THE EFFECT OF TRAINING IN SELF-REGULATED LEARNING ON MATH ANXIETY AND ACHIEVEMENT AMONG PRESERVICE ELEMENTARY TEACHERS IN A FRESHMAN COURSE IN MATHEMATICS CONCEPTS

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ABSTRACT

The purpose of this study was to examine the effect of training in self-regulated learning strategies on math anxiety and mathematics achievement among preservice teachers. The self-regulated learning strategies examined included personal time management, how to read your mathematics textbook for understanding, organizational skills, mathematics test taking and preparation, and the use of estimation in solving mathematics problems. Preservice elementary teachers with these improved learning skills may in turn become more successful teachers of mathematics. The effect of training in self-regulated learning as a treatment for math anxiety is not well established. However, self-regulated learning has been associated with improved mathematics and science problem solving (De Corte, Verschaffel, & Op't Eynde, 2000; Taylor & Corrigan, 2005; Zan, 2000). Increased use of self-regulated learning strategies has also been associated with a reduction in test anxiety (Hofer & Yu, 2003; Pintrich, 2000; Zeidner, 1998). Therefore, training in self-regulated learning strategies has the potential to reduce math anxiety among preservice elementary teachers. Elementary education majors in a course in mathematics concepts were given training in self-regulated learning strategies. A control group of similar students received the same classroom instruction by the same college professor. The professor did not participate in the training sessions that were led by this researcher. Both treatment and control groups were given pretests and posttests: the Abbreviated Mathematics Anxiety Scale - to measure math anxiety, the Motivated Strategies for Learning Questionnaire - to measure use of self-regulated learning strategies, and a Mathematics Achievement Test - to measure changes in content knowledge. The analyses used *t*-tests and correlations to compare the participants' pretest and posttest scores on the three scales. The use of self-regulated learning strategies was not shown to reduce math anxiety or improve achievement among the elementary education majors in this study. This result may have been due to various limitations, such as insufficient time for applying and following up on the training and an inability to fully embed the training into the course content. Future research should investigate if, given the proper conditions, self-regulated learning strategies will reduce math anxiety and improve the learning of mathematics concepts, leading to more effective mathematics teaching in the elementary classrooms.

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TABLE OF CONTENTS

Page

ABSTRACT iv

ACKNOWLEDGEMENTS...vi

LIST OF TABLES x

CHAPTER

1. INTRODUCTION 1

Background.. 1
Definition of Math Anxiety 4
Definition of Self-regulated Learning.. 7
Definition of Mathematics Concepts Measured in this Study 8
Research Questions 9
Statement of Purpose 9
Rationale for the Study 10
Summary 12

2. REVIEW OF LITERATURE 13

Introduction 13
Framework 14
Math Anxiety 15
Math Anxiety among Preservice Elementary Teachers................. 23
Math Anxiety and Attitude about Mathematics 27
Mathematics Achievement.. 29
Mathematics Achievement among Preservice Elementary Teachers 30
Self-regulated Learning and Mathematics..................................... 31
Summary 35

3. METHODOLOGY 38

Research Design 38
Approval of the Research Project and Informed Consent 40
Participants 40
Instrumentation 42
The Abbreviated Mathematics Anxiety Scale................................ 42

The Motivated Strategies for Learning Questionnaire 44
Mathematics Achievement Test 46
Pilot Study 51
Procedure 53
Treatment 54
Data Analysis 55
Summary 60

4. RESULTS 62

Introduction 62
Analysis of Math Anxiety 66
Analysis of Math Anxiety and Mathematics Achievement 70
Analysis of Self-regulated Learning and Mathematics Achievement 74
Training in Self-Regulated Learning Strategies and Math Anxiety 80
Summary 81

5. DISCUSSION AND CONCLUSIONS 82

Introduction 82
Research Findings 83
Limitations 89
Implications for Practice 95
Conclusion 98
Recommendations 100

REFERENCES CITED 102

APPENDIXES

A. INFORMED CONSENT FORM 128

B. ABBREVIATED MATH ANXIETY SCALE 130

C. PERMISSION TO USE ABBREVIATED MATH ANXIETY SCALE 132

D. MOTIVATED STRATEGIES FOR LEARNING QUESTIONNAIRE 134

E. PERMISSION TO USE MOTIVATED STRATEGIES FOR LEARNING QUESTIONNAIRE 137

F. MATHEMATICS ACHIEVEMENT TEST 139

G. PERMISSION TO USE PRAXIS QUESTIONS 141

H. LESSON OUTLINES ON SELF-REGULATED LEARNING STRATEGIES . 143

I. STUDENT HANDOUTS 152

LIST OF TABLES

Table Page

3.1. Participant Age for Treatment and Control Groups 41

3.2. Participant Sex for Treatment and Control Groups 41

3.3. Participant Ethnicity for Treatment and Control Groups 42

4.1. Descriptive Statistics for Participants on All Scales and Subscales 64

4.2. Pearson Correlations among All Scales and MSLQ Subscales for All Participants 65

4.3. Descriptive Statistics for AMAS Pretest and Posttest Scores for Treatment and Control Groups 67

4.4. Descriptive Statistics for MAT Pretest and Posttest Scores for Treatment and Control Groups 70

4.5. Pearson Correlations between AMAS Score and MAT Score for Treatment and Control Groups 73

4.6. Spearman Correlation between AMAS Score and MAT Score for Treatment and Control Groups 74

4.7. Descriptive Statistics for MSLQ Pretest and Posttest Scores for Treatment and Control Groups 75

4.8. Descriptive Statistics for MSLQ Subscales Pretest and Posttest Scores for Treatment and Control Groups 75

4.9. Paired Samples *t*-tests on Pretest/Posttest Scores of MSLQ and its Subscales for Treatment and Control Groups 77

4.10. Spearman Correlation between MSLQ Score and MAT Score for Treatment and Control Groups 80

4.11. Spearman Correlation between MSLQ Score and AMAS Score for Treatment and Control Groups 81

CHAPTER 1

INTRODUCTION

Background

"Teachers' comfort with, and confidence in, their own knowledge of mathematics affects both what they teach and how they teach it" (NCTM, 1991, p. 132). Studies have suggested that when a teacher's mathematical content knowledge is weak it will likely affect the learning outcomes of her/his students (Adler, Ball, Krainer, Lin, & Novotna, 2005; Ball, 1990; Hill, Rowan, & Ball, 2005). Research has also indicated that most preservice elementary teachers lack the depth of mathematical understanding necessary for instruction at a conceptual level (Ball, Lubienski, & Mewborn, 2001; Groth & Bergner, 2006; Hadfield, Littleton, Steiner, & Woods, 1998; Peck & Connell, 1991). However, this mathematical concept knowledge is critical to the ability of teachers to create a learning environment for their students (Ball, 1988). According to Stevens and Wenner (1996), in order for elementary teachers to teach the fundamental concepts of mathematics they need a high level of conceptual understanding themselves.

Furthermore, teachers with weak content knowledge are less likely to use reform teaching methods such as those proposed by the National Council of Teachers of Mathematics (NCTM). Researchers have found that these techniques promote effective mathematics teaching (Ball, 1990; Ball, Hill, & Bass, 2005; Tishler, 1980). "To be effective, teachers must know and understand deeply the mathematics they are teaching and be able to draw on that knowledge with flexibility in their teaching tasks" (NCTM, 2000, p. 17).

Math anxiety is related to both the content knowledge and the teaching methods used by elementary teachers. Math anxiety involves the negative feelings or behaviors associated with the learning of mathematical concepts, solving mathematical problems, or performing everyday mathematical tasks (Hembree, 1990; Richardson & Suinn, 1972; Tobias, 1991). Due to their math anxiety many students enroll in fewer mathematics courses and perform poorly in the ones they do take (Brady & Bowd, 2005; Hembree, 1990; Tooke & Lindstrom, 1998). Additionally, elementary teachers with high levels of math anxiety may spend less class time on mathematics and more time on other topics with which they are more comfortable (Trice & Ogden, 1987). Some studies have found that the math anxiety of the teacher could be passed on to their students (Austin, Wadlington, & Bitner, 1992; Bulmahn & Young, 1982; Kelly & Tomhave, 1985; Vinson, 2001), possibly leading to a cycle of continuing math anxiety. Teachers with math anxiety tend to use lecture and rote learning, avoiding uncomfortable questions from the students (Bush, 1989; Norwood, 1994). By contrast, various studies have shown that students tend to have lower math anxiety when working in small groups, interacting with each other, and constructing their own mathematical knowledge (Alsup & Sprigler, 2003; Bulmahn & Young, 1982; Furner, 1996), aspects more related to a reform classroom structure.

