ABSTRACT

USING A MATHEMATICS FLUENCY INTERVENTION AS A METHOD OF REDUCING MATHEMATICS ANXIETY IN FEMALE STUDENTS

by Rachel Elizabeth Mathews

The purpose of this study was to examine the relationship between mathematics fluency and mathematics anxiety in female elementary students. It was hypothesized that a mathematics fluency intervention (FASTT Math) would help students increase mathematics automaticity, and therefore decrease mathematics anxiety. Fourth grade female students' levels of mathematics anxiety were measured using the *Mathematics Anxiety Rating Scale - Elementary* (Suinn, Taylor, & Edwards, 1988). Students either received the FASTT Math intervention or typical classroom instruction. At the conclusion of the intervention, the subjects were reassessed using the *MARS-E*. Results indicated that students who completed the FASTT Math intervention did increase their automaticity, but did not experience significantly decreased levels of mathematics anxiety. This study supported the hypothesis that although female students typically perform at a similar level as their male peers in mathematics, they perceive their abilities as being significantly lower.

USING A MATHEMATICS FLUENCY INTERVENTION AS A METHOD OF REDUCING MATHEMATICS ANXIETY IN FEMALE STUDENTS

A Thesis

Submitted to the

Faculty of Miami University

in partial fulfillment of

the requirements for the degree of

Education Specialist

Department of Educational Psychology

by

Rachel Elizabeth Mathews

Miami University

Oxford, OH

2013

Advisor:____

Dr. Raymond Witte

Reader: _____

Dr. Susan Mosley-Howard

Reader: _____

Dr. Sally Lloyd

Table of Contents

Abstract	
Title Page	
List of Tables	iii
Introduction	1
Review of the Literature	3
Research Design	10
Results	14
Discussion	21
References	27
Appendices	33

List of Tables

- Table 1 Paired Samples t-tests for Pretest-Posttest Measures of Mathematics Fluency
- Table 2 Paired Samples t-tests for Pretest-Posttest Measures of Mathematics Anxiety (Experimental Site)
- Table 3 Paired Samples t-tests for Pretest-Posttest Measures of Mathematics Anxiety (Control Site)
- Table 4 Independent Samples t-tests for Pretest Measure of Mathematics Anxiety (Experimental and Control Sites)
- Table 5 Independent Samples t-tests for Posttest Measure of Mathematics Anxiety (Experimental and Control Sites)

Introduction

Mathematics anxiety is defined by Tobias and Weissbrod (1980) as "The panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem" (p.65). Tobias has also referred to mathematics anxiety as an illness because it involves both emotional and cognitive dread (Tobias, 1978). In a nation that consistently lags behind other countries in the area of mathematics performance, math anxiety is not only common, but becoming more tolerable. Burns (1998) asserts that approximately two-thirds of adults have a deep dislike and fear of mathematics. In addition, children as young as third grade have shown signs of mathematics anxiety. As students mature, avoidance becomes an effective method for eluding math failure. Older students who experienced math difficulty as children often avoid taking math classes in college and typically sustain feelings of mathematics anxiety into adulthood (Cates & Rhymer, 2003).

There are numerous studies (Ashcraft & Kirk, 2001; Meece, Wigfield, Eccles, 1990; Eysenck, Derakshan, Santos, & Calvo, 2007) supporting a negative correlation between mathematics anxiety and math performance. For example, Ashcraft and Moore (2009) found a negative correlation of (r= -.27) between mathematics anxiety and math performance. In a similar study, Ashcraft and Krause (2007) determined that when anxious students fixate on their anxiety during a test, the working memory resources needed to complete the task at hand are depleted, therefore hindering their performance. For this reason, one's math test scores may not be an accurate measure of his or her true ability.

In 1988, a software program called FASTT Math was developed by Ted Hasselbring at Vanderbilt University. The purpose of FASTT Math is to help students develop basic math fact fluency through customized computer activities. Wong and Evans (2007) determined that without the ability to quickly recall facts from memory, students tend to focus on basic skills (such as finger counting) instead of attending to the current mathematical task. FASTT Math's purpose is to help children learn to quickly recall facts from memory, increase their automaticity, and reduce the use for basic skills, which can hinder their performance.

The FASTT Math program utilizes a research-validated Fluency and Automaticity through Systematic Teaching with Technology (FASTT) ideology (Tom Snyder Productions, 2005). FASTT is composed of seven steps, consisting of: 1) identification of fluent and non-

fluent facts; 2) limited presentation of non-fluent information; 3) problem/answer pairs; 4) use of "challenge times"; 5) organized presentation of non-fluent material; 6) drill-and-practice activities; and 7) computerized progress monitoring (Hasselbring, Lott, & Zydney, 2005). Based on their scores, students are placed in one of the following groups: fluent, near fluent, or not fluent/underperforming (Lehner, 2008).

FASTT Math has been shown to be an effective mathematics fluency intervention over several years, and its effectiveness has been tested with approximately 400 elementary school students (Tom Snyder Productions, 2005). In one study by Lehner (2008), students completed one ten-minute FASTT Math multiplication activity per day, over a period of 44 days. This intervention resulted in 80% of students progressing from the "underperforming" grouping to the "near fluent" grouping. In another study, students using FASTT Math had an average gain of 10.5 math facts per hour of practice (Hastings, 2010). In this same study, students had retention levels (percentage of math facts retained after mastery) of 82-97%, with a mode of 90% after a latency period of four months.

Given the effectiveness of the FASTT Math program on mathematics fluency, the present study investigated the relationship between a computerized fluency intervention and mathematics anxiety levels in elementary-age female students. Considering the long-term implications of poor math performance, this researcher wanted to examine elementary-aged female students, as they represent a particularly vulnerable target group.

The study hypothesized that students' mathematics fluency would increase following the six-week fluency intervention. Additionally, the study theorized that as students' mathematics fluency increased, their mathematics anxiety would decrease. In particular, this study attempted to decrease math anxiety felt by female students while taking math tests through a computer-based mathematics fluency intervention. The author hypothesized that female students would rate themselves as experiencing higher levels of mathematics anxiety on the self-report scales. It was also hypothesized that the intervention with these students would increase recall speed of math facts. Because of this, the author anticipated that a student's successful completion of FASTT Math would significantly lower mathematics anxiety in female students.

Review of the Literature

Mathematics Anxiety

Mathematics is an area in which most children in the United States perform more poorly when compared with other developed nations (Feifer, 2007). Many of these children may suffer from math anxiety (Ashcraft & Ridley, 2005; Hembree, 1990; Meece, Wigfield, & Eccles, 1990). Mathematics anxiety is defined by Terrell (2006) as "a feeling of anxiousness, fear, nausea, frustration, and uncertainty brought about by a request to perform mathematic operations or use mathematics to problem solve" (p.2). Mathematics anxiety can be felt in both high-risk testing situations as well as low-risk classroom activities (Ashcraft & Moore, 2009).

There may be a growing incidence of math anxiety due in part to the increasing use of high-stakes standardized testing. Since the institution of the No Child Left Behind Act of 2001, standardized testing has become prevalent in schools as a method of measuring academic progress (U.S. Department of Education, 2010). For this reason, teachers feel increased pressure to help students meet the goals mandated by state or national academic standards. In turn, this can place a great deal of stress on the students. While a low to moderate level of anxiety may aid in test performance, high levels of anxiety can cause severe emotional and/or physiological responses, which disrupts cognitive activity (Kargar, Tarmizi, & Bayat, 2010).

