. Because little research has been dedicated to the relationship between mathematical creativity and math anxiety, Sharma designed this study to determine if there is a developed strategy effective in fostering mathematical creativity, if there is a difference between students who have high mathematics anxiety versus low mathematics anxiety in regard to mathematical creativity, and if there is an interaction between math anxiety treatment and mathematical creativity.

Sharma defined mathematical creativity as “the ability to overcome fixation as well as conceptualizing, proposing, and even testing unusual solutions of problem(s) of mathematics” (2014, p. 3). He created three phases for fostering mathematical creativity. In the first phase, students were given a demanding math problem in which the teacher encouraged multiple responses and recorded all solutions. The second phase was entitled “Cooperative Confrontation” and students were grouped together to find various solutions to a problem. The worksheets were collected, and feedback was provided on the solution strategies, as well as listed on the board. The final phase, “Independent Thought,” required students to create their own problem similar to the problem posed in phase two. Students then chose one of the problems from their classmates to solve independently, and were provided with feedback about the relevance and appropriateness of responses.

The study consisted of 111 students ranging in age from 14-17. The students attended three different schools, and were randomly assigned to the experimental and control groups. Both groups of students were given a *Sharma and Sansanwal Mathematical Creativity (*S^2MCT) pretest (designed by the researcher, 2012), which consisted of 20 items assessing problem solving, problem creation, and overcoming fixation in math. Students were told to provide as many solutions as possible. The students in the experimental group were taught lessons from the phases above meant to foster mathematical creativity in 35-minute blocks for 40 days. The control group continued with routine activities and problems, including direct instruction and independent problem solving. On the fifth day of the treatment condition, participants in both groups were given the Mathematics Anxiety Scale (MAS) (designed by the researcher, 2011) to determine levels of mathematics anxiety present. The scale consisted of 22 positive statements and 22 negative statements to be rated on agreement by the participant. At the end of the 40-day treatment period, both the control and experimental groups were given the S^2MCT as a posttest.

The results showed that students in the treatment group with high levels of mathematics anxiety had lower mean scores on the mathematical creativity component in comparison to the students with low or moderate anxiety. In the control group, the opposite occurred: students with high levels of mathematics anxiety had higher mean scores on the mathematical creativity component. Looking at students who had average levels of math anxiety in the treatment group shows that they had lower mean scores of mathematical creativity than those who had low math anxiety. However, the students who had average levels of math anxiety in the control group showed that they had higher mean scores of mathematical creativity than those who had low math anxiety. These results suggest that students with low math anxiety may experience significantly more benefits from mathematical creativity instruction than their high or moderate anxiety counterparts. Further, the researcher concluded that the strategy for fostering mathematical creativity through phases was more successful at exposing students to different exercises and strategies than the traditional model, thus making them more creative and active in their mathematical interactions.

In the first study, Park, D., Ramirez, G., and Beilock, S. L. (2014) found that the mathematic performance of students with high levels of anxiety was not affected if the students were able to expressively write about their emotions prior to the math task. In the second study, Sharma, Y. (2014) found that mathematical creativity was more beneficial for students who experienced low levels of mathematics anxiety as opposed to those who experienced high levels of mathematics anxiety. Both of these studies furthered research on methods attempted to increase students' working memory capacity, specifically for students who experienced math anxiety. The next section highlights research conducted on interventions for students who experience mathematics anxiety or specific mathematics disabilities.

Interventions for Math Anxiety and Math Disabilities

The studies in this section go beyond math anxiety coping mechanisms, and broach the area of interventions and tactics used to increase mathematics performance despite anxiety, stress or worry. Each study uses a specific intervention—*Solve It!* and math tutoring—to address problem solving strategies in students with anxiety and students who are at risk of mathematics disabilities.

In Fuchs, Compton, Fuchs, Paulsen, Bryant and Hamlett's (2005) study, the researchers sought to determine the effectiveness of math tutoring on cognitive and academic measures, as well as the decrease in prevalence of math disabilities. The researchers highlighted the need for more studies related to mathematics due to the fact that most studies conducted so far pertain almost strictly to basic fact assessment and simple computation, leaving out other main components of mathematics curriculum. Another concern is the limited approaches to mathematics disability prevention and intervention, which thus far, has been primarily done at the class-level. In order to address some of these concerns, the design of this study has a threefold purpose: to determine the effectiveness of continual tutoring on math components such as concepts, applications, fact fluency, computation, and arithmetic word problems; to determine how prevalent and severe mathematic disabilities are with and without preventive tutoring; to explore the cognitive characteristics that are crucial to developing math competence.

The researchers sought to identify children at risk (AR) for developing math difficulties in first grade classrooms across ten different schools. Teachers involved in the study completed a questionnaire explaining their whole-class math instructional methods. Next, the Curriculum-Based Measurement (CBM) Computation, Addition Fact Fluency, Subtraction Fact Fluency, and CBM Concept/Applications were used in a whole-class format in order to determine the AR and not at risk (NAR) students. Once students were identified for the aforementioned categories, teachers were told the names and given the opportunity to nominate 11 additional students who they suspected were AR. Students were then officially identified as being AR, and were randomly assigned to the control or tutoring conditions. This created four separate "groups" of students: control, AR tutored students, individually tested and deemed NAR, group tested and deemed NAR.

There were seven measures of mathematic performance given as a pre and posttest: CBM Computation, Addition Fact Fluency, Subtraction Fact Fluency, First-Grade Concept/Applications, Story problems, WJ III Applied Problems, WJ III Computation. Cognitive tests included tasks assessing intelligence, language ability, nonverbal problem solving, phonological processing, processing speed, concept formation, and working memory. Teachers completed the Social Skills Rating System (SSRS) to indicate the frequency of 18 different behaviors in relation to attention.

The participants were all first-grade teachers from a total of ten schools in a southeastern district, which equated to 41 classrooms. Using the measures described above, 139 students were identified as AR and randomly assigned to the study conditions. The researchers included twelve tutors who worked with small groups of students in 30-minute sessions. Students would also work on Math Flash for ten additional minutes after the tutoring session, which was designed to promote automatic retrieval of math facts. The tutoring sessions followed scripted lessons in a 17-lesson sequence, all of which included a worksheet and some type of manipulative. Due to the number of sessions it required to complete a topic, groups completed between 35 and 48 sessions with their tutor. Students completed independent worksheets in order to demonstrate mastery on a topic (90%), and mastery was assessed each day.

The results showed that as a supplement to regular classroom mathematics instruction, preventive tutoring was effective specifically in reference to concepts/applications, and on story problems. The AR tutored students showed a greater rate of improvement than the AR control group, and on the WJ III Calculation, the results showed the AR tutored students exceeded both the AR control group and the NAR classmates. The results also showed that the preventive tutoring condition actually reduced the prevalence of MD in the participating first-grade students. The researchers also found that the rating of student attention given by the teacher was an accurate predictor of distractibility, which can contribute to the presence of MD.

In the last study, Fuchs, Compton, Fuchs, Paulsen, Bryant and Hamlett (2005) found that preventative mathematic tutoring was related to improvement. In the next study, Montague, Krawec, Enders and Dietz (2014) studied the effectiveness of a specialized mathematics problem-solving curriculum compared to a normal district curriculum. Their findings were consistent with the findings in the first study.

In Montague, Krawec, Enders and Dietz's (2014) study, the researchers sought to determine the effectiveness of a specific math intervention on the problem-solving performance of middle school students. The researchers discussed the complexity of mathematical problem solving as the driving force of their research, specifically highlighting that there are two phases of problem-solving: problem representation and problem execution. Current research is focused on individual problem-solving strategies rather than a problem-solving process or routine which shows students how to apply their knowledge to every word problem. The researchers sought to determine how effective *Solve It!* is as an intervention for problem solving ability. *Solve It!* is a routine which seeks to have students internalize the cognitive processes and strategies of problem solving in order for them to become automatic. The study was designed to determine the effects of *Solve It!* on math problem solving ability, and the effects of *Solve it!* on math and reading achievement for intervention and comparison groups of students.