Many people associate math anxiety with females. Are these sex differences real? Some researchers have found differences related to sex (Betz, 1978; Brush, 1978; Dew, Galassi, & Galassi, 1983; Hembree, 1990), while others found no such differences (Resnick, Viehe, & Segal, 1982; Richardson & Suinn, 1972). More recent studies suggest that sex differences in mathematics anxiety are minimal (Felson & Trudeau, 1991; Hyde, Fennema, Ryan, Frost, & Hopp, 1990; Kazelskis, Reeves, & Kersh, 2000; Wood, 1988). In a meta-analysis Hyde, Fennema, Ryan, Frost, and Hopp (1990), for example, found no gender effect for math anxiety. Thus, it may be that math anxiety affects both sexes equally.

Since math anxiety is associated with mathematics achievement (Cates & Rhymer, 2003), it is important to look at sex and mathematics achievement. Dwyer (1997) found that high school girls take fewer mathematics courses than boys, thus not preparing themselves for college level mathematics. "Gender differences in math scores generally begin at the point at which girls stop taking advanced math and science courses" (Kerr, 1985, p. 405). However, when girls continue to take mathematics courses through high school, their achievement (as measured by NAEP-type items) is similar to that of the boys (Ma & Wilkins, 2007). Therefore, training in self-regulated learning strategies, which reduces math anxiety, could lead to higher levels of mathematics achievement among females.

In light of the research findings that math anxiety affects the mathematical preparation of teachers, as well as their approach to teaching mathematics, interventions that reduce math anxiety are indicated. There exists little research on specific treatments for reducing math anxiety among preservice teachers. This research study used training in several self-regulated learning strategies as an approach to reduce math anxiety among preservice teachers. These strategies included organization skills, time management, reading a mathematics textbook for understanding, estimation in mathematics, test taking and preparation (Kiewra, 2002; Pape & Smith, 2002; Schunk & Ertmer, 2000; VanderStoep & Pintrich, 2003; Williams, 1994). Training in self-regulated learning offers an opportunity for students to improve their approach to learning. If these future teachers, as college students, can be trained to take responsibility for their own learning, they may be able to create a positive learning environment in their classrooms.

Definition of Math Anxiety

Richardson and Suinn (1972) created the Mathematics Anxiety Rating Scale (MARS) to measure the math anxiety of undergraduate college students. As a definition, the authors state "math anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of academic situations" (p. 551).

In 1990, Hembree conducted a meta-analysis of 151 studies that used the construct of math anxiety . The studies reviewed included doctoral dissertations, journal articles, and ERIC documents. The qualifying studies specified correlation coefficients, sample sizes, and scores from validated instruments. Participants in 122 of the studies were described as postsecondary. In one part of the meta-analysis, Hembree identified variables that correlated with math anxiety. He found that female college students displayed more math anxiety than males. Higher math anxiety related to lower mathematics performance, but no direction of causation was determined. Among college majors, elementary education majors exhibited the highest level of math anxiety, while mathematics and science majors exhibited the lowest. Ability level and IQ scores had only small correlations to math anxiety. From this study, Hembree developed a definition of math anxiety as "a learned condition more behavioral than cognitive in nature" (Hembree, 1990, p. 45). Additionally he stated, "the construct appears to comprise a general fear of contact with mathematics, including classes, homework, and tests" (p. 45).

Tobias (1978, 1980, 1991) was an early activist on behalf of students who were having difficulties with mathematics despite being intellectually competent. She has been given credit for bringing research on math anxiety to the forefront of issues in mathematics education. Much of her research is based on her work with over 600 undergraduate students in a math anxiety clinic that she established at Wesleyan University in the 1970's. She came to believe that math anxiety was a political issue that was being used to sort students into roles for future employment. In her view, women and minorities were being unfairly kept out of mainstream positions by their high levels of math anxiety. Tobias defined math anxiety as a fear of mathematics and the language of mathematics as well as the burden of negative feelings and thoughts when performing tasks related to mathematical topics. Tobias stated strong views based on personal experience. However, the results of her research are not based on any quantitative analysis using instruments or qualitative evaluations of case studies. It must be noted, though, that her description of the minimal relationship of math anxiety to intellect and ability are consistent with Hembree's (1990) findings. Thus, while it is hard to separate her analysis from her personal opinions, she has managed to convince many people that her methods may be effective at reducing math anxiety.

Miller and Mitchell (1994) also reported on their research on math anxiety among college students. Their study led them away from the description of math anxiety as an irrational fear. Students reported fears based on past negative experiences that made their performance in mathematics difficult and mathematics test taking especially hard. Students also described embarrassing moments that created a view of mathematics as a subject to be avoided. These students had fears of mathematics based on previous negative experiences that were never properly moderated. The data in this study were collected qualitatively from informal personal interviews with students in the classroom.

Perry (2004) surveyed his students during the first week of each class over several years using a set of written questions. He reported that college students' math anxiety was based on fears of failure and feelings of inadequacy. Some students experienced frustration due to only learning mathematics on a superficial level. With no deep understanding, these students relied on memorization of formulas and the hope they would pick the right formula when needed. Perry found a "pervasive mathematical illiteracy amongst college students" (p. 322). Perry's description of math anxiety, like that of Tobias (1991) and Miller and Mitchell (1994), derives from personal experience, not formal experimental studies.

Blending the definitions of math anxiety from several researchers, I have adopted the following working definition for the purpose of this study: math anxiety involves the negative feelings or behaviors associated with the learning of mathematical concepts, solving mathematical problems, or performing everyday mathematical tasks (Hembree, 1990; Richardson & Suinn, 1972; Tobias, 1991).

Definition of Self-regulated Learning

Pintrich (2000) described self-regulated learning as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment" (p. 453). Others have added that self-regulation refers to self-generated thoughts, feelings, and behaviors that are oriented to attaining goals (Boekaerts & Niemivirta, 2000; Zimmerman, 2000). Self-regulated learners are able to set their own appropriate goals, evaluate progress toward these goals, use a variety of cognitive and metacognitive strategies, and monitor and modify their choice of strategies to accomplish academic tasks and adjust to changing needs (Butler & Winne, 1995; Heikkilä & Lonka, 2006; Zimmerman, 2000). Students who are self-regulated learners tend to have high levels of academic achievement, leading them to take responsibility for their own learning (Pintrich & de Groot, 1990; Sungur & Tekkaya, 2006). They have higher academic self-efficacy, related to knowledge of their abilities to achieve their goals (Fuchs et al., 2003; Schunk, 1986; Zimmerman, 1995). In evaluating their progress toward achieving their goals, self-regulated learners attribute their success or failure to their own effort or strategies, not luck or some other uncontrollable source. These students view their performance outcomes as something that is within their own control (Hofer, Yu, & Pintrich, 1998; Schunk & Ertmer, 2000). Therefore, students who are self-regulated learners have learned to take responsibility for their own learning (Pintrich & de Groot, 1990; Sungur & Tekkaya, 2006).

Definition of Mathematics Concepts Measured in this Study

The mathematics concepts measured in this study include computation and estimation using several numeration systems. These concepts highlight some of the foundations of topics for elementary mathematics education as described in the National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (2000). For this study computation is defined by the operations of addition, subtraction, multiplication, and division. The numeration systems are defined to be the whole numbers, the integers, and the rational numbers. Furthermore, the rational numbers take the form of fractions, decimals, and percents. Computational estimation is also included in mathematics concepts. Estimation in place of exact computation or as a check on a difficult computation is called for in the *Principles and Standards for School Mathematics* (2000). "Students should evaluate problem situations to determine whether an estimate or an exact answer is needed" (NCTM, 2000, p. 36). Thus, the current definition of mathematics concepts includes computation and estimation using the operations of addition, subtraction, multiplication, and division on the sets of the whole numbers, the integers, and the rational numbers as appropriate to the elementary school curriculum.

Research Questions

This study was guided by the following research questions concerning students in a mathematics course at the first-year college level covering the topics appropriate to the elementary school mathematics curriculum:

1. Does training in self-regulated learning strategies reduce math anxiety among preservice elementary teachers?
2. Is a reduction in math anxiety associated with an increase in mathematics achievement among preservice elementary teachers?
3. Does training in self-regulated learning strategies increase mathematics achievement among preservice elementary teachers?

Statement of Purpose

The purpose of this study was to determine whether training in self-regulated learning strategies could affect the level of math anxiety of preservice teachers taking a first-year course on mathematics concepts appropriate to the elementary education curriculum. Furthermore, the study examined the association of math anxiety with mathematics achievement. This study provided training in self-regulated learning strategies, which included discussions on methods to improve participants' strategies for learning that may be useful in other current and future college courses.

Rationale for the Study

Students with high levels of math anxiety have more difficulty in understanding mathematics content and perform at a lower level of accomplishment than those students with lower levels of math anxiety (Brady & Bowd, 2005; Hembree, 1990). Due to their low comfort level with mathematics, many of these students take fewer mathematics courses in preparation for their teaching career (Meece, Wigfield, & Eccles, 1990). As elementary teachers their high level of math anxiety may lead them to spend less time preparing for their mathematics lessons and, when in the classroom, to spend less time teaching mathematics compared to other subjects (Swetman, Munday, & Windham, 1993). They may be less likely to make connections to mathematics during lessons that are not specifically focused on mathematics. For example, if in the course of reading a story, a situation arises that involves numbers in some way, a less anxious teacher might grab the opportunity to tie in a quick mathematics lesson before moving on to the next part of the story lesson. A more math anxious teacher might overlook this learning opportunity in favor of continuing the lesson at hand. More specifically, a story being read to the class might involve a group of children sharing cookies. The less math anxious teacher might choose to ask questions of the class on the various ways the cookies could be distributed among the children, while the more math anxious teacher might skip over this opportunity to link an everyday occurrence of mathematics into the flow of the lesson.