A significant number of individuals in the U.S. population are plagued by mathematics anxiety, and the disorder affects people of all ages (Ashcraft & Moore, 2009). Perry (2004) asserts that the onset of mathematics anxiety typically occurs at an early age. This may be due to the pressure on schools to teach mathematical concepts at a very young age, sometimes as early as pre-school and kindergarten (Begley, 2007). Because mathematics anxiety is a difficult concept to quantify, it is challenging to accurately identify the number of individuals who have mathematics anxiety. For this reason, the actual prevalence of math anxiety is unknown. It is estimated by Campbell (2005), however, that approximately 20% of individuals may suffer from some form of mathematics anxiety. This study also indicated that women are more likely to experience mathematics anxiety than men. According to Richardson and Suinn (1972), mathematics anxiety can occur in many settings and is not limited to the classroom alone. For

instance, adults may experience math anxiety when performing everyday tasks, such as calculating a tip at a restaurant or balancing a checkbook (Ashcraft & Moore, 2009).

Several studies suggest that mathematics anxiety can develop in children as young as grades 3 and 4 (Jackson & Leffingwell, 1999; Ashcraft & Moore, 2009; Ma, 1999). Jackson and Leffingwell (1999) performed a study that evaluated the grade level (kindergarten through college) at which mathematics anxiety first occurred for college students who were training to become teachers. Participants were asked to describe their worst or most challenging mathematics experience from kindergarten through college and were also asked to cite any components that made their mathematics experiences more positive. The researchers discovered that only 7% of the participants had positive experiences in mathematics courses from kindergarten through college. Of these participants, 16% began experiencing mathematics anxiety in grades 3 or 4 and 26% started feeling mathematically anxious in grades 9, 10, and 11 (Jackson & Leffingwell, 1999). Approximately 27% of the participants felt mathematics anxiety during their freshman year in college. While grades 3 and 4 do not typically have the highest rates of mathematics anxiety occurrence, math anxiety appears to be an issue for students at these grade levels. In addition, recent research (Sevey, 2012) supports the contention that mathematics anxiety in grades 3 and 4 should be further examined.

Math Anxiety and Performance

In the educational system today, considerable emphasis is placed on student progress, which is often measured by standardized tests. Student achievement and advancement rely heavily on the results of high-stakes tests, most of which include a math portion. According to the 2009 National Assessment of Educational Progress (NAEP), 18% of fourth grade students in the United States were performing at "Below Basic Skills", while 27% of 8th grade students were also in the "Below Basic Skills" range (The Nation's Report Card, 2011).

Studies by Ashcraft & Moore (2009), Ma (1999), and Zakaraia & Nordin (2008) have demonstrated a negative correlation between mathematics anxiety and mathematics performance. The relationship between mathematics anxiety and performance indicates that as mathematics anxiety increases, mathematics performance decreases (Ashcraft, 2002). In stressful situations, students' worry of failure is enhanced, and feelings of anxiety compete with the cognitive

resources needed to complete the task. In other words, the pressure of the math task taxes the student's working memory resources needed for accurate computation (Beilock, Gunderson, Ramirez, & Levine, 2010). Ma's 1999 study demonstrated comparable findings. Ma found that by reducing mathematics anxiety, mathematics performance can increase exponentially, bringing a highly anxious "average" student's scores from the 50th to the 71st percentile. This study concluded that if math anxiety can be reduced, mathematics achievement can significantly increase.

Hembree's meta-analysis (1990) noted similar findings. Hembree stated that there is a causal relationship between mathematics anxiety and math performance, asserting that higher mathematics achievement typically accompanies reduced feelings of mathematics anxiety (Hembree, 1990). Hembree also hypothesized that treatment (such as cognitive restructuring or systematic desensitization) can improve the performance of a highly-anxious child to a level of mathematical achievement associated with low math anxiety (Hembree, 1990). In addition, Hembree's meta-analysis determined that math anxiety is correlated with (but separate from) test anxiety. A study by Kazelskis et al., (2000) supported this claim; this study also indicated that mathematics anxiety and test anxiety are separate entities (Ashcraft, 2002).

Eyseck and Calvo's (1992) model of general anxiety effects, also called processing efficiency theory, can be readily applied to mathematics anxiety. This model theorizes that general anxiety disturbs cognitive functioning because the individual devotes valuable cognitive resources to intrusive, anxious thoughts (Ashcraft, 2002). In situations involving math anxiety, students become preoccupied with thoughts involving a fear of math, as well as impending mathematical failure. As a result, students' math performance diminishes. This is due to the pervasive, negative thoughts, which detract attention from the primary task (i.e., the mathematics test) (Ashcraft, 2002).

Math Anxiety in Girls

Mathematics is an area of education in which gender stereotypes of male and female skills are strongly evident. On average, only 30% of university graduates in mathematics are female (OECD, 2004). However, the achievement gap has continued to shrink over the past few decades (Frenzel, Pekrun, & Goetz, 2005). Although female students consistently report higher levels of mathematics anxiety, male and female students typically have similar achievement in

the area of mathematics (Frenzel, Pekrun, & Goetz, 2005). Hyde, Fennema, and Lamon (1990) noted similar findings; males generally do not outperform females in understanding mathematics concepts or computational ability. Results from Frenzel, Pekrun, & Goetz (2005) suggest that female students' beliefs regarding low mathematics competency creates a "female emotional pattern"; this was described as a low reported level of enjoyment and pride in their mathematics skills. These female students also reported higher levels of anxiety, hopelessness, and shame when completing mathematics tasks (Frenzel, Pekrun, & Goetz, 2005). The authors argued that emotions are critical components of one's well-being and can positively or negatively impact student learning.

Mathematics anxiety in female students may be due largely to the influence of stereotype threat. Steele & Aronson (1995) defined stereotype threat as "being at risk of confirming, as self-characteristic, a negative stereotype about one's group" (p.797). Stereotype threat is a social theory that typically applies to minorities, such as African American individuals and women. Several studies indicate that when one is in a situation in which he or she might be judged based on a stereotype, overall performance diminishes (Steele & Aronson1995; Spencer, 2001; Aronson, Brown, Good, Lustina, Keough, & Steele, 1999). Steele theorizes that when women are in a situation in which they can confirm the negative stereotype that men are superior in the field of mathematics, the worry of confirming that stereotype causes a disruption in mathematics performance (Spencer, Steele, & Quinn, 1998).

In 1998, Spencer, Steele, and Quinn conducted a study involving 28 men and 28 women from the University of Michigan. Half of the students completed a test in which no gender differences were reported by the researcher. The other half of the students were informed that the test yielded tremendous gender differences, with men consistently achieving higher scores than women (Spencer, Steele, & Quinn, 1998). The results of this study showed that when participants were informed that there were strong gender differences between the scores of the test, the men greatly outperformed the women on tasks of mathematical computation. Conversely, when students were told that there were no significant gender differences between male and female scores, the women outperformed the male participants (Spencer, Steele, & Quinn, 1998).

Another factor that strongly influences math anxiety in female students is teacher attitudes regarding mathematics. Beilock, Gunderson, Ramirez, and Levine (2010) reported that math-anxious female teachers may model negative feelings for mathematics, which their female students may notice and copy. Because children are more likely to emulate same-gender role models, female teachers may unintentionally encourage their young female students to harbor anxious feelings regarding mathematics. This could have widespread consequences for young students, as elementary education majors have the highest reported levels of mathematics anxiety among college majors (Beilock, Gunderson, Ramirez, & Levine, 2010).

Math Anxiety Prevention and Interventions

Researchers within the field of mathematics anxiety have determined a growing need for interventions and prevention. Krinzinger, Kaufmann, & Willmes (2009) state that because mathematics anxiety can occur in younger students, preventative steps should be taken to help students avoid becoming math-anxious in adolescence. In addition, Begley (2007) hypothesizes that addressing mathematics anxiety early in a student's life may help reduce feelings of mathematics anxiety later in his or her academic career.