Participating middle and K-8 schools were matched based on the Florida Comprehensive Assessment (FCAT) math and reading tests. One of the schools in each pair was randomly assigned to the intervention condition, and a seventh-grade math teacher from every school was nominated to participate in the study. Teacher nominations were based on mathematics certification, teaching classes with LD students, and willingness to attend a *Solve It!* workshop before the school year started. Intervention teachers used *Solve It!* materials, including instructional guides, scripted lessons, class charts, student cue cards, and practice problems, beginning in October. They continued the Solve It! intervention throughout the school year, which consisted of three days of intensive instruction followed by weekly problem-solving practice sessions. All students in the intervention group received the Solve It! instruction in tandem with the district curriculum. Comparison teachers were told to conduct “business as usual,” using the district curriculum that provides a four-step problem solving strategy: Explore, Plan, Solve, and Examine. Additionally, the curriculum highlights 12 key concepts as problem solving strategies for mathematics, providing supplementary sections of text highlighting and outlining these strategies. Each text chapter contains practice word problems in which teachers were directed to focus on for at least one class period per week. Curriculum based measures (CBMs) were developed using 30 test items from the Solve It! manual, and were used to measure progress of the intervention and comparison groups. The CBMs were administered to the intervention group prior to the intervention as a baseline, and then monthly for the rest of the school year (totaling seven administrations). The CBMs were also administered to the comparison group, but only four times following the baseline.

The intervention group was observed for teacher behavior, preparation, and implementation of the lesson. Researchers observed one intervention class period for three days of initial instruction for each intervention teacher, and were given feedback to help improve future lessons. The comparison group teachers were observed at least once while observing a typical lesson on math word problem solving. Lessons were analyzed to determine if the instructional procedures outline by the curriculum were implemented in the comparison schools.

The sample consisted of twenty matched pairs of middle schools, totaling 40 schools. These schools were recruited from 78 middle and K-8 schools in the Miami-Dad County Public School system. The 40 participating schools participated based on principal agreement, and represented a range of FCAT performance levels, as well as SES levels. All intervention and comparison group teachers were nominated seventh-grade teachers, and thus all participating students were seventh-grade students.

Through the progress monitoring of the CBMs, results showed that the seventh-grade students in the intervention group showed significantly greater growth in math problem solving than the comparison group who received the normal district math curriculum. The difference in growth rates on the FCAT was actually not statistically significant, but the intervention appeared to have similar effects on growth rates for students with LD. Interestingly, the intervention used supported students of varying ability when it was originally designed for students with LD, thus making these findings timely when most schools are moving towards including LD students in the general education population. The findings generally supported the effectiveness of Solve It! as an intervention for improving problem solving abilities in middle school students. Further, the findings suggest that specialized, evidence-based instruction may have a positive impact on middle schools students' math achievement, including low achieving, average achieving, and LD students.

In the first study, Fuchs, Compton, Fuchs, Paulsen, Bryant and Hamlett (2005) found that students who were at risk for developing math difficulties benefited from receiving preventative tutoring. In the second study, Montague, M., Krawec, J., Enders, C., and Dietz, S. (2014) found that a specialized problem-solving curriculum had a positive affect on problem solving abilities and math achievement of middle school students. Both studies concluded that specialized interventions were beneficial for student who were at risk of developing math difficulties, and were even of benefit to the general education populations.

Conclusion

Current research suggests that math anxiety and stress significantly lowers the available working memory space of mathematics students. Research conducted by McQuarrie, Siegel, Perry and Weinberg (2014) showed a relationship between high cortisol reactivity levels in students who were facing "high-stakes" mathematics situations and low scores on the mathematics performance task. Due to the lowered working memory capacity in math students, these same students struggle with the complexities of problem solving required in nearly every mathematics curriculum across a multitude of elementary and middle schools in the nation. In the study conducted by Trezise and Reeve (2014), findings showed that in the presence of worry, stress, or anxiety, high working memory capacity would likely changed to low working memory capacity. Further, in research conducted by Swanson, H. L. (2014), findings showed that students who had low working memory capacity were unlikely to benefit from cognitive problem-solving strategies. Research provides that in order for students to be able to complete multi-stage and complex mathematics problems, students need to have high working memory capacity in order to be successful.

Although the origin of the math anxiety present across the general student population vastly changes by student—and sometimes has a combination of the factors discussed in the research above—the effect remains consistent across many studies: students struggle to consistently and effectively complete grade-level math tasks when struggling with math anxiety. Tutoring and specialized supplemental problem-solving curriculum have demonstrated pockets of success amongst high anxiety students, but it appears as though self-identification and self-expression of math anxiety aids students in lowering the emotional effects and controls anxiety has over them. In research conducted by Park, Ramirez and Beilock (2014), findings supported the use of creative writing as a way to diminish feelings of anxiety and stress before completion of mathematics tasks. Alternately, research conducted by Sharma, Y. (2014) showed that attempts at exposing students to creativity in mathematics proved most beneficial to students who experienced low levels of math anxiety as opposed to those who experienced high levels of anxiety. Findings in a study by Fuchs, Compton, Fuchs, Paulsen, Bryant and Hamlett (2005) highlighted that the use of preventative tutoring in tandem with district curriculum was directly related to greater levels of improvement in students who were at risk for math difficulties, even to the extent of playing a role in reducing the prevalence of mathematics disabilities. Students who experienced math anxiety found many benefits in additional support and supplemental curricular approaches to problem solving, specifically in instances in which they could adequately express any feelings of worry, stress, or anxiety.

Chapter 3

Procedures

This research was derived and inspired by research conducted by Park and Beilock (2014). This study is summarized in Chapter 2, and aimed at determining the effectiveness of using creative writing prior to completing a mathematics examination. In this study I asked students to self-identify their level of mathematics anxiety on a rating scale, and then write about the anxiety/worry/stress they were feeling before beginning a practice math exam. The sample for the research conducted by Ramirez and Beilock were college students, while the students I interacted with every day were middle school students. Additionally, the math examination used in their research were practice exams, while the exams I knew to cause the most stress for my students were the standardized and benchmark examinations given throughout the school year. My research adapted many of the ideas put forth in the research conducted by Ramirez and Beilock for middle school students. I derived the self-reported anxiety ratings from the same resource used in their previous research, and used the same methods for allowing uninterrupted creative writing time prior to a "high-stakes" examination. The "high-stakes" examinations used in my study were the Measures of Academic Progress (MAP, Northwest Evaluation Association, 2000), and the district mathematics Benchmark exam, created in Data Director by using the Common Core State Standards (Common Core State Standards Initiative, 2012) of mathematics.

Description of Participants

The sample used for this study were 24 sixth grade students from a middle school in a large Midwestern city. The participants were chosen because the 24 sixth grade students made up my homeroom class at the time of data collection, and were also one of my middle school math classes at the time. All students in the sample qualified for the free and reduced lunch program upon enrollment. The sample consisted of 10 male and 14 female students; 22 of these students were African American, and two of these students were Hispanic. One of the male participants did not complete the study after the first round of the creative writing intervention due to personal reasons, so the results were based on a sample of 23 students. Based on mathematics standardized tests scores at the time of data collection (including the MAP test and district Benchmark examinations created according to grade-level Common Core State Standards), the sample included students who were testing at a first grade level equivalent in math all the way up to include students who were testing at a third year of high school level equivalency in math. My students were also grouped in accordance with the MAP test RIT band levels at the time, and were meeting with me during independent practice times to work in concentrated small groups on material that was applicable to their current math level and capability level. At the time of data collection, the participants had already taken the MAP test two times prior to the installment to be described in this study. Additionally, the students had already taken the district mathematics Benchmark examination three times prior to the installment to be described in this study. Both tests were accompanied with school-wide and in-class incentives of achievement and mastery, as well as personal growth. Both the MAP and Benchmark scores were discussed and highlighted in detail with students' parents during every parent-teacher conference throughout the school year. Further, students were aware of personal goals of mastery and growth on these achievement tests. Personal MAP goals were computed based on 1.5 years of growth in each subject, and mathematics Benchmark goals were set at 70% mastery and/or 10% growth in between every installment of the examination.