In an effort to reduce the math anxiety of preservice teachers Gresham (2007) reported success in the use of self-regulated learning. Gresham defined math anxiety as "a feeling of helplessness, tension, or panic when asked to perform mathematics operations or problems" (p. 183). In a mathematics methods course with required 12-week field experience practicum in a K-6 classroom, she found that self-regulated learning strategies such as self-monitoring and self-evaluation along with training in the use of manipulatives could reduce math anxiety.

Self-regulated learners are active participants in their own learning, are able to select from a repertoire of strategies and to monitor their progress in using these strategies toward a goal (Pape, Bel, & Yetkin, 2003). Gynnild (2008) found that academically successful students utilized self-monitoring skills, such as self-evaluation and comprehension monitoring. Less successful students used self-regulated learning strategies much less frequently.

Self-regulated learning has also been shown to improve student learning. Camahalan (2006) found that students who were taught self-regulated learning skills over a six-week period performed significantly better on a mathematics achievement test than the control group. The self-regulated learning strategies taught included self-evaluation, planning, organization, maintaining records of their work, and self-monitoring. These students met for one-hour sessions five days a week for six weeks. The first two weeks involved instruction in the strategies, while the next four weeks were dedicated to practicing and evaluating their progress in using the strategies on their mathematics lessons.

Students with improved self-regulated learning strategies may be able to overcome their math anxiety to become more successful teachers of mathematics. This study examined the use of training in self-regulated learning strategies to reduce the math anxiety of preservice teachers and to improve their mathematics content knowledge.

Summary

Preservice elementary teachers with high levels of math anxiety tend to take fewer mathematics courses, leading to lower levels of mathematics content knowledge. Furthermore, their math anxiety may make them less likely to use reform methods of teaching mathematics in their classrooms. The focus of this study was to investigate the effects of training in self-regulated learning strategies on math anxiety and mathematics achievement of preservice teachers in a first-year course in mathematical concepts.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

High levels of math anxiety may inhibit preservice elementary teachers from achieving success in mathematics classes required to prepare them for classroom teaching (Alsup, 2004). Reducing their math anxiety level should make it easier for these students to be successful in these classes and in turn to use their mathematical knowledge base to prepare for their future mathematics teaching responsibilities. Furthermore, since teachers are often responsible for the direction of their own professional development, these preservice educators will need to be more than active participants, they will need to become active directors of their own learning process. This shift is especially important for teachers in traditional K-12 classrooms because each teacher will be forced to decide how to create a classroom learning environment based on the unique combination of students, subject matter, and self-perceptions of her/his individual development as a teacher (Alsup, 2004).

This literature review will describe how self-regulated learning may be useful in reducing math anxiety and improving mathematics achievement. It is organized in four main sections. First, the framework illustrates background information and provides a reference point for this study. The second section describes how research into math anxiety reveals its effects on preservice teachers and their attitudes toward mathematics. Third, the discussion of achievement levels in mathematics explores its relationship with math anxiety.

The review concludes with a discussion of the use of self-regulated learning in providing a path toward reducing math anxiety among preservice elementary teachers.

Framework

Problem solving in mathematics is a dynamic and constructive process (De Corte et al., 2000). It requires each student to manage his or her own learning and problem-solving activities (De Corte et al., 2000). Self-regulation then becomes a critical part of effective learning and problem solving. This framework for the learning of mathematics in the classroom involves four fundamental components: "acquiring a mathematical disposition as the ultimate goal, constructive learning processes as the road to the goal, powerful teaching-learning environments as support, and assessment as a basis for control and feedback" (De Corte et al., 2000, p. 688).

The views of De Corte et al. (2000) are in agreement with the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* (1989), which state that the skills associated with self-regulated learning are fundamentally important in creating a mathematical disposition, which is a primary goal of mathematics education. In order for students to become successful learners, they must become active participants in and directors of their own learning process. These students must manage and monitor their own progress toward their self-defined goals (De Corte et al., 2000; Zimmerman, 1989). They should master and apply problem solving skills and self-regulated learning strategies in order to reach important academic goals (De Corte et al., 2000; Zimmerman, 1989).

Furthermore, self-regulated learning among preservice science teachers has been found to be promoted through teaching in a problem-based, flexible, student-centered environment (Taylor & Corrigan, 2005). This type of environment has also been shown to improve the self-confidence and content knowledge of preservice science teachers (Taylor & Corrigan, 2005). Zan (2000) found that college students who had consistently failed a required mathematics examination were able to improve their academic achievement through an intervention using self-regulated learning skills. Zan's program stressed student planning and organization skills, leading to improved self-evaluation exercises and work on problem solving.

The effect of training in self-regulated learning as a treatment for math anxiety is not well established. However, self-regulated learning has been associated with improved mathematics and science problem solving (De Corte et al., 2000; Taylor & Corrigan, 2005; Zan, 2000). Self-regulated learning has also been associated with a reduction in test anxiety (Hofer & Yu, 2003; Pintrich, 2000; Zeidner, 1998). Therefore, training in self-regulated learning strategies may be effective in reducing math anxiety among preservice teachers.

Math Anxiety

There has been some disagreement in the research literature on the definition of math anxiety (Rounds & Hendel, 1980; Wood, 1988). Some definitions emphasize physical reactions related to doing mathematics (Fennema

& Sherman, 1976; Posamentier & Stepelman, 1986); other definitions emphasize feelings of apprehension, uneasiness, and fear evidenced in mathematics-related situations (D'Ailly & Bergering, 1992; Sandman, 1980; Sovchik, Meconi, & Steiner, 1981); and yet others emphasize worry about mathematics and negative affective reactions to mathematics (Wigfield & Meece, 1988).

More recently, Gresham (2007) described math anxiety as a feeling of helplessness, tension, or panic when asked to perform mathematics operations or problems. Bursal and Paznokas (2006) and Gresham (2004) depicted math anxiety as a lack of applied understanding and an irrational dread of mathematics. The typical reaction of the math anxious student is to avoid the subject entirely. Math anxiety has also been described as a state of discomfort which occurs in response to situations involving mathematical tasks which are perceived as threatening to self-esteem, and can often create a negative attitude toward the subject (Burns, 1998; Zettle & Raines, 2000).

Due to this lack of agreement on the definition of math anxiety, numerous instruments have been created that intend to measure this construct. These instruments include the Mathematics Anxiety Rating Scale (MARS) by Richardson and Suinn (1972), which has several variants, the Mathematics Anxiety Scale (MAS) by Fennema and Sherman (1976), the Anxiety Toward Mathematics Scale (ATMS) by Sandman (1979), and the Mathematics Anxiety Questionnaire (MAQ) by Wigfield and Meece (1988). The MARS assesses mathematics evaluation anxiety and numerical anxiety (Alexander & Martray, 1989; Hopko, 2003; Plake & Parker, 1982; Rounds & Hendel, 1980). The MAS and the MAQ assess negative affect, while the MAQ also assesses the dimension of worry (Kazelskis et al., 2000). The ATMS assesses general uneasiness in mathematics situations (Dew et al., 1983; Dew, Galassi, & Galassi, 1984; Wilhelm & Brooks, 1980).

In addition, there is some overlap between the instruments that measure math anxiety and test anxiety, due in part to the fact that many early studies of math anxiety were based on studies of test anxiety (Kazelskis et al., 2000). The MARS, the MAQ, and the MAS all contain a substantial (at least 20%) number of items exploring mathematics test anxiety. It has even been suggested that math anxiety is a form of test anxiety (Richardson & Woolfolk, 1980). However, this viewpoint may be due to the manner in which the MARS (Richardson & Suinn, 1972) was created. It was originally based on numerous items found in the Suinn Test Anxiety Behavior Scale (STABS) (Suinn, 1969), modified to refer more specifically to mathematics test anxiety issues. Similarly, the MAQ (Wigfield & Meece, 1988) was constructed to include items measuring Worry and Emotionality, reflecting these two components of the Test Anxiety Inventory (TAI) (Spielberger, 1977), on which it was based. As Kazelskis (2000) states, "Mathematics anxiety needs to be established as unique and separate from test anxiety. ... What is needed is a multidimensional definition of mathematics anxiety from which adequate measurement of the construct can begin" (p. 140).