Although mathematics anxiety is becoming more common in younger grades, there are several methods to combat it. One technique of mathematics anxiety prevention is through bibliotherapy. Bibliotherapy is "the process of using books to help children think about, understand, and work through social and emotional concerns" (Barancik, 2011, p. 62). Books are typically selected when a book's character(s) experiences trauma similar to the student, elicits discussions, or has been suggested as a preventative tool (Herbert, 1997). One book that is often recommended for mathematics anxiety bibliotherapy is *The Math Curse* (Scieska & Smith, 1995). The book chronicles the story of a little girl who sees math problems everywhere that she goes, and fears she will not be able to solve them. Teachers can use this book to prompt discussions about methods of math problem solving and feelings of worry regarding mathematics (Furner & Duffy, 2002).

A number of mathematics anxiety interventions have been utilized over the past few decades. These include alternative test formats, such as journal entries (Furner & Duffy, 2002). Other alternate test options such as reflections, and group tests (Furner & Duffy, 2002) are also acceptable mathematics anxiety interventions. In addition, relaxation techniques have been

shown to be effective methods for reducing mathematics anxiety (Furner & Berman, 2003).

Cognitive behavior therapy, or CBT, proposes that one's thoughts directly influence behaviors and feelings (National Association of Cognitive Behavior Therapists, 2007). CBT is often used because it allows individuals to change the way that they think without changing the environment. One area of CBT that has been effectively employed in reducing mathematics anxiety is cognitive restructuring. Cognitive restructuring is the process of replacing negative thought patterns with constructive thoughts (Merriman-Webster, 2011). Claude Steele employed cognitive restructuring in his study of women and mathematics (1999), during which he informed students that a mathematics test yielded significant gender differences in scores. He "warned" female students that they might not perform as well as their male counterparts, and therefore altered their expectations for success. Conversely, cognitive restructuring can also be used in a positive way to encourage students.

Beilock, Gunderson, Ramirez, & Levine (2008) also recommend that students practice problems so that computation becomes more automatic; as a result, mathematical computation becomes less stressful for the students. One program that requires students to practice mathematics facts is FASTT Math. FASTT Math is a mathematics fluency software program that provides systematic instruction through customizable, timed activities. The purpose of the program is to train students to rapidly recall basic math facts so that their recall becomes automatic, thereby increasing the speed of computation. The FASTT Math program uses a computer-based assessment that presents students with mathematics equations and measures the latency of their responses (Tom Snyder Productions, 2005). By recording the latency between the presentation of the equation and the student's response, FASTT Math determines whether the student is using counting strategies or rapid recall (or *automaticity*). This intervention program can be used with students in grades 2 or higher and is available in English and Spanish. FASST Math can be used in a variety of settings, including before-school math programs, homeroom activities, computer lab periods, intervention sessions, and summer school (Tom Snyder Productions, 2005). FASTT Math is a comprehensive, yet concise program that can be effectively used for as little as 10 minutes per day, three times per week.

In a study by Hasselbring and Goin (1988), students who were struggling in math were divided into two groups; one group received fifty-four days of 10-minute sessions using FASTT

Math, while the other group received standard fluency instruction provided by their classroom teacher. The students who participated in the FASTT Math program gained approximately 19 new fluent facts over the course of the intervention. Conversely, the students who received only the traditional classroom instruction gained seven new fluent facts over the same period of time (Hasselbring & Goin, 1988). Within this study, the maintenance data for the effectiveness of FASTT Math also proved to be promising. When the FASTT Math students were tested four months later, they had regressed by only 6 facts. This indicated that FASTT Math helped these students become fluent at a high level, and allowed them to retain the information better over time (Hasselbring & Goin, 1988).

Conclusion

Research indicates that there is a significant relationship between mathematics anxiety and mathematics performance. Ashcraft & Krause (2001) determined that as mathematics anxiety increases, students' math performance decreases as a result of the depletion of cognitive resources. The present study attempted to decrease mathematics anxiety through implementation of the FASTT Math mathematics fluency intervention, with the intent to diminish mathematics anxiety as competency is attained. This study also sought to determine whether FASTT Math's fluency activities would help students gain automaticity when recalling basic math skills, and consequently decrease mathematics anxiety in a group of fourth grade female students from a local elementary school. It was hypothesized that the FASTT Math training would enhance female students' math fluency, thereby lowering their levels of mathematics anxiety after completing the program.

Research Design

Participants

Participants in this study consisted of 50 fourth grade female students from two elementary schools in the Midwest (Summerside Elementary and Batavia Elementary). Both schools are located in Clermont County, which is an area of southwestern Ohio that borders Kentucky. The experimental site (Summerside Elementary) is situated in the West Clermont Local School District and has approximately 479 students. Summerside Elementary was recently given an "Effective" designation by the Ohio Department of Education (2012). Approximately 46.2% of students who attend Summerside Elementary are economically disadvantaged, and students with disabilities comprise 8.8% of the student population.

The control site (Batavia Elementary) is located in the Batavia Local School District and serves approximately 876 students. Batavia Elementary was recently given an "Excellent" designation by the Ohio Department of Education (2012). Approximately 51.2% of students at Batavia Elementary are economically disadvantaged, and students with disabilities compose 14.5% of the student population.

The study began with 62 participants, but 12 of these participants did not complete the *MARS-E* posttest measure. Therefore, these individuals were excluded from analyses. Participants ranged in age from 9 to 11 years. All fourth grade female students who attended the elementary schools were invited for participation. Informed consent was obtained from all participating children's parents/legal guardians prior to data collection. Child assent was also obtained.

Materials

Mathematics anxiety. In this research study, mathematics anxiety was defined as a feeling of panic and helplessness that one experiences when solving a math problem. This construct was measured using the *Mathematics Anxiety Rating Scale – Elementary (MARS-E)*. The *MARS-E* is a self-report used to measure the severity of mathematics anxiety in elementary age students (grades 4-6) (Suinn & Edwards, 1988). The *MARS-E* can be administered in a group format and takes approximately 15 minutes to complete. It consists of 26 statements and

uses a five-point Likert scale (1 = Not at all nervous, 5 = Very, very nervous) to determine anxiety levels in children. Students whose score fell at the 75^{th} percentile or higher with a raw score of 57 (out of 130) were placed in the High Anxiety group.

The *MARS-E* contains questions involving school, as well as non-school items (Suinn & Edwards, 1988). School items consist of questions involving testing, writing on the board, reading out loud, and participating/being present in math class. The non-school questions are composed of "consumer situations", such as making change (Suinn & Edwards, 1988). The non-school questions make up approximately one-fourth of the total assessment questions. There is one total score for the *MARS-E* assessment, simply called "Total Score". The *MARS-E* has an internal construct validity of (.88). All *MARS-E* testing was conducted by the researcher.

FASTT Math. FASTT Math is a computerized intervention program designed to increase math fluency in elementary-age children (Hasselbring, 1988). Based on intervention results from previous studies, an effective intervention schedule for the FASTT Math program requires approximately 10 minutes of participation 3 to 5 days per week for a minimum of 4 weeks. The software provides the student with directions to answer questions in each module. Previous studies confirm that participation in the FASTT Math program helps approximately 80% of students develop greater math fluency (Hastings, 2010; Hasselbring & Goin, 1988).

Procedures

This study utilized a pretest-posttest design by assessing the anxiety levels of female students prior to and immediately following a six week FASTT Math intervention program. Additionally, the study employed a comparison analysis by comparing the levels of anxiety in students who completed the intervention with students who did not participate in the fluency intervention.

A quasi-experimental design was implemented by dividing participants into the experimental or control groups, with 25 students per group. The students who attended Summerside Elementary School served as the experimental group because the fourth grade classes had access to the FASTT Math Program. The students at Batavia Elementary served as the control group because they did not receive the computerized intervention for the purpose of this research study.