Description of Procedures

The first phase of the action research was to collect data on the students' anxiety levels. All students in the sample were given an anxiety survey (Appendix A) derived from the Short Math Anxiety Rating Scales (SMARS, Alexander & Martray, 1989), which was adapted to more accurately reflect situations of stress/worry/anxiety for a middle school student as opposed to a college student. The anxiety survey included 30 situations in which students were directed to indicate the level of anxiety experienced in each of those situations. Students could check only one level of anxiety according to five different rating scales: "Not at all," "A little," "A fair amount," "Much," and "Very much." Each of the anxiety rating possibilities was then assigned a number in order to determine the overall level of anxiety across all 30 situations. The lowest anxiety rating was assigned a 1, and each increased by an increment of one, with the highest anxiety rating scale receiving the score of 5. The participants scored according to the anxiety level chosen, and each survey was given a total anxiety score based on the sum score of rating levels chosen. The highest level of anxiety possible was 150; the lowest anxiety level possible was 30.

Once all the anxiety survey scores were determined, students then needed to be split into four groups: High Anxiety (HA) control group, High Anxiety intervention group, Low Anxiety (LA) control group, Low Anxiety intervention group. Students who scored between 71 and 150 were qualified as HA, and students who scored below 70 were qualified as LA. This differentiation was used due to a natural gap in the rankings students reported on the survey. Many students who indicated higher levels of anxiety scored in the upper 80s and above, while students who indicated lower levels of anxiety primarily scored in the lower 50s and below. The

HA group was composed of 14 students (6 males, 8 females), and the LA anxiety group was composed of 10 students (4 males, 6 females).

Students within the HA and LA groups then needed to be split into control and intervention groups. In order to do this, I used each student's score on the winter installment of the MAP examination. This standardized exam is unique insomuch as it adapts to the level of the student taking the exam, which more accurately reflects the level of mathematics computation and ability than a criterion-referenced exam based on Common Core State Standards. In order to divide students into control and experimental groups within the HA and LA distinction, I needed to ensure that the skill levels were homogenous across all four groups. I feared that if I failed to account for the students' skill levels at the time of data collection and randomly divided students into groups, I would not have been able to intentionally isolate anxiety as a factor that influenced achievement and growth. Students within the HA and LA distinctions were placed in descending order based on their winter MAP scores. Within the HA distinction, I alternated students' placement in the intervention and control group. Students ranked 1, 3, 5, 7, 9, 11, 13 according to MAP data were assigned to the HA intervention group, and students ranked 2, 4, 6, 8, 10, 12, 14 were assigned to the HA control group. The HA intervention group consisted of 7 students (3 males, 4 females), and the LA intervention group consisted of 7 students (3, males, 4 females). The same procedures were used to divide the LA distinction into intervention and control groups. The LA intervention group consisted of 5 students (4 males, 1 female), and the LA control group consisted of 5 students (5 females).

Both the HA and LA intervention groups were assigned to the creative writing intervention prior to two of the final "high-stakes" tests of the school year: the spring installment of the MAP examination, and the spring installment of the standards-based Benchmark examination created by HOPE Christian schools based on mathematics CCSS. All participants were directed to completely clear their desks of any materials besides a pencil, and were told to sit silently. Participants were told that they may or may not receive a sheet of paper with directions to write, and if they did not receive this paper, they needed to remain seated silently. I specifically directed participants who did not receive the writing intervention to patiently wait for the other participants to complete their writing, and not take out any materials to work on. I directed the control group participants to not take out a book to read, but to begin to focus on the test they were going to take in a few moments. The HA and LA intervention groups were then given a single sheet of paper which contained directions for the creative writing intervention (Appendix B). The directions specifically stated that the participants should write for four minutes about how they are feeling in regards to the test they are taking, and to be very honest about those feelings. The directions included a statement about the writing form not being graded. I set a timer for four minutes, and told the intervention group participants to begin writing. As soon as the timer went off, intervention group participants immediately stood up and brought the writing form to the front of the classroom. I immediately placed the writing forms into a folder, and proceeded to give directions for the test. I was intentional about not making any comments about the writing intervention in order to provide space for all participants to continue to think about the test during the transition. By minimizing the amount of talking I was doing, participants had the freedom to continue to process what they needed to do to be successful on the test, and to mentally prepare for the test to begin. This process was replicated a little over two weeks later on the second installment of the “high-stakes” test.

Description of Data Collection

On both of the “high-stakes” tests the HA and LA intervention groups participated in the creative writing intervention, I ran data reports on the scores attained by the participants. For the MAP test, I ran the Achievement Status and Growth Summary Report on the MAP provider portal, Northwest Evaluation Association (NWEA). The data pertinent to this study was the spring 2015 test RIT score (Appendix C), which showed the scores the participants achieved on the test right after the intervention. I ran the same report to document the MAP scores students had achieved in the winter installment of the test, which was the installment before the participants were exposed to the creative writing intervention. As mentioned above, the MAP winter scores were also used to determine the assignment of the participants to the control and intervention groups. The data on these reports were used to determine the average achievement level on the MAP test across all four groups in the study, as well as to compare the growth on the test between the winter and spring installments for all participants. In order to determine if the creative writing intervention was effective, I sought to compare if the achievement levels and scores on these reports differed across the control and intervention groups within the HA and LA distinction. Additionally, I used these reports to determine if there was a difference in growth on the test after being exposed to the creative writing intervention.

For the district Benchmark examination, I ran the Classroom Performance Summary report on Data Director (Appendix D), the portal in which the network creates criterion-referenced examinations to determine mastery on Common Core State Standards of mathematics. The mathematics Benchmark is the exact same 50-question exam given to sixth grade students over four installments in order to measure mastery of the CCSS taught. I recorded the percentage mastery of all participants in the spring installment of the Benchmark, as well as the percentage mastery in the winter installment—the test previous to the exposure of the creative writing intervention. Again, I sought to determine if the overall percentage mastery on the final installment of this test differed across the control and intervention groups. The overall mastery percentage also showed which participants, or group of participants, mastered more of the mathematics CCSS. Perhaps even greater of a focus was the data on the points of growth between the winter and spring installments of this test. I used these reports to determine if there were significant differences in percentage points of growth on this test after participants were exposed to the creative writing intervention.

A final piece of data collection used was an analysis of the creative writing samples created by the intervention groups. Although this form of data collection was somewhat subjective, I attempted to tally the number of statements in the creative writing samples that suggested stress/worry/anxiety previous to taking the tests. I did this analysis in order to determine if there was a greater level of self-proclaimed anxiety discussed among the LA or HA intervention group participants.

Conclusion

The design of my research was primarily aimed at comparing the scores and achievement levels of participants assigned to four research groups: LA control and intervention groups, HA control and intervention groups. The high-stakes tests in which intervention participants were exposed to the creative writing intervention prior to taking were by nature, stressful. Participants were constantly aware of when these tests were taking place, what scores they needed to attain in order to meet school-wide growth goals, and how they could successfully participate in school-wide testing incentives. Due to the pressure placed on achievement, the creative writing intervention was aimed at providing an outlet for participants to express the stress/worry/anxiety they were feeling before immediately taking the test, and thus possibly lowering those feelings in order to allow for heightened focus. The assignment of participants to control and intervention groups through the use of the anxiety scores and current achievement levels attempted to create groups that were not already disproportionate in terms of mathematics ability. The data collected for analysis of effectiveness were primarily the scores themselves. I sought to analyze if there were major differences in scores and growth across the intervention and control groups, and across the LA and HA distinctions. The following section will discuss the results found, and the analysis of these exam and growth scores.

Chapter 4

Results

In this chapter I present the data collected on the effectiveness of the creative writing intervention on the self-reported mathematics anxiety levels of 24 sixth grade students. The primary focus of data analysis was to determine if the creative writing intervention effected the growth shown on two "high-stakes" standardized math exams: MAP (Northwest Evaluation Association, 2000) mathematics, and a district mathematics Benchmark. In this chapter, growth between test installments is analyzed first. Growth is measured by the difference in scores for each participant in the study between the last two installments of each test. The growth data were then used to compare experimental and control group average growth across the high and low anxiety distinctions in order to isolate the creative writing component as a benefactor in decreasing anxiety before the examinations. Finally, correlation data between the scores of both installments of each test were compared across the low and high anxiety distinction in order determine the strength of the relationship between test scores. The analysis of the data included in this section highlights creative writing as a possible tool of decreasing anxiety and promoting increased test scores and growth numbers.