To investigate math anxiety, early studies performed by Richardson and Suinn (1972) using their 98-item Mathematics Anxiety Rating Scale measured the math anxiety of undergraduate college students. The MARS, along with its shortened and revised versions, has become the most commonly used evaluation instrument for identifying math anxiety (Kazelskis, 1998). In relation to other areas of mathematics studies, MARS scores have revealed a negative correlation with scores on tests of mathematics skills (Dew et al., 1984; Richardson & Suinn, 1972). Two subscales of the MARS have been identified through analysis; Mathematics Evaluation (or Test) Anxiety and Numerical Anxiety (Hopko, 2003; Kazelskis, 1998; Plake & Parker, 1982; Rounds & Hendel, 1980). The Numerical Anxiety subscale of the MARS reflects everyday situations requiring some form of numerical manipulation (Zettle & Raines, 2000). This dimension of math anxiety applies to practical, everyday situations that require the use of numbers in calculations (Bessant, 1995; Rounds & Hendel, 1980), such as monetary decisions like balancing a checkbook or calculating a tip. The Mathematics Evaluation Anxiety subscale relates to evaluative apprehension about mathematics testing and related activities (Zettle & Raines, 2000). Beyond test taking and test preparation, this factor also deals with course-related activities such as homework and the use of the textbook (Bessant, 1995; Rounds & Hendel, 1980).

Further analysis of math anxiety was undertaken by Alexander and Martray (1989). They created a revised version of the Mathematics Anxiety Rating Scale (RMARS). They used factor analysis to obtain a 25-item scale that retained the original dimensions of Mathematics Evaluation Anxiety and Numerical Anxiety while separating the dimension of Mathematics Course Anxiety (Alexander & Martray, 1989; Baloglu, 2002; Kazelskis, 1998) also referred to as Classroom Performance Anxiety (Satake & Amato, 1995). Mathematics Course Anxiety included items pertaining to buying a mathematics textbook or watching a teacher explain an equation on the board. Additionally, Alexander and Martray (1989) found that math anxiety, as measured by RMARS scores, was related to mother's education level, father's occupation, and student's attitude toward mathematics.

An investigation by Plake and Parker (1982) also attempted to define math anxiety. In a manner similar to Alexander's and Martray's (1989) development of the RMARS, Plake and Parker (1982) developed the Mathematics Anxiety Rating Scale-Revised (MARS-R). The MARS-R "was developed to provide a more efficient index of statistics or mathematics course-related anxiety" (Plake & Parker, 1982, p. 551). This 24-item scale was developed from a factor analysis of the original MARS and also features two dimensions. The two subscales identified by Plake and Parker (1982) are Learning Mathematics Anxiety (LMA) and Mathematics Evaluation Anxiety (MEA) (Hopko, 2003; Malinsky, Ross, & Pannells, 2006). The LMA items related to the process of studying statistics or mathematics. They involved class-related activities, such as watching a teacher work an equation or signing up for a mathematics class, as well as activities related to studying statistics or mathematics, such as looking through the pages of a mathematics book (Plake & Parker, 1982). The MEA items relate to the evaluation or testing of statistics or mathematics learning. These items are concerned with preparing for a mathematics test or actually taking a mathematics test (Plake & Parker, 1982). The MARS-R has found common usage in the research literature for identifying people with high levels of math anxiety (Hopko, 2003).

Hopko (2003) based his own version of the MARS, the AMAS, on a factor analysis of the MARS-R. He started with the two subscales identified by Plake and Parker (1982) in the MARS-R, Learning Mathematics Anxiety (LMA) and Mathematics Evaluation Anxiety (MEA). From there he used factor analysis to create a 9-item revised model that he called the Abbreviated Mathematics Anxiety Scale (AMAS). This final form of the AMAS reflects Hopko's preference for items that evaluate the active mathematical calculation and performance process or address anticipatory anxiety (Hopko, Mahadevan, Bare, & Hunt, 2003). Hopko's intensive analysis of the AMAS offers strong evidence for its reliability and validity (Hopko et al., 2003). He concluded that this new measure "may be an externally valid, more parsimonious, and superior measure of math anxiety as compared with the original instrument (MARS-R)" (Hopko et al., 2003, p. 181).

The 12-item Mathematics Anxiety Scale (MAS) is one of nine scales designed by Fennema and Sherman (1976) to measure attitudes they saw as important to the learning of mathematics (Kazelskis, 1998). The MAS is intended to assess "feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics" (Fennema & Sherman, 1976, p. 4). It has become the second-most-widely-used instrument for measuring math anxiety after the MARS and its variants (Kazelskis, 1998). MAS scores were found to be related to the number of years of high school mathematics completed

(Betz, 1978). MAS scores have also been related to confidence in learning mathematics and to mathematics achievement (Dwinell & Higbee, 1991). Through factor analysis, Kazelskis (2002) identified two main factors: Negative Affect Towards Mathematics and Positive Affect Towards Mathematics. Consistent with the intentions of Fennema and Sherman (1976) the items of the negative affect factor indicated feelings of discomfort, uneasiness, and confusion when dealing with mathematics. Positive Affect Towards Mathematics may not have been intended by the authors to be a separate factor, however Kazelskis (2002) found that several items reflected a sense of ease, a lack of discomfort, and the absence of fear when dealing with mathematics. Although the negative affect factor is similar to dimensions found in the mathematics literature, the positive affect factor appears to be unique to the Kazelskis' (2002) factorial analysis. It is interesting to note that while the MAS was written for high school students, many researchers found no difficulty in using the original MAS with college students (Dew et al., 1983; Dew et al., 1984; Kazelskis, 1998; Kazelskis et al., 2000; Kazelskis & Reeves, 2002). Betz (1978), however, believed that the items were not appropriate for post-secondary students and rewrote ten of the items for use in her study of math anxiety among college students.

The Anxiety Toward Mathematics Scale (ATMS) (Sandman, 1979) is a subscale of Sandman's Mathematics Attitude Inventory. It has been mentioned sparsely in the research literature. In my search of the literature I was only able to identify three studies that used the ATMS (Dew et al., 1983; Dew et al., 1984; Wilhelm & Brooks, 1980). The ATMS is made up of only six items. This brevity makes the scale efficient, but there are questions regarding its reliability and validity (Dew et al., 1983; Resnick & Schmid, 1994). A review in the Buros Institute's Mental Measurements Yearbook described the entire Mathematics Attitude Inventory as "seriously deficient" (Resnick & Schmid, 1994, p. 664). The review further states that the ATMS is inferior to other readily available instruments such as the Mathematics Anxiety Rating Scale and the Mathematics Anxiety Scale (Resnick & Schmid, 1994). The lack of reliability and validity data may explain, at least in part, why the ATMS has not seen greater use.

The Math Anxiety Questionnaire (MAQ) was initially constructed by Meece (1981) to assess the worry and emotionality components of mathematics anxiety. Wigfield and Meece (1988) revised the instrument to include 11 items with 7-point Likert-type scales. These items were chosen for their "focus on negative affective reactions to doing math activities in school and on students' concerns about their performance in mathematics" (Wigfield & Meece, 1988, p. 211). In published studies the MAQ has seen moderate use (Kazelskis, 1998; Kazelskis & Reeves-Kazelskis, 1999; Wigfield & Meece, 1988; Williams, 1994). Consistent with Bessant's (1995) comments on math anxiety as having factors of worry and emotionality, confirmatory factor analysis of the items of the MAQ supported the two factors of Worry and Negative Affective Reactions (Kazelskis, 1998; Wigfield & Meece, 1988; Williams, 1994). Wigfield and Meece (1988) reported significant correlations between MAQ scores and measures of mathematics ability perceptions, mathematics task demands, mathematics interest, and mathematics performance.

The many interpretations of the definition of math anxiety are reflected in the variety and modifications of these math anxiety instruments. The 98-item MARS scale was reduced to 24 items (MARS-R), and then down to nine items (AMAS) to make it easier to administer. While math anxiety was originally seen as mostly a variation on test anxiety, more recently many researchers have viewed it as bi-dimensional. Typically the dimensions include a form of mathematics evaluation anxiety combined with some form of numerical anxiety or learning mathematics anxiety.

Math Anxiety among Preservice Elementary Teachers

Many studies have reported high levels of math anxiety among preservice elementary teachers. Hembree (1990) analyzed 151 studies of math anxiety to determine relationships and common effects. Over 80% of these studies involved college level students. Using meta-analysis, Hembree concluded that elementary education majors displayed the highest level of math anxiety of any college major. Furthermore, students in mathematics for elementary education courses had the highest levels of math anxiety among students in all the college mathematics courses studied. In addition, highly math-anxious students were less inclined to take additional mathematics courses. Hembree determined that these preservice teachers were ill prepared to lead their students due to weak mathematical backgrounds and negative views toward mathematics.

Several treatment studies showed higher levels of math anxiety for preservice elementary teachers. The effects of treatments that attempted to reduce math anxiety will be discussed in the following sections.