In order to screen students for mathematics anxiety, district approval was first obtained. After receiving district approval, the students' parents or legal guardians were contacted and asked to sign a letter of consent. The letter of consent described the study and requested permission allowing the students to participate in the mathematics anxiety assessments, as well as the FASTT Math intervention program. It also addressed the rights of the parents and students to decline participation.

When permission was obtained from the students' parents and the students themselves, the researcher administered the pretest measure (*MARS-E*). Identification numbers were assigned to the individual students in order to maintain confidentiality. The title on the *MARS-E* forms was also obstructed so as not to influence the students' answers by seeing the word "anxiety". The directions and questions for each assessment item were read aloud to the students, who followed along with a printed copy. Students who earned *MARS-E* scores of 57 (out of 130) or higher were identified as having high levels of mathematics anxiety, and were invited to participate in the intervention program. Students who earned scores below the cutoff of 57 did not complete the intervention program and were excluded from analysis.

After assessing the students' mathematics anxiety, the students' fact fluency was measured using the FASTT Math pretest. The pretest assessed each user's level of mathematics competency prior to implementation of the intervention. Students were required to answer basic facts questions as quickly and accurately as possible. Equations that they could answer in less than five seconds were stored in a bank of fluent facts (Hasselbring, 1988). The facts that were not yet fluent were targeted for additional practice. The FASTT Math intervention occurred five days per week over a 6-week period of time. The students completed FASTT Math's math fluency exercises for approximately 10 minutes each day. Post-test data was collected after the conclusion of the intervention program. The researcher then reassessed the female students' levels of math anxiety using the *MARS-E*.

In the present study, the researcher chose to emphasize the acquisition of basic multiplication skills, based on the fourth grade mathematics objectives comprising the Common Core State Standards in Ohio. One facet of the fourth grade content standards is multi-digit multiplication (Common Core State Standards Initiative, 2013). The researcher proposed that if some fourth grade students struggled with basic multiplication fact fluency, it would be very

difficult for these students to gain an understanding of multi-digit multiplication and successfully complete problems involving these skills. This would likely result in increased anxiety levels. As such, the present study assisted students in gaining basic multiplication fact fluency through a computerized program, which helped prepare them to complete higher-level math activities during their fourth grade year.

Results

The present research study attempted to answer the following questions:

Hypothesis 1: Female students' mathematics fluency will increase following the six-week FASTT Math fluency intervention.

Hypothesis 2: Female students' mathematics anxiety will significantly decrease as mathematics fluency increases (following completion of the mathematics fluency intervention).

Hypothesis 3: Students' levels of mathematics anxiety will be significantly lower at the experimental site, following completion of the mathematics fluency intervention.

The data collected in this study were analyzed using the Statistical Package for the Social Sciences (SPSS). A paired samples t-test was conducted to measure the effectiveness of the FASTT Math program on students' mathematics fluency. A paired samples t-test was run to compare the impact of the fluency intervention on anxiety levels between the experimental and control groups. This assisted in determining if student reports of mathematics anxiety decreased after receiving the FASTT Math intervention. An independent samples t-test was conducted to determine if there was a significant difference in *MARS-E* pretest scores in the experimental group and pretest scores in the control group. An independent samples t-test was also completed to evaluate if there was a significant difference in the MARS-E posttest scores of the experimental group compared to the MARS-E posttest scores of the control group.

Table 1

	Paired Samples Statistics										
		Mean	N	Std. Deviation	Std. Error Mean						
Pair 1	FLUENCYPRE	10.4000	25	4.44410	.88882						

28.1600

FLUENCYPOST

Paired Samples t-tests for Pretest-Posttest Measures of Mathematics Fluency

Paired Samples Test

25

5.54286

1.10857

			Paired Differences						Sig. (2- tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	FLUENCYPRE FLUENCYPOST	-17.76000	3.84361	.76872	-19.34656	-16.17344	-23.103	24	.000

Test of Hypothesis 1

To test the first hypothesis that students' mathematics fluency would increase after completing the FASTT Math intervention, the children completed the computerized FASTT Math pretest activity. The pretest activity required students to answer a variety of basic multiplication facts as quickly and accurately as possible. A student's fluent facts were stored in a grid and non-fluent facts were targeted for review. A paired samples t-test was conducted to evaluate the effectiveness of the intervention on math fact fluency. The results indicated that the mean fact fluency score after the intervention (M = 28.16) was significantly higher than the mean fact fluency score before the intervention (M = 10.40), t(24) = 23.1033, p.<.05. The first hypothesis was supported because students' math fact fluency significantly increased following the six-week FASTT Math intervention (see Table 1).

Table 2

Paired Samples t-tests for Pretest-Posttest Measures of Mathematics Anxiety (Experimental Site)

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	EXPPRE	61.3600	25	18.47719	3.69544
	EXPPOST	56.2400	25	18.82658	3.76532

Paired Samples Statistics

Paired Samples Test

			Pair	ed Differend	ces		t	df	Sig. (2- tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	EXPPRE EXPPOST	5.12000	25.81234	5.16247	-5.53481	15.77481	.992	24	.331

Table 3

Paired Samples t-tests for Pretest-Posttest Measures of Mathematics Anxiety (Control Site)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pair 1 CONPRE	63.9600	25	19.15611	3.83122
CONPOST		68.1600	25	19.80463	3.96093

Paired Samples Test

			Pair	ed Differen		t	df	Sig. (2- tailed)	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	CONPRE - CONPOST	-4.20000	18.58987	3.71797	-11.87352	3.47352	-1.130	24	.270

Test of Hypothesis 2

To test the second hypothesis that mathematics anxiety would decrease as mathematics fluency increased, students at the experimental and control sites completed the *MARS-E* at the beginning of a six-week block. The students at the experimental site then received six weeks of the FASTT Math intervention and students serving in the control group received typical classroom instruction. At the conclusion of the program, both groups were reevaluated using the *MARS-E*.

A paired sample t-test was conducted to evaluate whether the experimental group's levels of mathematics anxiety decreased after the intervention. The experimental group's pretest anxiety scores were compared to their posttest anxiety scores. Table 2 illustrates the pretest and posttest scores of the students at the experimental site. The results indicated that the experimental group's mean mathematics anxiety scores were slightly lower after the intervention (M = 56.24) than the mean mathematics anxiety scores before the intervention (M = 61.36), t(24) = 0.9918, p>.05. However, the difference in these scores was not statistically significant.

A paired-sample t-test was also conducted to compare the control group's pretest anxiety scores to their posttest anxiety scores. Table 3 presents the pretest and posttest scores of the students at the control site. The results indicated that the control group's mean mathematics anxiety scores were actually higher after receiving the classroom math instruction (M = 68.16) than they were prior to the instruction period (M = 63.96), t(24) = 1.1296, p.<.05. The second hypothesis was not supported because students' mathematics anxiety did not significantly decrease in the experimental group, following the completion of the mathematics fluency intervention.