The mean scores for the mathematics MAP (Northwest Evaluation Association, 2000) exam were calculated for each installment (Winter and Spring) for all four groups included in the study: Control High Anxiety (HA), Experimental High Anxiety (HA), Control Low Anxiety (LA), and Experimental Low Anxiety (LA) (see Table 1). The mean score for the control HA group increased from 209.29 to 210.71 from the winter to spring, indicating 1.42 points of growth (see Figure 1). The mean score for the experimental HA group increased from 208 to 209.67 from the winter to spring, indicating 1.67 point of growth (see Figure 1). The mean score for the control LA group increased from 217 to 226.6 from the winter to spring, indicating 9.6

points of growth (see Figure 2). The mean score for the experimental LA group increased from 219.2 to 222 from the winter to spring, indicating 2.8 points of growth (see Figure 2).

Table 1

MAP Test Growth

Control HA (Participants)	Anxiety	MAP Winter	MAP Spring
1	86	177	180
2	72	207	200
3	96	207	220
4	73	211	218
5	83	214	209
6	81	221	220
7	94	228	228
	Mean	**209.2857143**	**210.7142857**

Exp HA (Participants)	Anxiety	MAP Winter	MAP Spring
1	82	182	190
2	73	229	225
3	82	194	196
4	109	209	204
5	76	210	
6	86	215	219
7	77	217	224
	Mean	**208**	**209.6666667**

Control LA(Participants)	Anxiety	MAP Winter	MAP Spring
1	53	197	213
2	61	217	223
3	44	219	232
4	37	223	232
5	67	229	233
	Mean	**217**	**226.6**

Exp LA (Participants)	Anxiety	MAP Winter	MAP Spring
1	66	209	205
2	52	216	222
3	56	219	221
4	64	221	222
5	36	231	240
	Mean	**219.2**	**222**

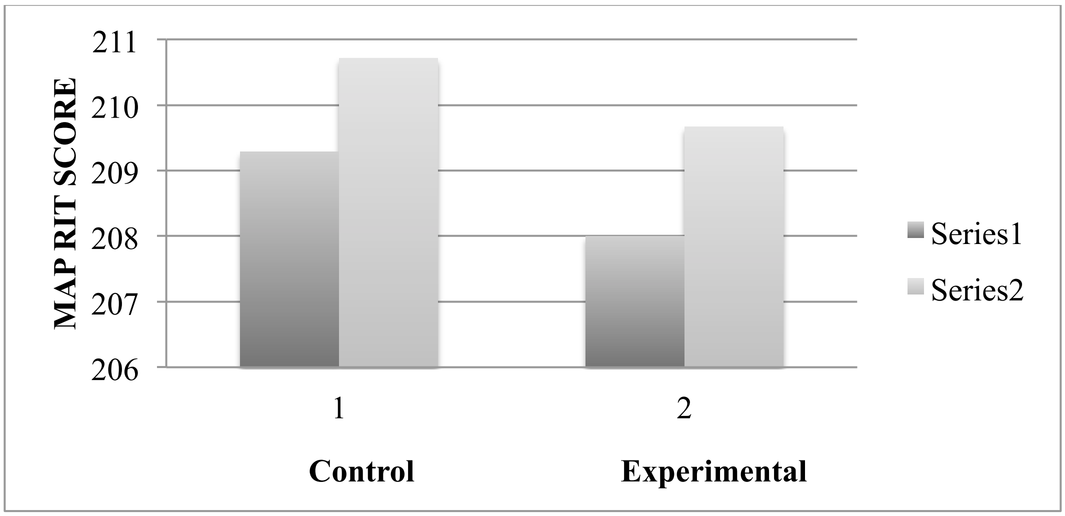

Figure 1. High Anxiety MAP growth for control and experimental groups over two test installments. Series 1 was the Winter installment of the MAP; Series 2 was the Spring Installment of the MAP.

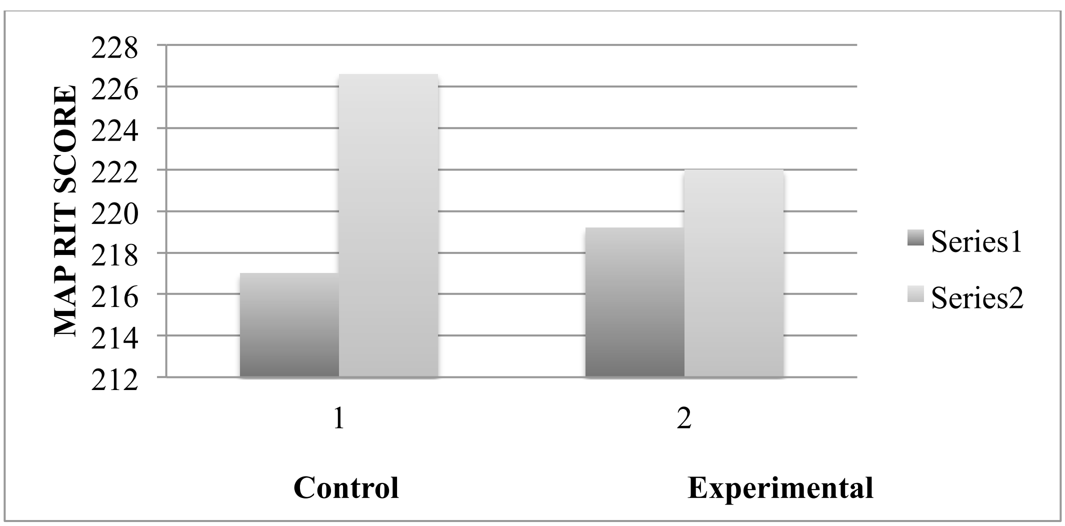

Figure 2. Low Anxiety MAP growth for control and experimental groups over two test installments. Series 1 was the Winter installment of the MAP; Series 2 was the Spring Installment of the MAP.

Comparison of mean growth within the HA distinction shows that the participants who were part of the experimental group showed greater growth between test installments than the participants who were part of the control group. The difference between the points of growth for the control and experimental group was 0.25 points of growth. Comparison of mean growth within the LA distinction shows a greater discrepancy between the control and experimental groups. Participants who were part of the control group showed significantly greater growth between tests installments than the participants who were part of the experimental group. The difference between the points of growth for the control and experimental group was 6.8 points of growth.

To determine how strong the correlation was between scores on the first and second installments of the mathematics MAP (Northwest Evaluation Association, 2000) test, a Pearson correlation was run for all four groups included in the study. The correlation for the control HA group was 0.9087. At a $p<0.05$ level with five degrees of freedom, the correlation of 0.9087 exceeds the critical value of 0.754, signifying a strong relationship between test scores. The correlation for the experimental HA group was 0.9487. At a $p<0.05$ level with four degrees of freedom, the correlation of 0.9487 exceeds the critical value of 0.811, signifying a strong relationship between test scores. The correlation for the control LA group was 0.9409. At a $p<0.05$ with three degrees of freedom, the correlation of 0.9409 exceeds the critical value of 0.878, signifying a strong relationship between test scores. Finally, the correlation for the experimental LA group was 0.9721. At a $p<0.05$ level with three degrees of freedom, the correlation exceeds the critical value of 0.878, signifying a strong relationship between test scores. Within each anxiety distinction, the correlation signified the strength of the relationship between the test scores. The correlation between test scores for the experimental HA group was

0.04 points higher than the correlation in the control group, which signified a stronger relationship between scores when exposed to the experimental writing condition. Similarly, the correlation between test scores of the experimental LA group was 0.03 points higher than the correlation in the control group. Both experimental groups (HA and LA) showed a stronger correlation between test scores than the control groups.