In an experimental study using treatment and control groups, pre and post testing, and randomly assigned matched pairs, Wadlington, Austin, and Bitner (1992) used desensitization to reduce math anxiety in students taking a mathematics methods course. The researchers worked with 78 preservice elementary teachers. The focus of the research was on the treatment of math anxiety and negative math self-concept through the use of systematic desensitization techniques such as relaxation and imagination of low math anxious situations. The research showed that the students in the treatment group reported significantly lower scores ($p < .01$) on the Mathematics Anxiety Rating Scale (MARS) than the control group. However, the authors also found that the mean score reported by these preservice elementary teachers on the MARS was much higher than that of MARS norm groups (based on general college students) as stated by Suinn (1972). The results of this study show that systematic desensitization can reduce math anxiety among preservice elementary teachers.

In another study, Alsup (2004) evaluated 61 students in three sections of a mathematics concepts course for elementary teachers that he taught. The focus of this study was to compare constructivist and traditional teaching styles in mathematics content courses required as a prerequisite for the mathematics methods course. Alsup's math anxiety evaluation used the Abbreviated Mathematics Anxiety Rating Scale (AMARS) developed by Alexander and Martray (1989). Alsup found a pretest mean of 61 and determined that this qualified his participants as having a high level of math anxiety, as defined by scores at least one standard deviation above the mean reported for norm groups by Alexander and Martray (1989). The high math anxiety scores of these preservice elementary teachers were consistent with the high levels found in other studies (Hembree, 1990; Wadlington et al., 1992). The treatment courses implemented active learning and student involvement using small groups in a problem-solving curriculum. The control course was taught using standard lecture mode. The results of the study showed a significant reduction ($p < .05$) in math anxiety among the treatment group. However, there was no significant difference in math anxiety between the treatment and control groups. This study reveals an apparent teacher-effect, in that this professor was able to reduce the math anxiety of all of his students no matter what teaching method he implemented.

The following studies show some additional comparative data on the higher math anxiety levels of preservice teachers as compared to other college students. The students with a non-math/science orientation, typical of preservice elementary teachers, showed increased math anxiety when compared to students with a math/science orientation.

Malinsky (2006) evaluated the math anxiety levels of 481 university students, including education and non-education majors. The study used the Mathematics Anxiety Rating Scale Revised (MARS-R), developed by Plake and Parker (1982), to measure math anxiety. The study found a significant difference ($p < .05$) in math anxiety between two groups of preservice upper elementary teachers. Preservice teachers of upper elementary level mathematics or science had the lowest levels of math anxiety, while the future upper elementary language arts or social studies teachers had the highest levels. This is consistent with a study by Bulmahn (1982) which found that preservice elementary teachers who favored mathematics and science had significantly lower ($p < .05$) math anxiety than those who favored language arts and social studies. By comparison, Malinsky found that non-science majors taking a required physical science laboratory course had math anxiety levels in the middle, approximately at the mean norm level reported by Plake and Parker (1982).

In their analysis of the MARS scores of 238 elementary education students at a Canadian university, Brady and Bowd (2005) found a significant negative correlation ($r = -.28$) of MARS score to highest level of formal mathematics instruction completed, a positive correlation ($r = .52$) of MARS score to mathematics as the least liked subject, and a negative correlation ($r = -.46$) of MARS score to confidence to teach mathematics. The authors suggested that high levels of math anxiety could lead preservice teachers to complete insufficient mathematics course work (only one-third of participants had completed mathematics through grade 12), which in turn could lead to reduced confidence in teaching mathematics. This cannot be stated as a causal relationship, but is consistent with other studies which show that students with high levels of math anxiety take fewer college mathematics courses (Hembree, 1990; Ma, 1999; Zopp, 2000).

Overall, these studies show that many preservice elementary teachers have high levels of math anxiety. If their math anxiety leads them to take fewer mathematics courses in college, it may lead to weakness in their mathematics preparation for teaching.

Math Anxiety and Attitude about Mathematics

Aiken (1970) described attitude as "a learned predisposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept, or another person" (p. 551). McLeod (1992) added that this positive or negative response can be of moderate intensity and reasonable stability. Neale (1969) defined attitude toward mathematics as an aggregated measure of "a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (p.632). Ma and Kishor (1997) extended Neale's definition of attitude toward mathematics to include students' affective responses to the easy or difficult, as well as the importance or unimportance of mathematics.

Several studies have looked at students' attitudes and feelings about the study of mathematics. While these attitudes may change, by the time they get to the college level many students have developed a negative attitude toward the study of mathematics (Walmsley, 2000). This negative attitude has been associated with high levels of math anxiety, especially among preservice elementary teachers (Alkhateeb & Taha, 2002; Teague & Austin-Martin, 1981).

A study of college students by Bessant (1995) suggested that favorable attitudes toward mathematics might be associated with lower math anxiety. However, negative attitudes toward mathematics learning can be tied directly to increased math anxiety (Bessant, 1995). Bessant measured these negative attitudes in a study of the attitudes and math anxiety of 173 Canadian university students in a variety of mathematics classes. The participants responded to a 35-item, Likert-format, mathematics attitude scale as well as the MARS. The MARS scores correlated negatively to attitude results for the student-reported scales Enjoyment of Mathematics (r = -.52) and Scientific Value of Mathematics (r = -.21). This low level of enjoyment may be part of a socially acceptable dislike of mathematics. Further, students who do not develop an understanding of the usefulness of mathematics may be more likely to avoid it at every opportunity.

In a study mentioned previously, Brady and Bowd (2005) had the preservice elementary teachers respond to the MARS and a survey questionnaire. The results showed a positive relationship between the math anxiety level of the students and mathematics as the least-liked school subject. In a complementary finding, enjoyment of mathematics at the elementary level was negatively related to MARS score, as was enjoyment of mathematics at the secondary level. While these survey results are based on responses to questionnaire items, the results present a portrait of many preservice elementary teachers' negative attitudes toward mathematics, a subject they will be expected to teach upon graduation from college.

Philippou and Christou (1998) studied preservice teachers in Cyprus during a three-year program to teach mathematics concepts and methodology. The results of this study were twofold. The data revealed that (a) prospective teachers bring misconceptions and negative attitudes towards mathematics to teacher education programs, and (b) mathematics preparatory programs can provide an opportunity to influence mathematics attitudes in a positive way. As a result of this intervention, however, the preservice teachers had only slightly improved levels of math anxiety. The researchers stated that this may have been due to attitudes developed over their entire school life and in many cases may have been the outcome of established prejudices of the social environment (Philippou & Christou, 1998).

Students' negative attitudes toward the learning of mathematics have been tied to math anxiety by many researchers (Bessant, 1995). These results offer a picture of many preservice elementary teachers with negative attitudes toward mathematics being forced to prepare to teach mathematics to elementary students, who need highly effective mathematics teachers (Brady & Bowd, 2005). It is hoped that these future teachers can be made aware of methods to reduce their math anxiety. Training them in self-regulated learning strategies may help to reduce their math anxiety and prevent the transmission of their negative attitudes to their future students.

Mathematics Achievement

Students with high levels of math anxiety have shown weaker mathematics performance results than students with lower levels of math anxiety (Cox, 2002; Hembree, 1988). Students have also shown better achievement results when they incorporate self-regulation techniques into their learning practices (De Corte et al., 2000; Talbot, 1992). These factors play a role in influencing student achievement in mathematics. In this section I will discuss the mathematics achievement of preservice elementary teachers and the use of self-regulated learning strategies to improve mathematics achievement.

Mathematics Achievement among Preservice Elementary Teachers

Preservice elementary teachers often begin their college studies with a weak conceptual understanding of the topics of elementary school mathematics (Peck & Connell, 1991). This weakness may lead to lower achievement among their own students, especially in the lower elementary grades (Hill et al., 2005). Evidence of his deficiency has been documented by Ball (1990) and Ma (1999). More recently the No Child Left Behind Act requirement of "highly qualified teachers" has revealed more evidence of this lack of essential knowledge for teaching mathematics among many practicing elementary teachers (Hill et al., 2005).

The 252 preservice teachers that Ball studied in 1990 gave a picture of students whose mathematics understandings were "rule-bound and thin" (p. 449). Their performance revealed a capacity to solve standard problems presented in the usual manner, on which they could apply their knowledge of a standard algorithm. They had difficulty, however, in explaining the underlying mathematical principles. For an exercise on dividing fractions, most of these students could not identify the correct story problem, out of a list of four choices that represented the given arithmetic operation. In 2005, Hill, Rowan, and Ball wrote that "teachers of mathematics not only need to calculate correctly, but also need to know how to use pictures or diagrams to represent mathematics concepts and procedures to students, provide students with explanations for common rules and mathematical procedures, and analyze students' solutions and explanations" (p. 372). If teachers are uncomfortable with these concepts and procedures, then they will find it difficult to excite and encourage their students.

A research study on teaching style by Clute (1984) found that students with high levels of math anxiety had the lowest achievement scores among college students in a college mathematics survey course. Also, the students with low levels of math anxiety had the highest achievement scores. She also found that students with low math anxiety benefited most from the discovery learning style. The students with high math anxiety preferred the more tightly organized lecture style classes.