Table 4

Independent Samples t-tests for Pretest Measure of Mathematics Anxiety (Experimental and Control Sites)

Group Statistics

	MARSSCORES	Ν	Mean	Std. Deviation	Std. Error Mean
PREANX	EXPERIMENT	25	61.3600	18.47719	3.69544
	CONTROL	25	63.9600	19.15611	3.83122

Independent Samples Test

		Levene for Equ Varia	e's Test uality of ances	t-test for Equality of Means							
		F	Sig.	t	df	Sig. (2- tailed)	Mean Differenc e	Std. Error Differenc e	95% Confidence Interval of the Difference		
	Equal variances						-	-	Lower	Upper	
X	assumed	.052	.821	488	48	.627	-2.60000	5.32302	-13.30265	8.10265	
	Equal variances not assumed			488	47.938	.627	-2.60000	5.32302	-13.30301	8.10301	

Table 5

Independent Samples t-tests for Posttest Measure of Mathematics Anxiety (Experimental and Control Sites)

	MARSSCORES	N	Mean	Std. Deviation	Std. Error Mean
POSTANX	EXPPOST	25	56.2400	18.82658	3.76532
	CONPOST	25	68.1600	19.80463	3.96093

Group Statistics

		Levene Equ Var	's Test for ality of iances	t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2- tailed)	Mean Difference	Std. Error Differen ce	95% Confidence Interval of the Difference	
									Lower	Upper
POSTA NX	Equal variances assumed	.058	.810	-2.181	48	.034	-11.92000	5.46503	- 22.90818	93182
	Equal variances not assumed			-2.181	47.877	.034	-11.92000	5.46503	۔ 22.90890	93110

Test of Hypothesis 3

It was hypothesized that students at the experimental site would experience decreased levels of mathematics anxiety following completion of the intervention. To test this hypothesis, an independent samples t-test was run. This function compared the pretest anxiety data from the experimental site to the pretest anxiety data from the control site. It also compared the posttest anxiety data from the experimental site to the posttest anxiety data from the control site.

An independent samples t-test was run to compare the experimental group's pretest anxiety scores with the control group's pretest anxiety scores. The results indicated that the experimental group's mean anxiety ratings prior to the intervention (M = 61.36) were not significantly different from the control group's pretest anxiety scores (M = 63.96), t(48) = 0.4484, p>.05.

An additional independent samples t-test was conducted to compare the experimental group's posttest anxiety scores with the control group's posttest anxiety scores. The results indicated that there was a significant difference between the experimental group's mean mathematics anxiety posttest scores (M = 56.24) and the control group's mean mathematics anxiety posttest scores (M = 68.16), t(48) = 2.811, p<.05. Because there was a significant difference between the experimental and control group's posttest means, the third hypothesis was partially supported (see Table 5).

Discussion

Summary of Results

The purpose of this study was to examine the relationship between mathematics fluency and mathematics anxiety in female elementary students. It was hypothesized that the FASTT Math fluency intervention would help students increase mathematics automaticity, and through increased competency and positive feedback result in decreased mathematics anxiety.

Mathematics anxiety scores were obtained from students attending two suburban elementary schools in Ohio. Scores were analyzed from 25 fourth grade female students in the experimental group and 25 fourth grade girls from the control group, totaling 50 participants.

Although the present study was unable to support all of the hypotheses proposed, it did yield several important findings in the area of mathematics anxiety research with a female population. First, the results of this study supported previous research suggesting that the FASTT Math intervention significantly aids in the acquisition of basic math facts. Students in the experimental group who received the FASTT Math fluency intervention significantly increased their "bank" of fluent facts from completing the intervention. After a six-week period of time, the mean of fluent math facts significantly increased (M = 28.68) when compared to the mean prior to the intervention (M = 10.40); this data indicated that the students gained an average of 18.28 facts over the course of the intervention, which equates to approximately 3.05 facts per week.

The data from this study indicated that the students in the experimental group who received the FASTT Math program did not experience significantly decreased levels of mathematics anxiety following completion of the intervention, and Hypothesis 2 was not supported. While the experimental group's mean anxiety scores did decrease somewhat from pretest to posttest, the reduction in their anxiety levels was not statistically significant. The students who comprised the control group did not report reduced levels of mathematics anxiety following the six-week period, during which they received typical classroom instruction. This outcome was anticipated for the control group because they did not receive the mathematics fluency intervention, which was expected to result in reduced mathematics anxiety.

When the pretest MARS-E scores from the experimental group were compared to the pretest MARS-E scores from the control group, there was no significant difference. This

outcome was expected because the experimental group had not yet received the FASTT math intervention.

A significant difference was found between the anxiety posttest scores of the experimental and control groups. The control group experienced a slight increase in anxiety, which was likely due to continued difficulty in mathematics fluency and a lack of consistent positive feedback. The experimental group experienced a slight decrease in anxiety, which was likely due to improved mathematics fluency and computerized positive feedback as a result of their improved mathematics performance. These two conditions likely combined to generate a significant difference between the anxiety posttest scores, thereby suggesting that fluency instruction, when compared to no instruction, reduces math anxiety.

Implications for Instructional Practice

This research study yielded several insights in the area of mathematics instruction. According to Ohio's Common Core State Standards (2013), mathematics instruction during the fourth grade year has three foci: (1) developing fluency skills and understanding of multi-digit multiplication and division, (2) developing an understanding of fraction equivalence, adding and subtracting numbers with common denominators, and multiplying fractions by whole numbers, and (3) improving their understanding of properties of geometric figures. This study examined one of the main emphases of the Common Core by providing intensive, evidence-based intervention in the area of multiplication math fact fluency. This study found that students who participated in the fluency intervention significantly improved their mathematics fluency. For this reason, a mathematics fluency intervention could be used as an effective method to assist students in meeting some of the fourth grade Common Core mathematics standards.

This study addressed several strategies recommended by previous research for reducing mathematics anxiety. DeCaro, Rotar, Kendra, & Beilock (2010) suggested that students with math anxiety talk through the different steps of math problems when learning formulae; research has found that students who utilize this strategy often perform more accurately on tests than those who do not. The math intervention program incorporated this technique by presenting the mathematics facts to students both visually and auditorally (the FASTT Math program uses both pictures and narration to help students automatize math facts). This approach may have improved the students' ability to retain and recall math facts.

Additionally, Wadlington & Wadlington (2008) identified the following instructional strategies for students suffering from mathematics anxiety: (a) make mathematics content more interesting by including students' names or interests in problems; (b) avoid drawing attention to or ridiculing students who suffer from mathematics anxiety or experience poor performance in the areas of math, as this typically exacerbates the students' level of anxiety. The present research study addressed these strategies by allowing students to practice math facts while using a game-like format, thereby making the process of acquiring basic facts more interesting. This study also considered these strategies because the intervention was computer-based; the students could work at their own pace on targeted problems and perhaps feel less self-conscious if they experienced difficulty.

One factor that may have affected student performance during the course of the study was positive feedback. Students who completed the FASTT Math intervention received individual and specific ongoing praise from the computer as they completed the fluency activities. This may have contributed somewhat to their slightly lowered levels of mathematics anxiety. Research indicates that for every negative comment or experience that a student sustains, four positive comments or experiences must take place before the individual feels competent in his or her abilities (Sugai, Horner, & Gresham, 2002). As such, immediate positive feedback (in verbal and written forms) should be provided by educators whenever possible and at a rate suggested by research. Positive learning experiences and improved fact fluency should improve overall mathematics performance, thereby decreasing mathematics anxiety. Also, if a student's math anxiety remains high, it is possible that past negative experiences overshadow the students' short-term experiences (i.e., successfully completing the FASTT Math intervention).

The current study noted that there appeared to be a relationship between the female students' level of mathematics anxiety and self-perception of their math skills. Despite completing six weeks of the FASTT Math intervention program, many of the students in the experimental group continued to rate their mathematics anxiety as high. This may have been due to societal messages that males are superior to females in the area of mathematics, along with the girls' potential fear of confirming this stereotype.

This result is consistent with past research which supports the theory that although female students may successfully acquire mathematics facts and skills, they may continue to self-evaluate their math anxiety as high and performance as low (Frenzel, Pekrun, & Goetz, 2005). It

is possible that fluency-based programs do not decrease mathematics anxiety because they are not specifically designed to address those needs. For this reason, it is critical for teachers to be cognizant of the learning needs of students who suffer from mathematics anxiety and, as stated previously, positive feedback should be utilized whenever possible. It may also be helpful to incorporate a cognitive-behavior therapy approach so that students learn to engage in positive self-talk when completing mathematics tasks.