The mean scores for the district mathematics exam were calculated for each installment (Winter and Spring) for all four groups included in the study: Control HA, Experimental HA, Control LA, and Experimental LA (see Table 2). The mean score for the control HA group increased from 61.43% to 66% correct from the winter to spring, indicating 4.57 percentage points of growth (see Figure 3). The mean score for the experimental HA group increased from 52.33% to 59.33% correct from the winter to spring, indicating 7 percentage points of growth (see Figure 3). The mean score for the control LA group increased from 71.2% to 81.6% correct from the winter to spring, indicating 10.4 percentage points of growth (see Figure 4). The mean score for the experimental LA group increased from 64% to 73.2% correct from the winter to spring, indicating 9.2 percentage points of growth (see Figure 4).

Table 2

District Math Benchmark Growth

Control HA (Participants)	Anxiety	District Winter	District Spring
1	86	46	22
2	72	46	58
3	96	70	76
4	73	74	76
5	83	56	68
6	81	68	78
7	94	70	82
	Mean	**61.4285714**	**66**

Exp HA (Participants)	Anxiety	District Winter	District Spring
1	82	32	26
2	73	70	78
3	82	32	32
4	109	46	58
5	76		
6	86	56	80
7	77	78	82
	Mean	**52.3333333**	**59.3333333**

Control LA (Participants)	Anxiety	District Winter	District Spring
1	53	62	82
2	61	62	76
3	44	82	94
4	37	68	74
5	67	82	82
	Mean	**71.2**	**81.6**

Exp LA (Participants)	Anxiety	District Winter	District Spring
1	66	50	52
2	52	60	78
3	56	72	80
4	64	50	70
5	36	88	86
	Mean	**64**	**73.2**

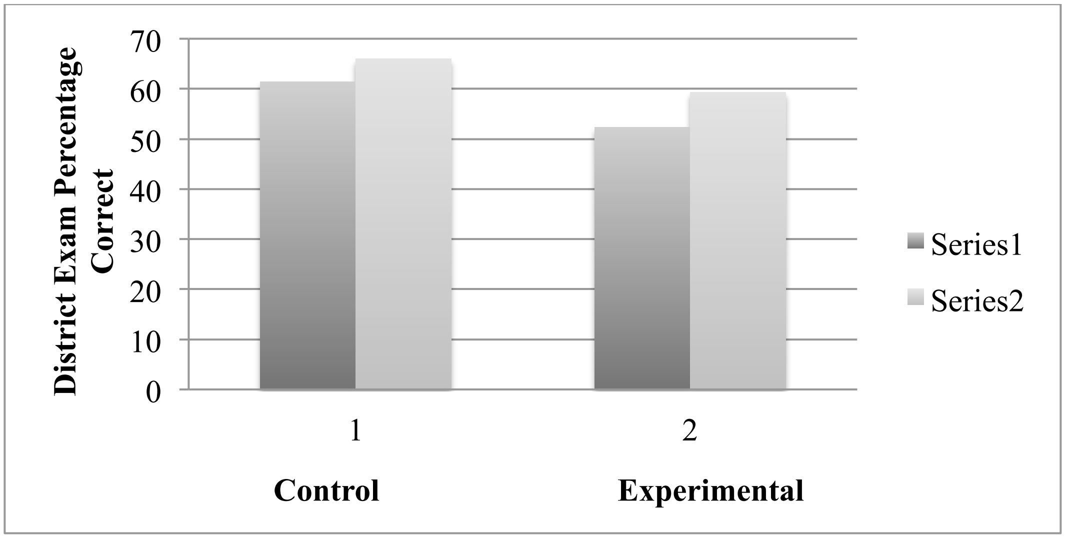

Figure 3. High Anxiety District Mathematics Exam growth for control and experimental groups over two test installments. Series 1 was the Winter installment of the District Exam; Series 2 was the Spring Installment of the District Exam.

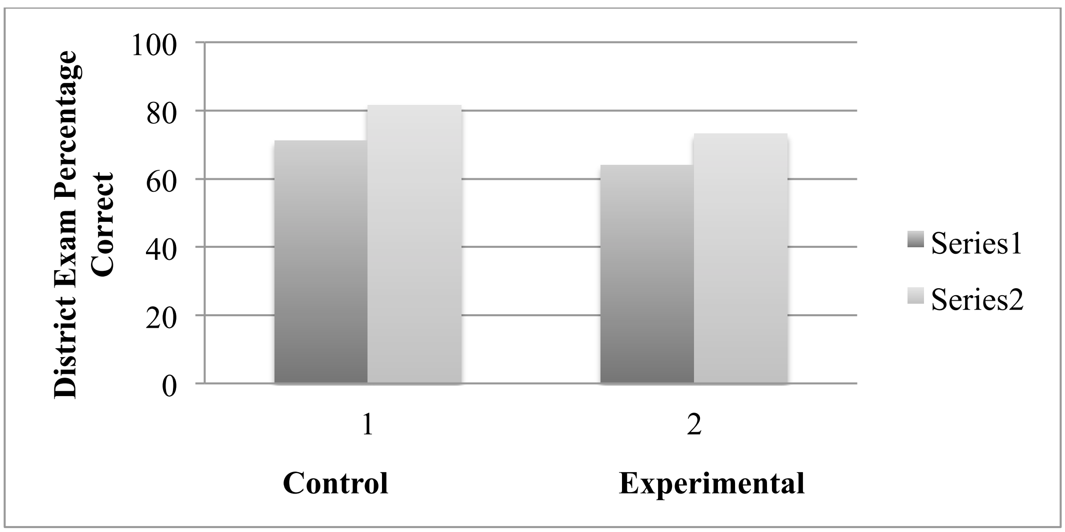

Figure 4. Low Anxiety District Mathematics Exam growth for control and experimental groups over two test installments. Series 1 was the Winter installment of the District Exam; Series 2 was the Spring Installment of the District Exam.

Comparison of mean growth within the HA distinction shows that the participants who were part of the experimental group showed greater growth between test installments than the participants who were part of the control group. The difference between the points of growth for the control and experimental group was 2.43 percentage points of growth. Comparison of mean growth within the LA distinction shows a smaller discrepancy between the control and experimental groups than the HA distinction. Participants who were part of the control group showed greater growth between tests installments than the participants who were part of the experimental group. The difference between the points of growth for the control and experimental group was 1.2 percentage points of growth.

To determine how strong the correlation was between scores on the first and second installments of the district mathematics test, a Pearson correlation was run for all four groups included in the study. The correlation for the control HA group was 0.8273. At a $p<0.05$ level with five degrees of freedom, the correlation of 0.8273 exceeds the critical value of 0.754, signifying a strong relationship between test scores. The correlation for the experimental HA group was 0.9233. At a $p<0.05$ level with four degrees of freedom, the correlation of 0.9233 exceeds the critical value of 0.811, signifying a strong relationship between test scores. The correlation for the control LA group was 0.6640. At a $p<0.05$ with three degrees of freedom, the correlation of 0.6640 does not exceed the critical value of 0.878, signifying no relationship between test scores. Finally, the correlation for the experimental LA group was 0.8027. At a $p<0.05$ level with three degrees of freedom, the correlation does not exceeds the critical value of 0.878, signifying no relationship between test scores. Within each anxiety distinction, the correlation signified the strength of the relationship between the test scores. The correlation between test scores for the experimental HA group was 0.0959 points higher than the correlation in the control group, which signified a stronger relationship between scores when exposed to the experimental writing condition. Similarly, the correlation between test scores of the experimental LA group was 1.1387 points higher than the correlation in the control group. Both experimental groups (HA and LA) showed a stronger correlation between test scores than the control groups.

Overall, the data show greater mean growth between test installments across both the MAP exam and district mathematics exam for students in the low anxiety distinction. Growth is the key factor in data analysis due to the fact that students in the low anxiety distinction had higher test scores on both exams at the beginning of data collection in the winter. Looking specifically at the experimental condition, students in the high anxiety distinction showed greater growth between test installments when they were exposed to the creative writing intervention. In contrast, students in the low anxiety distinction showed less growth between test installments when they were exposed to the creative writing intervention. The correlation between test scores for students in the high anxiety distinction was stronger between the scores of students exposed to the creative writing intervention than those who were part of the control group. This finding also applied to the low anxiety group: the correlation between scores across test installments was stronger for the experimental groups exposed to the creative writing intervention than for those in the control group. The results support the effectiveness of the creative writing intervention specifically for the students in the high anxiety distinction.