Preservice teachers in a mathematics methods class that emphasized the use of manipulatives in learning mathematics improved their performance and also reduced their math anxiety in Vinson's (2001) research study. Finally, a Malaysian study revealed a low (r = -.32) but significant ($p < 0.05$) negative correlation between mathematics anxiety and achievement among first-year university students. These studies provide ample evidence that to improve mathematics achievement we need to also reduce math anxiety.

Mathematics Achievement and Self-regulated Learning

In this section I will discuss several self-regulated strategies that have been shown to improve mathematics achievement. Included in the strategies are personal time management, organization, reading of the mathematics textbook, as well as test taking and preparation.

Jones and Byrnes (2006) have defined self-regulation as "how much the student monitors his or her performance, allocates/plans time effectively, is strategic, is organized, and is emotionally regulated, and avoids being sidetracked by distractions" (p. 335). To investigate self-regulated learning Bembenutty and Zimmerman (2003) created a scale that looked at aspects of self-regulation such as how well students kept records, set goals, selected strategies, controlled their environment, monitored their own actions, rewarded themselves, and used estimation. Several authors agree that students must manage and monitor their own progress toward their self-defined goals (De Corte et al., 2000; Zimmerman, 1989). They should master and apply problem solving skills and self-regulated learning strategies in order to reach important academic goals (Zimmerman, 1989).

De Corte, Verschaffel, and Op't Eynde (2000) presented the view that mathematics itself is an active and constructive process, which implies that learning mathematics requires learners to assume control over their own learning and problem-solving activities. They further state that self-regulation constitutes a feature of effective learning and problem solving. In the authors' view, self-regulation, in addition to metacognitive processes, also encompasses motivational and emotional as well as behavioral monitoring and control processes. They elaborate their position by situating self-regulation in a theoretical framework of learning mathematics from instruction with "acquiring a mathematical disposition as the ultimate goal" (De Corte et al., 2000, p. 685).

The National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* (1989) takes a similar view that the skills associated with self-regulated learning are fundamentally important in creating a mathematical disposition, which is a primary goal of mathematics education. In order for students to become successful learners they must become participants in the learning process.

Personal time management is one of the most important strategies for students to use to follow through on their proximal and long-term goals (Pintrich, 2000; Schunk & Ertmer, 2000; VanderStoep & Pintrich, 2003). Successful college students have been found to schedule their activities and study time more effectively than their less successful peers, especially in the first semesters out of high school (Light, 2001). Students who developed better time management skills early in their college careers showed higher achievement (Hofer & Yu, 2003; Zimmerman, Greenberg, & Weinstein, 1994). Schmitz (2006) evaluated a training program that included time management, including long term and short term planning and the avoidance of procrastination. The result was a significant improvement in students' time management skills and overall achievement.

Self-regulated learning of mathematics requires using effective strategies to organize and process information (Schunk & Ertmer, 2000). Students' increased use of organizational strategies has been shown to lead to improved learning outcomes (Zusho, Pintrich, & Coppola, 2003). Zimmerman (2001) found that high achieving students were more likely to use a rearrangement of instructional materials to improve their learning. Kiewra's (2002) students found success using a variation of outlining referred to as matrix notes. A study by Hofer, Yu, and Pintrich (1998) described the successful use of network sketching and mapping to identify key ideas. This method was recommended for deeper understanding of the material compared to rehearsal strategies. Students also need to create a positive study environment to allow them to read and comprehend their textbook and analyze their notes more effectively (Schunk & Ertmer, 2000; VanderStoep & Pintrich, 2003).

Many students have difficulty reading their mathematics textbook. VanderStoep and Pintrich (2003) reported good results when students established a goal of comprehension, which requires active reading. Students should ask themselves questions as they read to check on understanding of the material and to write a summary as they finish each section. Hofer, Yu, and Pintrich (1998) found skimming and doing a task analysis of the material was also effective for comprehension. They also recommend moderating the pace of the reading to fit the difficulty of the material and rereading as necessary for understanding.

Self-regulated learners monitor their performance outcomes on tests, quizzes, and homework to evaluate their progress (Pape & Smith, 2002). They use the results to attribute success or failure to effort or strategy use, rather than innate ability, leading them to modify strategies where appropriate. They get satisfaction from achieving success through their own efforts (Schunk & Ertmer, 2000). Test-taking strategy workshops that teach quantitative test-taking strategies have produced successful outcomes (Williams, 1994). VanderStoep and Pintrich (2003) recommended that students plan their time and stick to a schedule to prepare for the test. They suggested that students allocate the available time according to the value of the test questions. They further recommended the approach of always doing the easiest questions first. These strategies were designed to help students regulate their behavior during the test.

Summary

Various interpretations of the definition of math anxiety have led to a multiplicity of instruments to measure the construct. The MARS (Richardson & Suinn, 1972), and MARS-based scales have gained wide acceptance. These instruments favor the two-dimension view of math anxiety including Mathematics Evaluation Anxiety and Learning Mathematics Anxiety. The Fennema-Sherman (1976) Mathematics Anxiety Scale is also popular. This scale is designed to measure negative affect toward mathematics. Other available instruments measure negative affect, positive affect, worry, and general uneasiness in mathematics situations. The current study used the AMAS (Hopko, 2003) to measure the math anxiety of preservice elementary teachers.

Preservice elementary teachers have been identified as having especially high levels of math anxiety (Alsup, 2004; Hembree, 1990; Wadlington et al., 1992). This leads them to take fewer mathematics courses, leaving them poorly prepared to teach the mathematics that will be required when they enter the classroom (Brady & Bowd, 2005). They bring with them a certain attitude toward mathematics. This attitude may reveal their liking or disliking of mathematics, tendencies toward participation in mathematics activities, and their views of mathematics as easy or difficult, important or unimportant. Self-efficacy beliefs inform their performance and influence their choice of activities (Cooper & Robinson, 1991; Finney & Schraw, 2003). Teachers' efficacy beliefs are directly linked to and influence effort in the pursuit of goals - and persistence in the face of adversity (Bursal & Paznokas, 2006; Pajares, 2005).

Mathematics achievement is central to a teacher's role as director of learning activities in the classroom. Math anxiety may reduce students' performance results. The quality teacher will attempt to develop students' intrinsic motivation, so that they become involved in academic tasks for their enjoyment. This goal can be achieved through a focus on learning goals such as understanding and mastery of mathematical concepts. The teacher will build on students' competence and work with their curiosity. The goal is to develop a mastery orientation among the students.

Research has indicated that many preservice elementary teachers lack a deep conceptual understanding of mathematics (Ball et al., 2001). This understanding is fundamental to effective teaching in the elementary classroom (Stevens & Wenner, 1996). Improving the self-regulated learning skills of these students could reduce their math anxiety and result in them taking more mathematics courses and being more successful in the courses that they take (Hembree, 1990). For the current study, training in self-regulated learning strategies included personal time management, how to read your mathematics textbook for understanding, organizational skills, preparation for mathematics tests, and the use of estimation in solving problems. Preservice elementary teachers with these improved learning skills may in turn become more successful teachers of mathematics.

CHAPTER 3

METHODOLOGY

Research Design

The purpose of this study was to determine if training in self-regulated learning strategies would reduce the level of math anxiety and improve the achievement level of preservice teachers taking a first-year course on mathematics concepts appropriate to the elementary curriculum. The research questions that this study sought to answer, in relation to topics appropriate to the elementary school level, include, first, does training in self-regulated learning strategies affect math anxiety among preservice teachers in a first-year mathematics course? Second, does any reduction in math anxiety correspond to an increase in achievement among preservice teachers in a first-year mathematics course? Third, does training in self-regulated learning strategies correspond to an increase in achievement among preservice teachers in a first-year mathematics course?

A quasi-experimental non-equivalent control group design (Campbell & Stanley, 1966) was used. The treatment group was made up of those students who agreed to participate in the training in two sections of a mathematics concepts course. The control group included those students who agreed to participate from a different section of the mathematics concepts course. Students could not be randomly assigned to treatment or control groups, as these were intact groups already assigned to class sections. Both groups were given pretests. The treatment group received the training in self-regulated learning strategies, while the control group received no treatment. Both groups were given posttests. The non-equivalent control group design offered control of most threats to internal and external validity, including the main effects of history, maturation, testing, and instrumentation (Campbell & Stanley, 1966). Since this was a quantitative design, qualitative data sources were not as salient.

I conducted 20-minute training sessions on three separate occasions over a five-week period in the regular classroom. This involved handouts on the self-regulated learning strategies as they were discussed. I also encouraged students to ask questions and to talk to their classmates about the strategies. The treatments were designed to provide training in the following areas: personal time management, organization, reading of the mathematics textbook, test taking and preparation, as well as the use of estimation in mathematics. In the literature review, I gave some background information on the importance of these self-regulated learning strategies. I will describe in more detail the implementation of the strategies later in this chapter. Students continued to receive standard classroom instruction from the university professor at all times, whether they were participating in the treatment or not. I did not participate in any of the classroom instruction. The professor did not participate in any of the treatments.