Limitations

While the present study utilized a pretest-posttest design with designated experimental and control groups, a true experimental design was not employed. Because the students were divided into groups based on their schools (and access to the FASTT Math program), the researcher did not use random assignment. The school that had access to the FASTT Math program (Summerside Elementary) was selected as the experimental site and the school that did not have access to the intervention program (Batavia Elementary) was chosen as the control site. Future research should implement the FASTT Math program in a larger, single school or district and then randomly assign students to the experimental and control groups.

Another limitation of the study was that the researcher did not evaluate the pretest and posttest mathematics fluency of the students in the control group. This was due to the fact that the primary focus of the study was on assessing anxiety. However, future research should assess the pretest and posttest mathematics fluency of both groups in order to provide a comparison and determine the degree to which the FASTT Math program assisted in basic fact acquisition.

It is important to note that one major limitation of this study was the presumption that mathematics anxiety is directly and singularly tied to mathematical knowledge. While research suggests that math anxiety can manifest for numerous reasons (i.e., teacher attitudes, student self-perceptions of skills, et cetera), the researcher chose to focus on one quantifiable aspect connected to student math anxiety (i.e., fluency). However, future research should continue to investigate other potential sources of mathematics anxiety in the academic setting. These sources may include teacher attitudes about girls and mathematics achievement, negative internal self-talk, or societal perceptions of male versus female mathematical ability. Thus, a mental health approach could be implemented as a method of reducing mathematics anxiety. This may consist of teaching students different strategies to cope with math anxiety or how to use cognitive restructuring in order to change negative self-talk.

This study did not examine other environmental variables that may have impacted student attitudes about mathematics, and this proved to be an additional limitation. Some influential factors that may have impacted student mathematics anxiety include the time of year when the study was conducted (i.e., were the students preparing for high-stakes assessments or preparing for a break from school), the duration of the intervention (which was relatively short for measuring the effects of an intervention), and the teaching styles and attitudes of the educators involved. It may be beneficial for future researchers to examine the mathematics anxiety levels of students at different times during the school year. It may also be helpful to provide female teachers with a survey about their attitudes regarding mathematics; researchers could then examine the levels of mathematics anxiety of female students in those classrooms and determine if the teachers who expressed higher levels of mathematics anxiety also had female students with high math anxiety.

Future Research and Conclusions

The present study determined that students who received the FASTT Math intervention significantly increased their basic fact fluency. Additionally, it determined that there was a significant difference in mathematics anxiety levels between students who received the intervention and those who did not. Although the students within the experimental group did not experience significantly decreased levels of mathematics anxiety between pre and post-test, they did demonstrate *slightly* decreased levels of anxiety. Based on research suggesting that automaticity can aid in reducing anxiety, the data collected in the present study indicate that the mathematics fluency intervention had some positive effect on reducing the experimental group's mathematics anxiety.

This researcher believes that additional research is necessary in order to further explore the link between mathematics anxiety and mathematics fluency. In the future, it may be beneficial for researchers to extend the duration of the mathematics fluency program to ensure that students retain the information and receive positive feedback for successful performance over an extended period of time. The author also proposes that a latency check be performed following the conclusion of the program to monitor the students' retention of facts. It may also assist in determining the long-term effects of the fluency intervention on mathematics anxiety.

Future research may also include a longitudinal study to track the students' mathematics anxiety across grade levels. This may provide additional instructional information for

development and modification of the mathematics curriculum. In addition, future research should examine larger samples from more diverse populations. The author also proposes that male students be included in future research to serve as an additional comparison group. Research indicates that male students typically rate themselves as having lower levels of mathematics anxiety and higher levels of math competency (Frenzel, Pekrun, & Goetz, 2005), so this data could provide insight into student perceptions and attitudes of mathematics based on gender.

Although the present study did not support all of the hypotheses proposed, it did support previous research asserting that the FASTT Math fluency program significantly aids in basic facts acquisition. It determined that there was a significant difference in the posttest anxiety scores between the students who completed the intervention and those who did not. It also examined the effects of a computerized fluency intervention on an elementary-age female population. Because female students are at a higher risk for developing and sustaining feelings of mathematics anxiety into adulthood, this is an area of research that should be continually addressed and monitored in the future. Teachers and parents should be particularly cognizant of their attitudes when working with female students on math tasks, so as not to perpetuate the stereotype that females are inherently inferior to males in the area of mathematics. Finally, future research should examine other factors that may influence math anxiety, such as its relationship to grade promotion, achievement testing, and high-stakes testing.

References

- (2013). Mathematics, Grade 4: Introduction. *Common Core State Standards Initiative*. Retrieved from: http://www.corestandards.org/Math/Content/4/introduction.
- Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science*, *11*(5), 181-185).
- Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety and performance. *Journal of Experimental Psychology: General*, *130*(2), 224-237.
- Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review*, 14(2), 243-248.
- Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment*, 27(3), 197-205.
- Aronson, J., Brown, J., Good, C., Lustina, M., Keough, K., & Steele, C. (1999). When white men can't do math: Necessary and sufficient factors in stereotype threat. *Journal of Experimental Social Psychology*, 35(4), 29–46.
- Barancik, S. (2011). Bibliotherapy: Good book = happier kid? Best Children's Books: Find, Read, or Write.
- Begley, T. A. (2007). *An investigation of mathematics anxiety across third, fourth, and fifth grade*. Unpublished master's thesis, Central Connecticut University New Britain.
- Beilock, Gunderson, Ramirez, and Levine (2010). Female Teachers' Math Anxiety Impacts Girls' Math Achievement. The University of Chicago.
- Burns, M. (1998). Math: Facing an American Phobia. California: Math Solutions Publications.

- Campbell, J. I. D. (Ed.) (2005). *Handbook of mathematical cognition*. New York: Psychology Press.
- Cates, G. & Rhymer, K. (2003). Examining the Relationship Between Mathematics Anxiety and Mathematics Performance: An Instructional Hierarchy Perspective. *Journal of Behavioral Education*, 12(1), 23-34.
- Feifer, S. (2007). The Neuropsychology of Math Disorders: Diagnosis and Intervention. Frederick County Public Schools.
- Frenzel, A., Pekrun, R., & Goetz, T. (2005). Girls and mathematics—a hopeless issue? A control-value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education*, 22(4), 497-514.
- Furner, J. M., & Berman, B. T. (2003). Math anxiety: overcoming a major obstacle to the improvement of student math performance. *Journal of Research on Childhood Education*, 79 (3), 170-174.
- Furner, J. M., & Duffy, M. L. (2002). Equity for all students in the new millennium: Disabling math anxiety. *Intervention in School and Clinic*, 38(2), 67-74.
- Hasselbring and Goin (1988). Research Foundations & Evidence of Effectiveness for FASTT Math. Scholastic Research & Results. New York: Scholastic.
- Hasselbring, T., Lott, A., & Zydney, J. (2005). Technology-supported math instruction for students with disabilities: Two decades of research and development. Washington, DC: American Institutes for Research.