Analysis of growth data for the MAP (Northwest Evaluation Association, 2000) mathematics examination showed greater growth for students in the High Anxiety distinction when exposed to the creative writing condition than those in the control group exposed to the creative writing condition (see Figure 1 and 2). Analysis of the correlation between scores across test installments showed stronger correlation between test scores across the experimental creative writing conditions than the control condition. Analysis of the growth data for the district mathematics Benchmark exam showed greater growth for students in the High Anxiety distinction when exposed to the creative writing condition than those in the control group. However, for the students in the Low Anxiety distinction, the growth was higher for the students in the control condition than those exposed to the creative writing condition (see Figure 3 and 4). Similar to the correlational analysis of the MAP exam, analysis of the correlation between scores across test installments for the district Benchmark showed stronger correlation between test scores across the experimental creative writing conditions than the control conditions. In the following chapter, I will provide an explanation of the results, a discussion of limitations, and a recommendation for students based on my findings.

Chapter 5

Conclusions

The action research described in the previous chapters sought to determine how varying anxiety levels among middle school students affected performance on "high-stakes" mathematics exams. The idea for the research design came from research conducted by Park, Ramirez and Beilock (2014) who sought to first classify the anxiety levels of college students in hypothetical mathematics scenarios using a self-reported anxiety measure, and then provided students classified as High Anxiety with a creative writing intervention prior to stress-inducing mathematics examinations. The purpose of the creative writing intervention in their study was to determine if creative writing freed up working memory capacity and decreased the amount of stress experienced before the mathematics exam, thus enabling students who experience math-induced anxiety to achieve similar results to their low anxiety peers. Although Park, Ramirez and Beilock's (2014) study aimed at anxiety levels of college students, this action research sought to investigate the effects of anxiety on middle school students.

The middle school students comprising the mathematics classroom discussed in this action research represented staggering varieties of mathematics "levels" and capabilities, and predictably, staggering varieties of mathematics stress and anxiety. These students, as well as students across the United States, are constantly exposed to and evaluated on "high-stakes" exams. These exams are often messaged as critically important to their academic success on grade level content, as well as key contributors to promotion to subsequent grade levels and programs. Students are frequently asked to complete standardized state tests such as MAP (Measures of Academic Progress, Northwest Evaluation Association, 2000), district benchmark examinations geared at mastery on Common Core State Standards (Common Core State Standards Initiative, 2012), classroom unit quizzes and assessments, and entrance exams at varying age/grade levels. The amount of stress placed on students to achieve is staggering, and seems to most definitely affect their ability to achieve. Much like Park, Ramirez and Beilock's (2014) study, this action research sought to address a possible intervention to help lower the anxiety experienced prior to presumably stressful "high-stakes" mathematics examinations. Specifically, the research sought to determine if the intervention actually helped students identified as High Anxiety achieve similar or greater growth on consecutive installments of two high-stakes mathematics examinations than their Low Anxiety-identified peers.

This concluding chapter will seek to connect the action research to existing research related to math anxiety, working memory capacity, self-efficacy, creativity, and ultimately interventions for math anxiety and math disabilities. Additionally, the chapter will provide an explanation of the results stated above, as well as a discussion of the strengths and limitations of the research design and implementation. Finally, recommendations will be offered on the basis of the research results outlined above.

Connections to Existing Research

In this section, research on mathematics anxiety summarized in Chapter 2 will be reviewed in order to connect literature to the current action research purpose and design. This section will provide specific detail as to how the current action research was founded and designed, as well as provide context for the interest in which the action research was founded.

Much of the literature around mathematics anxiety and the effects of anxiety on student performance allude to the effects of anxiety on the working memory capacity of the student. However, many researchers have sought to determine what the cause of the mathematics anxiety actually is prior to focusing on how the present anxiety affects the learner. In Kesici and

Erdogan's (2010) study, researchers used self-reported anxiety and achievement motivation scales to conclude that social comparison is a contributor to mathematics anxiety. They found that many students who experience low self-esteem essentially foster mathematics anxiety because they perceive themselves as less capable of mastery. Further research on the origin of mathematics anxiety sought to determine the connection between gender and anxiety. In Griggs, Rimm-Kaufman, Merritt and Patton's (2013) study, researchers determined that boys and girls reported similar self-efficacy in math, but that students who experienced greater anxiety reported fewer efficacies. Finally, in Tracie's (2004) study, the researcher used mathematics journals to determine the self-reported root of mathematics anxiety, and found that students who used an expressive writing journal began to have more positive responses to mathematics. Although the cause of anxiety was not the focus of this action research, Kesici and Erdogan's (2010) study highlighted useful measures in determining ways in which students could self-report mathematics anxiety levels, which was eventually utilized for this action research. Additionally, Tracie's (2004) study directly informed the use of expressive writing as a useful tool in reducing mathematics anxiety. This study, as well as Ramirez and Beilock's (2014) study, informed the research design of using an expressive writing prompt (Appendix B) prior to two "high-stakes" mathematics exams in this action research. Similar to both aforementioned studies, this action research specifically asked students to talk about their thoughts and feelings regarding the upcoming test in hopes of reducing their anxiety levels and ultimately boosting their performance.

Literature on working memory was critical in informing and educating this action research because it became clear that an intervention was necessary to reduce anxiety levels of students who became overly nervous or stressed before "high-stakes" mathematics exams. If anxiety was a key contributor in lowering achievement due to working memory, then the creative writing experimental condition needed to be aimed at reducing the anxiety levels in High Anxiety students, and ultimately freeing up working memory capacity.

In Ganley and Vasilyeva's (2014) study, researchers found that there were increased levels of worry in female participants, which caused a decrease specifically in visuospatial working memory, and ultimately, lower performance on a mathematics exam. In McQuarrie, Siegel, Perry and Weinberg's (2014) study, researchers used cortisol levels as a measure of reactivity and stress in the participants. They found that reactivity according to cortisol levels in the participants' brains was a predictor of performance. Specifically, students with high reactivity showed lower scores on working memory tasks than their low reactivity counterparts. In Trezise and Reeve's (2014) study, researchers concluded that participants had varied response time/speed on algebraic tasks depending on their working memory capacity. Perhaps even more interesting, researchers found that in the presence of worry, the available working memory actually decreases. In Swanson's (2014) study, the researcher introduced specific learning strategies to students who were at risk for developing math difficulties, but was unable to find enough support to claim that these learning strategies actually benefited students with low working memory capacity. Finally, in Zentall's (1990) study, the researcher specifically focused on the speed of fact retrieval in students with learning disabilities or Attention Deficit Disorder. The main conclusion drawn from this research was many of the current instructional models contain skill deficits, and skill deficits are a major predictor of higher-level problem solving skills.

The literature on working memory capacity continued to support the idea of the students' need of available working memory capacity in order to achieve on mathematics tasks and/or examinations. Although this action research did not necessarily adapt specific components or measures used in the aforementioned studies, it most certainly sought to study whether or not creative writing as an experimental condition had the ability to free up working memory capacity in the participants in the presence of worry, much like the interventions outlined in the studies above. Further, the literature on working memory capacity aided in the design of this action research insomuch as it sought to compare the effectiveness of the creative writing intervention across two conditions: High Anxiety (HA) and Low Anxiety (LA). By utilizing an experimental and control group across the two anxiety distinctions, the differing results in test scores and test growth could be discussed in terms of increased working memory capacity and lowered anxiety.