To minimize any possible influence of variation in pedagogical styles the same professor taught all sections of this course. By using a single professor, course structure variables such as the text, content, grading, and test formats were held constant. For additional control over course content, all students took the same departmental examinations.

Approval of the Research Project and Informed Consent

The Temple University Institutional Review Board (IRB) reviewed the research plan before implementation of the study. The IRB approved the request for human subject research. Approval was also obtained from the instructor.

Informed consent to participate in the study was obtained from each participant before implementation of the research study. The informed consent form (see Appendix A) provided the participants with an explanation of the nature of the research, full disclosure of any risks associated with the research, and information regarding their right to terminate their participation in the study at any time with no penalty. All participants completed and returned consent forms before the initiation of the study.

Participants

Participants were students at an urban university in the Northeastern United States enrolled in three sections of a freshman level mathematics concepts course during the spring semester of 2008. Two sections were designated for the treatment in self-regulated learning strategies. Of the 60 students in these two sections, 15 students were education majors who completed the pretest and the posttest. These 15 served as the treatment group for the purposes of this analysis. The third section received no treatment. Of the 32 students in this group, 14 were education majors who completed the pretest and the posttest. This group was designated as the control group. Random assignment to classes was not possible as these were intact groups already registered for their specific class section.

Table 3.1 shows the breakdown of treatment and control groups by age. The majority of the students in both groups were between 18 and 20 years of age. The mean age for the treatment group was 21.5 years, due to the inclusion of several older students, while the mean age for the control group was somewhat younger, 19.4 years.

Table 3.1. Participant Age for Treatment and Control Groups

Age	Treatment		Control	
	Frequency	Percent	Frequency	Percent
18	1	6.7	3	21.4
19	7	46.7	7	50.0
20	1	6.7	2	14.3
21	2	13.3	1	7.1
22	1	6.7		
23			1	7.1
27	1	6.7		
29	1	6.7		
31	1	6.7		
Total	15		14	

Table 3.2 displays the breakdown of the groups by sex. Over 85 percent of the participants in each group were female. This is common among elementary education majors, the majority of whom are female (Lackland, 1997; Payne & Manning, 1990).

Table 3.2. Participant Sex for Treatment and Control Groups

Sex	Treatment		Control	
	Frequency	Percent	Frequency	Percent
Male	2	13.3	2	14.3
Female	13	86.7	12	85.7
Total	15		14	

Table 3.3 shows the ethnicity of the treatment and control groups. While the majority of the students in each group were Caucasian, there were several African American students in each group. Altogether, these data demonstrate that the treatment and control groups have fairly similar characteristics by age, sex, and ethnicity.

Table 3.3. Participant Ethnicity for Treatment and Control Groups

Ethnicity	Treatment		Control	
	Frequency	Percent	Frequency	Percent
Caucasian	10	66.7	12	85.7
African-American	4	26.7	2	14.3
Other	1	6.7		
Total	15		14	

Instrumentation

Data were collected using the following instruments: (1) The Abbreviated Mathematics Anxiety Scale (AMAS), (2) the Motivated Strategies for Learning Questionnaire (MSLQ), and (3) a mathematics achievement test. To determine the effectiveness of training in self-regulated learning strategies on reducing participants' math anxiety and improving participants' achievement, the posttest scores of these measures were statistically analyzed for differences between the treatment and control groups.

The Abbreviated Mathematics Anxiety Scale

This research study used The Abbreviated Mathematics Anxiety Scale (AMAS), Hopko's 9-item revision of the Mathematics Anxiety Rating Scale - Revised (MARS-R), as its math anxiety evaluation instrument (see Appendix B).

Approval to use the instrument was obtained from Dr. Hopko (see Appendix C). The MARS-R (Plake & Parker, 1982) was designed to measure the math anxiety of undergraduate college students. Its 24 Likert type items measure levels of math anxiety with rating levels from (1) "Not At All" to (5) "Very Much." Each item describes a situation intended to provoke anxiety. For example, "Thinking about an upcoming mathematics test the day before you take it." The responses are converted to numerical values by assigning the weights of 1, 2, 3, 4, or 5 to each of the possible responses. The total score for the instrument is the sum of these item scores. Thus, the total AMAS scores can range from a minimum of 9 to a maximum of 45. Higher MARS-R scores are related to higher levels of math anxiety. Plake and Martray (1982) report that the MARS-R has a coefficient alpha reliability of .98 and is correlated .97 with the original Richardson and Suinn (1972) 98-item, full scale, Mathematics Anxiety Rating Scale on which it is based.

Hopko (2003) performed a confirmatory factor analysis on the AMAS using a large sample of 815 undergraduates. From this analysis he created a 12-item revised model with improved goodness-of-fit indexes. Basing his study on the two subscales identified by Plake and Parker (1982) in the MARS-R, Learning Mathematics Anxiety (LMA) and Mathematics Evaluation Anxiety (MEA), the AMAS produced reliability coefficients of .87 (LMA) and .95 (MEA). Each of the revised subscales reduced by more than half the number of items found in the MARS-R, yet the AMAS strongly correlated to the MARS-R with LMA values of $r = .98$, $p < .001$ and MEA values of $r = .95$, $p < .001$. The total scores from the AMAS and from the MARS-R also correlated strongly ($r = .97$, p

< .001). The nine items selected for the final revision were also construed to have greater face validity with respect to math anxiety than the items that were removed (Hopko, 2003). That is, Hopko stated that the remaining nine items refer more directly to feelings of anxiety as they relate to mathematics.

The Mathematics Anxiety Rating Scale (MARS), the basis for the AMAS, was created by Richardson and Suinn (1972) to measure the math anxiety of undergraduate college students. In evaluating the instrument, they found that the changes in MARS scores reflected the expected reductions in math anxiety resulting from behavior therapy treatment on 397 participants. This result reflected the authors' belief that math anxiety should respond to such therapy. The MARS scores also showed a negative correlation with the scores on a test of mathematics skills. This instrument has gained widespread use and is generally accepted as effective in distinguishing levels of math anxiety (Brush, 1981; Dew et al., 1983; Plake & Parker, 1982).

Analysis of the AMAS pretest data for all participants in this study ($n = 29$) produced a Cronbach's alpha of .90. The posttest data resulted in a value of .87. These values are consistent with Hopko's (2003) results.

The Motivated Strategies for Learning Questionnaire

Several subscales derived from the Motivated Strategies for Learning Questionnaire (MSLQ) were used in this study to evaluate participants' use of self-regulated learning strategies (see Appendix D). Approval to use the instrument was obtained from the University of Michigan Combined Program in Education & Psychology (CPEP) (see Appendix E). The MSLQ (Duncan &

McKeachie, 2005; Pintrich, Smith, Garcia, & McKeachie, 1991) is intended to assess college students' motivational orientations and their use of different learning strategies in a college course. The motivation section of the MSLQ is made up of 31 items that inquire about students' goals and their value beliefs related to the course. The learning strategies section is made up of 31 items dealing with students' use of cognitive and metacognitive strategies. An additional section of 19 items assesses how the student manages a variety of resources. The items are scored on a Likert scale with a range from (1) "Not at All True of Me" to (5) "Very True of Me."

For this study I selected 21 items from the 81-item MSLQ. All five items on test anxiety were chosen from the Test Anxiety subscale of the 31-item Motivation Section of the MSLQ. An example item would be, "When I take tests I think of the consequences of failing"(Pintrich, Smith, Garcia, & McKeachie, 1991, p. 15). These items were used to evaluate students' test preparation and test taking skills. The 31-item Learning Strategies Section of the MSLQ was the source of the additional 16 items. All four items were chosen from the Organization subscale to assess organization skills, such as, "I make simple charts, diagrams, or tables to help me organize course material"(Pintrich et al., 1991, p. 21). These items were chosen to evaluate how well students select appropriate information to study and make connections to this information. Seven items that assessed effective reading were chosen from the 12-item Metacognition subscale, for example, "When reading for this course, I make up questions to help focus my reading"(Pintrich et al., 1991, p. 23). These items were chosen to evaluate how well students used planning, monitoring, and self-testing of their reading. Five items that assessed time management were chosen from the 8-item Time and Study Environment subscale, including, "I make good use of my study time for this course"(Pintrich et al., 1991, p. 25). These items were chosen to evaluate how well students used planning, scheduling, and managing of their study time. Altogether, these 21 items reported on students' reading, organization, and time management skills, as well as provided information on their test anxiety.

Pintrich et al. (1991) report a scale reliability of .93 for the total MSLQ and a correlation with course final grade of .41. They report an alpha value of .80 for the Test Anxiety subscale and an alpha value of .64 on the Organization subscale, the two subscales that were included in their entirety in the current study. Sungur (2006) reported reasonable reliability coefficients and internal consistency. An item-level confirmatory factor analysis performed by Muis (2007) resulted in a moderate fit. Other researchers have reported results that support the psychometric quality of the MSLQ (Pintrich, Smith, & Garcia, 1993; Wolters & Yu, 1996; Wolters & Pintrich, 1998).