- Hastings, P. (2010). On the FASTT Road to Mathematical Success: Math in the Middle Institute Partnership Action Research Project Report. The University of Nebraska-Lincoln.
- Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, 21(1), 33-46.
- Hyde, J. Fennema, E. and Lamon, S. (1990). Gender differences in mathematics performance: A meta-analysis. *Psychological Bulletin*, 107(2), 139-155.
- Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *Mathematics Teacher*, *92*(7), 583-586.
- Kargar, M., Tarmizi, R. A., & Bayat, S. (2010). Relationship between mathematical thinking, mathematics anxiety and mathematical attitudes among university students. *Procedia Social and Behavioral Sciences*, 8, 537-542.
- Krinzinger, H., Kaufmann, L., & Willmes K. (2009). Math anxiety and math ability in early primary school years. *Journal of Psychoeducational Assessment*, 27(3), 206-225.
- Kazelskis, R., Reeves, C., Kersh, M. E., Bailey, G., Cole, K., Larmon, et al. (2000). Mathematics anxiety and test anxiety: Separate constructs? *The Journal of Experimental Education*, 68(2), 137-146.
- Lehner, P. (2008). What Is the Relationship Between Fluency and Automaticity through Systematic Teaching with Technology (FASTT Math) and Improved Student Computational Skills? Virginia Beach City Public Schools.
- Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education*, 30(5), 520-540.

- Mazzone, L., Ducci, F., Scoto, M. C., Passaniti, E., D'Arrigo, V. G., & Vitiello, B. (2007). The role of anxiety symptoms in school performance in a community sample of children and adolescents. *BMC Public Health*, 7, 347.
- Merriman-Webster (2011). Cognitive restructuring. Merriman-Webster, Incorporated: An Encyclopedia Brittanica Company.
- National Association of Cognitive Behavior Therapists (2007). Cognitive Behavioral Therapy. NACBT Online Headquarters.
- Organization for Economic Cooperation and Development (OECD) (2004). Differences in university graduates by field of study. OECD Education Database.
- Richardson, F. C, & Woolfolk, R. L. (1980). Mathematics anxiety. *Test anxiety: Theory, research and application*, 271-288. Hillsdale, NJ: Erlbaum.
- Perry, A. B. (2004). Decreasing math anxiety in college students. *College Student Journal*, 38(2), 321-324.
- Sevey, B. (2012). Mathematics anxiety, working memory, and mathematics performance: Effectiveness of a working memory intervention on reducing mathematics anxiety. OhioLink.
- Sherman, B & Wither, D. (2003). Mathematics Anxiety and Mathematics Achievement. *Mathematics Education Research Journal*, *15*(2) 138-150.
- Spencer, S. & Quinn, D. (2001). The interference of stereotype threat with women's generation of mathematical problem-solving strategies. *Journal of Social Issues*, *57*(1), 55-71.
- Spencer, S., Steele, C., & Quinn, D. (1998) Stereotype Threat and Women's Math Performance. Journal of Experimental Social Psychology, 35(4), 4–28.

- Steele, C. & Aronson, J. (1995) Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, 69(5), 797-811.
- Sugai, G., Horner, R. H., & Gresham, F. (2002). Behaviorally effective school environments. In M. R. Shinn, G. Stoner, & H. M. Walker (Eds), Interventions for academic and behavior problems: Preventive and remedial approaches (pp. 315-350). National Association of School Psychologists. Silver Spring, MD.
- Suinn, R., Taylor, S., & Edwards, R. (1988). Suinn mathematics anxiety rating scale for elementary school students (MARS-E): Psychometric and normative data. *Educational* and Psychological Measurement, 48, 979-986.
- The Nation's Report Card (2011). Mathematics. National Assessment of Educational Progress (NAEP). Washington, D.C.: Institute of Education Sciences, U.S. Department of Education.
- Terrell, S. (2006). Strategies for alleviating math anxiety in the visual learner. The University of Maryland University College (UMUC).
- Tobias, S. (1978). *Overcoming math anxiety*. Boston, Massachusetts: Houghton Mifflin Company.
- Tobias, S. (1987). Succeed with math: Every student's guide to conquering math anxiety. New

York: College Board Publications.

Tom Snyder Productions (2011). FASTT Math. New York: Scholastic.

U.S. Department of Education (2010). No Child Left Behind. The United States Department of Education.

Wong, M. & Evans, D. (2007). Improving Basic Multiplication Fact Recall for Primary School Students. *Mathematics Education Research 19*(1), 89–106.

Appendices

- A. Principal Letter of Consent (Summerside Elementary)
- B. Principal Letter of Consent (Batavia Elementary)
- C. Parent/Guardian Consent Form (Summerside Elementary)
- D. Parent/Guardian Consent Form (Batavia Elementary)
- E. Student Assent Script (Summerside Elementary
- F. Student Assent Script (Batavia Elementary)

Appendix A

Dear Principal (Summerside Elementary),

My name is Rachel Mathews and I am currently a third year graduate student studying School Psychology at Miami University. As part of my training to become a licensed school psychologist, I am required conduct a thesis study that will contribute to the current knowledge base of school age children. The purpose of my study is to examine the relationship between mathematics anxiety and automaticity of mathematics fluency in female elementary-age students.

My methodology includes having the participation of approximately fifty fourth grade female students. The students' parents or legal guardians will be sent a parental consent form indicating that the researcher would like to screen all fourth grade students for mathematics anxiety and ask for participation in the study, if selected. The parent consent form will describe the research process and request permission to allow the students to participate in the study. Students will also be required to give their assent to participate in the study. After obtaining consent and assent, the researcher will administer the pretest measure (*MARS-E*) to the fourth grade student at an elementary school. Following the universal screening, students who scored high on the *MARS-E* will be invited to receive the FASTT Math intervention.

A mathematics intervention (FASTT Math) will occur over five days per week over a 6week period of time. FASTT Math is a computerized intervention program for Windows and Mac whose purpose is to increase math fluency in elementary-age children. The students will complete FASTT Math's math fluency exercises for 10 minutes each day. The FASTT Math program is already being used as part of Summerside Elementary's curriculum. Post-test data will be collected after the conclusion of the intervention program. The researcher will then reassess the female students' levels of math anxiety using the *MARS-E*. The duration of this study is expected to be from February to April, 2012.

This study may yield several benefits for the students and school district involved. Students who participate in this study may enhance their mathematics skills and as a result, experience lower levels of mathematics anxiety. This study could have implications for raising district scores and ratings. Potential benefits include increased mathematics scores and higher Ohio Achievement Assessment (OAA) scores. At this point in time, there has been very little research examining the effect of a mathematics fluency intervention on reducing mathematics anxiety. Consequently, this is important and groundbreaking research that could lend to mathematics instruction in the future.

Your school's consideration and participation in this study are greatly appreciated. If there are any questions or concerns, please feel free to contact me at <u>mathewre@muohio.edu</u> or 614-571-4229. You may also contact the research advisor, Dr. Ray Witte, at <u>witter@muohio.edu</u>. If there are any questions regarding the rights of participants, please contact the Office of

Advancement of Research and Scholarship at 513-529-3600 or humansubjects@muohio.edu.

Thank you,

Rachel Mathews Graduate Researcher Miami University

Appendix B

Dear Principal (Batavia Elementary),

My name is Rachel Mathews and I am currently a third year graduate student studying School Psychology at Miami University. As part of my training to become a licensed school psychologist, I am required conduct a thesis study that will contribute to the current knowledge base of school age children. The purpose of my study is to examine the relationship between mathematics anxiety and automaticity of mathematics fluency in female elementary-age students. I will be examining the effectiveness of the FASTT Math intervention program at Summerside Elementary. Because the entire fourth grade is currently receiving the intervention, I am seeking a control group for my study.

My methodology includes having the participation of approximately fifty fourth grade female students at Batavia Elementary School. The students' parents or legal guardians will be sent a parental consent form indicating that the researcher would like to screen all fourth grade students for mathematics anxiety. After obtaining consent and assent, the researcher will administer the pretest measure (*MARS-E*) to the fourth grade student at an elementary school. After a six week period of time, the students will be screened again using the *MARS-E*. Because Summerside Elementary is already using the intervention program, your school will not need to purchase or implement the intervention program—the researcher will simply screen students twice within a six week period and compare their results to the students who have received the intervention.