The literature on the use of creativity and creative writing as benefactors for mathematics anxiety was most pivotal in the design of the current action research. As discussed above, Park, Ramirez and Beilock's (2014) study most directly informed the design of this action research insomuch as their participants were prescreened based on self-reported anxiety levels, split into control and experimental conditions, given a writing prompt specifically geared at eliciting thoughts and emotions, then given a mathematics examination. The current action research did not given a practice exam geared at inducing anxiety, but rather used high-stakes school-wide exams in which that participants were aware of the necessity to demonstrate high levels of achievement and growth. In Sharma's (2014) study, the researcher used lessons aimed at fostering mathematical creativity for the experimental group to determine the effect on math scores on a creativity component posttest. The results showed that students with lower anxiety experienced more benefits from the creativity lessons than those with high anxiety. The study served to solidify the design of the current action research, specifically the use of experimental and control groups across the HA and LA distinction. Similar to the design of Sharma's (2014) study, the action research design provided opportunity to compare the effectiveness (or lack thereof) of the creative writing condition across multiple sub-groups of participants to gain a deeper understanding of the effectiveness.

The last area of literature pertinent to the arena of mathematics anxiety is interventions available to students who are susceptible to anxiety, as well as to mathematics disabilities. In Fuchs, Compton, Fuchs, Paulsen, Bryant and Hamlett's (2005) study, the researchers determined that preventive tutoring resulted in a greater rate of improvement for students at risk for developing math difficulties, as well actually reducing the prevalence of Math Disabilities in the participants. In Montague, Krawec, Enders and Dietz's (2014) study, the researchers used a specialized mathematics intervention to target problem-solving performance of middle school students. The results showed that students exposed to the intervention showed greater growth in problem-solving abilities, with similar effects on growth for students with learning disabilities (LD). The focus on intervention for students with mathematics difficulties and LD was only tangentially related to the current action research. Of the participants chosen for the action research, there were presumably students who could be categorized as LD. However, due to the resources available within the school, as well as repeated instances in which parents did not fully disclose their child's diagnosis, there were no IEPs reported for any participants. Therefore, the findings of the current action research cannot be directly tied to MD or LD students, even though it would be of great interest to determine whether or not the writing intervention would be successful in lowering the anxiety levels of students specifically determined to have mathematics difficulties or learning disabilities.

Many of the findings from the studies on mathematics anxiety point to the notion that students need to be able to reduce anxiety or stress levels in order to achieve similarly to their peers who do not experience the same levels of anxiety or stress. The causes of anxiety seem to vary depending on the sample of participants chosen, including factors such as socio-economic status, location, self-esteem, self-efficacy, and gender. However, research suggests that in the presence of anxiety, working memory capacity will undoubtedly be affected—and so will performance (Trezise and Reeve, 2014). The design of this action research essentially targeted students who were especially prone to mathematics anxiety, and provided them with a way to cope with the anxiety by expressing themselves. Much like the studies reviewed above, the results of this action research showed similar—if not greater—growth for students who were able to reduce their level of anxiety by writing about their emotions prior to two high-stakes exams. By providing multiple conditions in the research design, and thus multiple avenues of comparison, the results of the action research support the notion that the "playing field" of achievement can be evened for students if there are ways in which they can cope with the academic stress they deal with—no matter where it comes from.

Explanation of Results

This section will discuss the results outlined in Chapter 4, and explain what the results imply. Specifically, the tables and figures provided in Chapter 4 will be expounded upon, and test results from both examinations will be compared across the four research groups: High Anxiety Control, High Anxiety Experimental, Low Anxiety Control, and Low Anxiety Experimental. Finally, commentary and explanation will be provided on the effectiveness of creative writing condition for the high anxiety participants.

The results for the mean scores on the mathematics MAP (Northwest Evaluation Association, 2000) exam showed significantly greater growth for the participants in both experimental and control groups who were in the Low Anxiety (LA) distinction than those who were in the High Anxiety (HA) distinction (see Table 1). This means that the actual points of growth on the MAP exam from winter to spring were more significant growth numbers for the LA distinction than for the HA distinction. Additionally, the actual raw test scores for the experimental and control groups in the LA distinction were significantly higher than the raw test scores for the two groups in the HA distinction. These results alone do not actually target or explain the main purpose of the action research, which is to attempt to isolate anxiety. These results indicate that the students who were placed in either LA group (experimental or control) had higher levels of achievement, regardless of their exposure to the creative writing condition. I fully expected this to be true insomuch as previous research indicates that students with little to no anxiety present naturally have more working memory capacity available. The students who were determined to be LA based on their anxiety survey (Appendix A) were also students who could be predicted to have low anxiety based on classroom performance, general demeanor, and overall confidence in their mathematics abilities. Conversely, students who were determined to be HA based on their anxiety survey were students who demonstrated discomfort and a lack of confidence in mathematics scenarios. In general, those in the HA distinction were also the lowest performers in math throughout the course of the school year.

The significant result in terms of growth on the MAP test is the comparison within the HA distinction. For the students who were determined to be HA, there was a greater amount of growth between test installments for the students who were able to creatively write prior to taking the test (see Figure 1). This means that among students who experience significant amounts of stress in mathematics scenarios, exposure to creative writing immediately before taking the test allowed them to achieve greater growth on the test than their HA classmates who did not get the opportunity to express any emotions or feelings prior to the test. In addition, the correlation between test scores from winter to spring installments was stronger for the HA students who were exposed to the writing condition than those who were not. This means that the growth between the two test installments is more significant and uniform across all students within the experimental condition. This is important because even though the raw MAP score for the control group in the HA distinction is slightly higher than the raw score for the experimental group, the correlation shows that the writing condition was successful in enabling students to show growth.

The results for the mean scores on the district Benchmark exam were similar to those discussed above. The results showed greater growth on the exam for students in the LA distinction than those in the HA distinction, regardless of being in the control or experimental condition. Similar to conclusions discussed above, the overall percentage score for both groups within the LA distinction were greater than the overall percentage score for both groups within in the HA distinctions (see Table 2). I would draw the same conclusions for the district examination as for the MAP: one would expect the students who experience low anxiety to also demonstrate greater mastery on the examination than the students who experience great amounts of anxiety. As was discussed in previous research, many of the students who experience stress and anxiety simultaneously experience low self-esteem and self-concept, thus affecting their ability to perform well on "high-stakes" exams.

Once again, the seemingly significant results are contained within in the HA condition. For the district Benchmark exam, the experimental group showed more growth on the exam than the control group within the HA distinction (see Figure 3). This means that the students who were exposed to the writing condition within the HA distinction were able to make more significant gains in terms of growth than those who were unable to write prior to taking the test.

Further, the correlation of test scores for those exposed to the writing condition were stronger than those who were not. Although once again the raw scores for the district Benchmark exam are higher for the control HA group than for the experimental HA group, the stronger correlation of scores across installments for the experimental group shows that the writing condition enabled students to make more growth between installments.

Analysis of the growth scores between test installments for both the MAP and the district Benchmark exam showed that the creative writing condition was especially effective for students within the HA distinction. The students who were able to express their feelings and emotions prior to taking these two exams showed greater growth between installments than the students who did not write. This was not true for the students categorized as LA, which suggests that in the absence of anxiety, stress, or worry, creative writing does not necessarily have an effect on test growth. The significance of these results is that students may be able to demonstrate more significant progress on mathematics examinations if they are able to have an outlet for some of the anxiety they experience in facing them. If given the ability to write prior to stress-inducing mathematics scenarios enables students to show more growth than had they not discussed their emotions, then these results suggest that creative writing may actually be a step towards equalizing the “playing field” of mathematic achievement in middle school students.

Strengths and Limitations

In this section, the strengths and limitations of the research design will be outlined and described. The strengths given for the current action research include the isolation of anxiety by controlling for current mathematic ability, and the use of two different types of exams for data collection. The limitations given for the current action research include the lack of longevity in the research design, as well as the limited number of participants involved.

The greatest strength of the research design was the attempt to isolate anxiety and the effectiveness of the creative writing condition by creating four groups: experimental HA, control HA, experimental LA, and control LA. Within this design, I tried to account for the greater achievement of students who identified as LA. As discussed above, the students who reported low anxiety were also the higher achieving students within the math class. Based on much of the research and literature on mathematics anxiety and its affects on achievement, I anticipated that my participants who identified as low anxiety would also be those who did not struggle in math. In response, I allocated the students identified as LA into the experimental and control groups by first placing them in order of mathematic ability based on the MAP (Measures of Academic Progress, Northwest Evaluation Association, 2000) math test scores. By first screening for mathematic ability, I was then able to allocate students into the control and experimental groups in alternating order of ability, thus creating two groups that were as "even" as possible in regards to mathematic ability. This was a strength in the research design because participants could not simply be randomly assigned to control and experimental groups without regard for their natural mathematic abilities. The procedural design of the research attempted to isolate anxiety as best as possible, and not skew the growth scores based on natural inclination of mathematic achievement.