This study may yield several benefits for the students and school districts involved. Students who receive the intervention may enhance their mathematics skills and as a result, experience lower levels of mathematics anxiety. This study could have implications for raising district scores and ratings. Potential benefits include increased mathematics scores and higher Ohio Achievement Assessment (OAA) scores. At this point in time, there has been very little research examining the effect of a mathematics fluency intervention on reducing mathematics anxiety. Consequently, this is important and groundbreaking research that could lend to mathematics instruction in the future.

Your school's consideration and participation in this study are greatly appreciated. If there are any questions or concerns, please feel free to contact me at <u>mathewre@muohio.edu</u> or 614-571-4229. You may also contact the research advisor, Dr. Ray Witte, at <u>witter@muohio.edu</u>. If there are any questions regarding the rights of participants, please contact the Office of Advancement of Research and Scholarship at 513-529-3600 or <u>humansubjects@muohio.edu</u>.

Thank you, Rachel Mathews - Graduate Researcher Miami University

Appendix C

Dear Parent/Guardian (Summerside Elementary),

My name is Rachel Mathews and I am a third year graduate student studying School Psychology at Miami University. I am conducting research at Summerside Elementary School as part of my graduate training. My research will examine the effects of the FASTT Math computer program on student learning The information collected will help us determine whether the FASTT Math computer program (which is currently being used at your child's school) is an effective program.

Your daughter is being invited to participate in this research study. With parental permission, female students in Grade 4 will be administered the *Mathematics Anxiety Rating Scale – Elementary*. This is a self-report scale that asks students how they feel about math. Approximately 50 girls will participate in this study. After completing 6 weeks of typical classroom activities involving the FASTT Math program, your child will be readministered the scale.

The computerized instruction (known as FASTT Math) will have your daughter practice math facts on the computer and play a mathematics game at the conclusion of each session. The sessions will meet five times per week for 10 minutes per session. Computerized test scores will be collected at the conclusion of the intervention program. The researcher will again check the female students' levels of math anxiety using the *MARS-E*.

Your daughter's participation in this study is completely voluntary. This research project is in no way related to your daughter's regular classroom requirement, so she may withdraw from the study at any time without consequences.

The results from the study will be completely confidential and kept in a locked file cabinet. ID numbers will be used instead of names on research files. All documentation from this study will be stored in a locked file cabinet. The researcher will be the only person who has a key to access this cabinet and the key matching student names to their corresponding identification numbers during data collection. Once all data has been collected and checked for accuracy, the key will be destroyed. The results from this study will be used as a Master's thesis.

Please indicate whether you would like your child to participate/not participate on the form below. Forms can be returned to your students' homeroom teacher.

If there are any questions or concerns, please feel free to contact me at <u>mathewre@muohio.edu</u> or 614-571-4229. You may also contact my research advisor, Dr. Ray Witte, at <u>witter@muohio.edu</u>. If there are any questions regarding the rights of participants, please contact the Office of Advancement of Research and Scholarship at 513-529-3600 or <u>humansubjects@muohio.edu</u>.

Thank you for your consideration and approval of your daughter's participation. Below is the consent form that must be returned to the researcher; you may keep the above portion. Your daughter will also be asked to sign an assent form to confirm her participation in the study. She will be assured that she may withdraw her participation at any time.

Please sign the form below and check one box to indicate your decision regarding your child's participation in the study.

Parent/Guardian Consent Form

I understand the purpose, procedures, and my parental rights in regard to the intervention study that will be conducted at Summerside Elementary. I have contacted or will contact the researcher if I have any concerns or questions regarding my daughter's participation in the study or the intervention.

I give permission for my child to participate in the study. I understand that I can contact the researcher regarding my child's progress at any time. I also understand participation is completely voluntary and that my child may withdraw from the intervention study at any time without negative consequences.

I do not give permission for my child to participate in the study.

Parent/Guardian Signature

Date

By signing above, I acknowledge that I am 18 years or older.

Appendix D

Dear Parent/Guardian (Batavia Elementary),

My name is Rachel Mathews and I am a third year graduate student studying School Psychology at Miami University. I am conducting research at Batavia Elementary as part of my graduate training. My research will examine students' feelings about mathematics tasks.

Your daughter is being invited to participate in this research study. With parental permission, female students in Grade 4 will be administered the *Mathematics Anxiety Rating Scale – Elementary (MARS-E)*. This is a self-report scale that asks students how they feel about math. Approximately 50 girls will participate in this study. With your permission, your child will be administered the MARS-E at the twice (once at the beginning of February and once in the middle of April).

Your daughter's participation in this study is completely voluntary. This research project is in no way related to your daughter's regular classroom requirement, so she may withdraw from the study at any time without consequences.

The results from the study will be completely confidential and kept in a locked file cabinet. ID numbers will be used instead of names on research files. All documentation from this study will be stored in a locked file cabinet. The researcher will be the only person who has a key to access this cabinet and the key matching student names to their corresponding identification numbers. Once all data has been collected and checked for accuracy, the key will be destroyed. The results from this study will be used as a Master's thesis.

If you would like your child to participate in this study, please sign the form below and return it to your child's homeroom teacher.

If there are any questions or concerns, please feel free to contact me at <u>mathewre@muohio.edu</u> or 614-571-4229. You may also contact my research advisor, Dr. Ray Witte, at <u>witter@muohio.edu</u>. If there are any questions regarding the rights of participants, please contact the Office of Advancement of Research and Scholarship at 513-529-3600 or <u>humansubjects@muohio.edu</u>.

Thank you for your consideration and approval of your daughter's participation. Below is the consent form that must be returned to the researcher; you may keep the above portion. Your daughter will also be asked to sign an assent form to confirm her participation in the study. She will be assured that she may withdraw her participation at any time. Parent/Guardian Consent Form

I understand the purpose, procedures, and my parental rights in regard to the intervention study that will be conducted at Batavia Elementary. I have contacted or will contact the researcher if I have any concerns or questions regarding my daughter's participation in the study or the intervention.

Please sign the form below and check one box to indicate your decision regarding your child's participation in the study.



I give permission for my child to participate in the study. I understand that I can contact the researcher regarding my child's progress at any time. I also understand participation is completely voluntary and that my child may withdraw from the intervention study at any time without negative consequences.



I do not give permission for my child to participate in the study.

Parent/Guardian Signature

Date

By signing above, I acknowledge that I am 18 years or older.

Appendix E

Student Assent Script (Summerside Elementary)

I am doing a project to see if the FASTT Math computer game you use in your math classes can help students feel less worried when they have to do math activities. I hope that if work with me on this project, you will get better at math and feel less nervous about doing math at school. Since you are already going to be doing the math program during your math class, you won't have to leave class to help me with this project. At the end of six weeks, you will be asked some questions about how you feel about doing math activities. All of the activities will just see how you feel about doing math and will not affect any of your grades. If you have any questions before, during, or after my study, you can ask them. If you decide you do not want to finish the project, you can ask to stop.

If you want to be a helper in this project, please tell me now. If you do not want to be part of the project, please tell me now. Being in the study is up to you, and no one will be mad or sad if you don't sign this paper or if you change your mind later.

Appendix F

Student Assent Script (Batavia Elementary)

I am doing a project to see how you feel about mathematics. I hope that if work with me on this project, you will think about math and how you feel about doing different math activities. I will ask you to answer some questions about how you feel when you do math. At the end of six weeks, you will be asked some more questions about doing math activities. All of the activities will just see how you feel about doing math and will not affect any of your grades. If you have any questions before, during, or after my project, you can ask them. If you decide you do not want to finish the project, you can ask to stop.

If you want to be a helper in this project, please tell me now. If you do not want to be a part of the project, please tell me now too. Being in the study is up to you, and no one will be mad or sad if you don't sign this paper or if you change your mind later.