Another strength in the research design was the use of two different types of assessments: the math MAP test, and the district mathematics Benchmark exam. These two tests differed insomuch as the MAP is a norm-referenced exam, which gives a score showing students' abilities as compared to students in their same grade level, and the district math Benchmark exam is a criterion-referenced exam, which gives a score showing students' mastery in Common Core State Standards for their current grade level. The use of two different tests allowed for the creative writing experimental condition to be applied to two different test installments across multiple weeks, rather than at a single time. Additionally, these two tests naturally evoked differing levels of nervousness and stress across participants, which led to a more natural test-taking environment for the participants involved. As the classroom teacher, I did not need to change much of the normal testing classroom environment in order to implement the creative writing condition for the experimental groups. These test installments were anticipated school wide—not simply for this research—and thus, students' growth scores were an accurate depiction of their current mathematic levels and grade-level mastery.

Although the use of the two different types of exams was a strength of the research design, I believe it was also one of the major limitations of the research. Perhaps obviously, collecting more data on the four different research groups would have been more beneficial in drawing accurate and precise conclusions about the benefits of the creative writing condition. The limitation is the longevity of the study, and ultimately, the limited exposure to the writing condition. The most exhaustive conclusions would have been those drawn after the four research groups were exposed to the control and experimental conditions for all MAP math and district Benchmark exam installments throughout the school year rather than the single installment. Further, it would have been interesting and beneficial in determining the effectiveness of the experimental condition to also gather data on in-class unit assessments and quizzes to determine if the creative writing condition was indeed effective in equalizing raw test scores across anxiety distinctions, rather than just growth scores.

Similar to the limitation of longevity is the limitation of participants. The research design included 26 sixth grade students because these students were part of my homeroom and mathematics class. This is a limitation because all participants involved received instruction from the same teacher, and were used to a particular testing environment as prescribed by my classroom procedures, goals, and guidance. The research would have been much stronger if there was simply more data to collect and more students to analyze, but also, if there were other instructors involved in the research. With more participants, I could have created more groups based on anxiety levels, which would have been narrower in scope than the current research design. In addition, I could have analyzed growth and raw score results based on homeroom classes to determine if teacher style and instruction affected these results in addition to anxiety levels and the creative writing condition. Overall, having more students involved in the research would have given a clearer picture of whether or not the creative writing condition was indeed effective in “evening out” the playing field for students with high anxiety, and also whether or not creative writing should actually be prescribed to students who experience high levels of stress prior to mathematics scenarios.

Recommendations for Student

In this section, I will provide recommendations for students based on the action research in tandem with the review of literature on mathematics anxiety. Recommendations for students will be geared first towards school, and then extended to home. These recommendations will be based on the data gathered and conclusions drawn in this action research.

Based on the data collected and reviewed above, my recommendation for students in the classroom who experience high levels of stress, nervousness, and/or anxiety prior to any mathematics task or scenario would be to creatively write about the feelings experienced in that moment. This recommendation would involve classroom teacher interaction with students insomuch as they would need to know which students experience these feelings, and to what extent they experience them. In addition, classroom teachers would need to plan time and space for students who become overwhelmed with nervous emotions to pause and be able to express themselves in a calm and quiet environment. The research design outlined above showed that students who experienced high anxiety and were able to express their emotions prior to mathematics exams showed more growth on these exams than their high anxiety peers who did not creatively write prior to the same exams. As mentioned above, these results were drawn based on one norm-referenced test, and one criterion-referenced test based on Common Core State Standards. The use of these separate tests supports the effectiveness of creative writing, and thus the recommendation, prior to any test—not simply tests based on Common Core State Standards. Because of these results, my recommendation for the classroom environment would be that all students experiencing anxiety would be asked to explicitly express their emotions immediately before attempting the anxiety-inducing task at hand, regardless of what the task may be.

One specific recommendation based on the action research design would be the expressive writing environment. In this action research, I provided participants in the experimental condition with four minutes to respond to a writing prompt which specifically asked them about the emotions they were experiencing at the moment (see Appendix B). My recommendation for implementing the creative writing for high-anxiety students would be to provide those students with a specific window of time, and a specific prompt to guide their thinking. In order to have students actually express their anxious emotions, the prompt needs to explicitly ask them to write about those emotions. In addition, students who are not writing prior to the math task will need to respect the writing time by remaining silent and not participating in anything distracting to those who are writing. My recommendation would be to have students sit silently and wait, or to have a book open prior to the start of the writing task. By creating an environment in which high-anxiety students can effectively express themselves, the classroom teacher may also be aiding these students in freeing up working memory capacity in order to achieve similarly on the mathematics task as the low anxiety students.

The research design outlined above did not account for the presence of anxiety in participants at home, nor the implication of occurrences at home affecting the anxiety levels or achievement levels of the participants at school. Because of this, I cannot provide any recommendations for students at home in order to aid them in reducing anxiety and/or increasing mathematic achievement. The only connection I can draw from this action research to implications for home is the presumed benefit of receiving insight into students' anxiety levels in regards to mathematics from the parent or guardian. My recommendation for the classroom teacher prior to determining the anxiety levels of students in a classroom would be to contact parents and/or guardians to get any additional information about students' tendencies, stresses, nervousness, and perceived anxiety towards math.

The results from this action research showed that students who experience great levels of mathematics anxiety actually outperform their high-anxiety peers if they are able to creatively write before taking a test. The results show that a creative writing intervention may actually be a successful step in equalizing the "playing field" of mathematic achievement if anxiety can be accounted for and dealt with. In response to these results, I believe the recommendation for all students who experience mathematics anxiety should be a guided creative writing activity prior to facing the mathematics task. If the creative writing task was effective in increasing growth on two mathematics exams in this action research, it may also prove to be effective in increasing growth on mathematics tasks for other classrooms.

Appendix A

Anxiety Survey

Name: ______________________________

Please indicate the level of your anxiety in the following situations. Please place a check in only ONE box on each line.

	Not at all	A little	A fair amount	Much	Very Much
1. Studying for a math test.					
2. Taking a quiz in a math course.					
3. Taking an assessment in a math course.					
4. Beginning to work on a math homework assignment.					
5. Being given homework assignments with many difficult problems the day before they are due.					
6. Thinking about an upcoming math test 1 week before.					
7. Thinking about an upcoming math test 1 day before.					
8. Thinking about an upcoming math test 1 hour before.					
9. Realizing you need a good grade on a math test in order to pass your math class for the quarter.					
10. Picking up math notes to begin a difficult math problem.					
11. Receiving your final math grade at Parent-Teacher conferences.					
12. Opening your math notes and seeing a full page of problems.					

13. Getting ready to study for a math test.					
14. Being given a "pop" quiz in a math class.					
15. Reading a cash register receipt after you purchase something.					
16. Being given a set of numerical problems involving addition to solve on paper.					
17. Being given a set of subtraction problems to solve.					
18. Being given a set of multiplication problems to solve.					
19. Being given a set of division problems to solve.					
20. Buying a math textbook/workbook.					
21. Watching a teacher solve an algebraic equation on the board.					
22. Listening to another student explain a math problem.					
23. Raising my hand in math class to participate.					
24. Walking into a math class.					
25. Realizing I need a good grade on my math MAP test in order to meet my goal.					
26. Realizing I need a good grade on my math Benchmark in order to meet my goal.					
27. Asking for help on math homework.					
28. Helping someone else with math.					

29. Receiving a grade lower than expected on a math quiz.					
30. Receiving a grade lower than expected on a math test.					

Appendix B

Experimental Condition Writing Prompt

Name: ____

Before you take this test, reflect on how you are feeling. You will write for 4 minutes on the lines below about how you feel *about the test*, times you have felt this way before, and why you think you might be feeling this. Be open and honest in your writing, it will not be graded!

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