Analysis of the MSLQ pretest data for all participants in this study ($n = 29$) produced a Cronbach's alpha of .63. Item-total correlation analysis was used to identify items that might improve the Cronbach's alpha value of the instrument if that item were removed. This analysis determines the Pearsonian correlation of an item's score with the total of scores on all other items. A low item-total correlation means the item is little correlated with the overall scale and can be removed from the scale. The results of item-total correlation analysis on the MSLQ suggested dropping items 2, 9, and 14 from the analysis of the pretest data. The revised alpha of the remaining 18 items was a more acceptable .71. Initial analysis of the posttest data resulted in alpha = .73. After dropping the same items as in the pretest analysis, the revised alpha was a still-acceptable .72. Since the entire 81-item MSLQ was not used in this study, no comparison is made to those published results. However, two subscales were used in their entirety, test anxiety and organization. For the test anxiety subscale the pretest alpha was .86 and the posttest alpha was .91. These results compared favorably with the published results of .80 (Pintrich et al., 1993). For the organization subscale the pretest alpha was .64 and the posttest alpha was .75. While these results compared favorably with the published results of .64 (Pintrich et al., 1993), they are low and could be improved by removing item 4. The revised alpha for the remaining 3 items was a more acceptable .85 on the pretest and .79 on the posttest.

The two other subscales used in this study, time management and reading skills, were derived from larger subscales, so there can be no alpha comparisons. The time management subscale had a pretest alpha of .74 and a posttest alpha of .66. While the pretest value is acceptable, the posttest value reflects low reliability. Item-total correlation analysis did not suggest any items for removal to improve this alpha value. This concern will be discussed in the next chapter. With regard to the reading skills subscale, the pretest alpha was .32 and the posttest alpha was .45. These alpha values could be improved by removing items 3, 9, 10, and 12, however the revised alpha values of .65 and .43 for pretest and posttest, respectively, were still less than the acceptable minimum of .70 for Cronbach's alpha. Issues dealing with the reliability of the subscales will be discussed in the limitations section of Chapter 5.

A triangulation examination of the connections between the AMAS and the MSLQ may be helpful in understanding their relationship. The results of the Test Anxiety subscale of the MSLQ compared favorably with the results of the AMAS. AMAS items 2, 4, and 8 assess test anxiety specifically. These items ask about feelings of anxiety while preparing for or taking a mathematics test. The correlation of the AMAS items with the Test Anxiety subscale score was .73 for the pretest and .52 for the posttest. Both the AMAS and the Test Anxiety subscale were highly reliable on their own. This result reinforces that reliability.

The AMAS also contained three items that measured organization skills, items 1, 5, and 9. This allowed some validity checking of organization skills. These items measure planning, preparation, and the use of tables. The correlation of the AMAS items with the Organization subscale score was .29 for the pretest and .41 for the posttest, which are low to moderate values. However, the full Organization subscale had low reliability, as described above. Using the revised item set, the correlation of the AMAS items with the Organization subscale score was .59 for the pretest and .56 for the posttest, both moderate values. Therefore, association with the previously validated AMAS scale strengthens the reliability of the Test Anxiety and Organization subscales.

Mathematics Achievement Test

I created the Mathematics Achievement Test (MAT) (see Appendix F) by selecting 10 Praxis I® test questions (reprinted by permission of Educational Testing Service, the copyright owner, see Appendix G) covering skill areas such as operations on fractions, decimals, and percents, as well as reasoning, problem solving, and estimation. The ten multiple-choice items were selected from previous Praxis tests. Each item was scored 1 for correct and 0 for incorrect. Thus, the Mathematics Achievement Test (MAT) scores ranged from a minimum of 0 to a maximum of 10.

The Educational Testing Service (ETS) has designed The Praxis Series™ of tests for states to use as part of their teaching licensing certification process. The Praxis I tests measure basic academic skills. For this study, representative Praxis I mathematics examination questions were chosen under the guidance of a panel of reviewers including two college-level professors with a background in mathematics education. Questions were chosen for their mathematics content and level of difficulty. The applicability of items to the required content knowledge of preservice elementary teachers was the primary consideration. Questions were chosen from items found online at the ETS web site and from sample items used in previous Praxis I examinations published by the ETS. Some questions tested understanding of basic computation skills; others involved reasoning, problem solving, or estimation. All questions were in the multiple-choice format. Scores from the sample Praxis I mathematics examination questions were used to determine the mathematics achievement levels of the participants in this study.

The ETS defines reliability for the Praxis tests as "[t]he tendency of individual scores to be consistent from one edition of the test to another (ETS, 2006, p. 2)." Data on Cronbach's alpha is not available in public ETS documents. In its recent publication, ETS (2006) listed data for 65,678 examinees who took the Praxis I mathematics examination during the period September 1, 2003 to June 30, 2006. The possible score range was 150-190. The median score was 179 with an average performance range of 174-184. The standard error of measurement was 2.8. Thus it is assumed that 67 percent of examinees would receive scores within 2.8 points of the average score they would get if they were to take this test multiple times.

ETS describes the validity of Praxis questions as follows.

> The validation process used to justify the interpretation of Praxis scores is consistent with the technical guidelines presented in the Standards for Educational and Psychological Testing (AERA, 1999). Central to the process is the connection or alignment between the content of the test and the knowledge and/or skills judged important for entry-level practice. This is accomplished through multiple means, beginning with a systematic analysis of job requirements (knowledge and/or skill levels). This analysis involves gaining the input of representative samples of educators and reviewing national disciplinary standards. Test development committees of educators and ETS subject experts conduct reviews for test content appropriateness and fairness (ETS, 2005, p. 3).

The questions used for this study were matched to the mathematical skills needed by preservice elementary teachers. These skill areas included operations on fractions, decimals, and percents, as well as the use of estimation, reasoning, and problem solving.

Analysis of the MAT pretest data produced a Cronbach's alpha of .61. The results of item-total correlation analysis suggested dropping items 3 and 4 from the analysis of the MAT pretest data. The revised alpha was a more acceptable .70. Initial analysis of the posttest data resulted in alpha = .48. After dropping the same items as in the pretest analysis, the revised alpha for the posttest was a less-than-acceptable .54. Since the ETS has not made Cronbach's alpha values publicly available, no comparison can be made regarding these results. Reliability issues pertaining to this instrument will be discussed in the limitations section of Chapter 5.

Pilot Study

In a pilot study at a small town university in the Northeastern United States during the fall semester of 2007, I studied 304 elementary education majors in a mathematics content course intended specifically for elementary education majors. Twelve sections of the course, taught by seven different professors, were included in the pilot study. These students completed the three instruments. It should be noted that I offered out-of-class training sessions in the self-regulated learning strategies during the semester of the pilot study. However, no students chose to participate in the sessions.

The data from the three instruments used during the pilot study were evaluated in preparation for this study. The mean age of the participants was 19.0 years, with a range of 17 to 40 years. The ethnic mix was 92.7% Caucasian, 3% African American, 3% Asian, 0.7% Hispanic, and 0.7% other. The pilot study participants were mostly female, 87.1%.

The pilot study AMAS scores had a mean of 21.56 (*SD* = 6.32). Cronbach's alpha for the AMAS was a reliable .87. The mean score on the MSLQ was 67.27 (*SD* = 10.18). Cronbach's alpha for the MSLQ was a reliable .80. The pilot study used 20 Praxis questions for the MAT scale. Cronbach's alpha for the MAT was borderline at .70. The mean for this version of the MAT was 10.81 (*SD* = 3.59). Pearson correlation analysis showed that AMAS scores and MSLQ strategy scores were correlated at a low level (*r* = -.499). This may be the result, at least in part, of the inclusion of a Test Anxiety subscale in the MSLQ strategy scores. Due to the negative direction of this correlation, higher MSLQ strategy scores are associated with lower AMAS scores and lower MSLQ strategy scores are associated with higher AMAS scores. This study will add to the limited literature on the relationship of math anxiety and the use of self-regulated learning strategies (Cox, 2002; Pape & Smith, 2002; Zopp, 2000). AMAS scores and MAT scores were correlated at a low to medium level (*r* = -.233). Due to the negative direction of this correlation, higher MAT scores are associated with lower AMAS scores and lower MAT scores are associated with higher AMAS scores. This reflected a negative relationship between math anxiety and mathematics achievement, as has been noted in the literature (Baloglu & Koçak, 2006; Betz, 1978; Ma, 1999; Meece et al., 1990). Finally, there was no apparent correlation between MSLQ strategy scores and MAT scores (*r* = .087), reflecting little association between self-regulated learning strategy use and mathematics achievement. This differs from the results reported by Camahalan (2006), Perels (2005), and Nota (2004), which supported the use of self-regulated learning strategies to improve mathematics achievement.

In response to time concerns raised by professors during the implementation of the three instruments in the pilot study pretest, I decided to reduce the number of questions on the MAT from 20 to 10 to save time. The 10 items with the greatest variance in student response were chosen for maximum effectiveness in evaluating differences in mathematical achievement. That is, MAT items that most of the pilot study participants scored correctly or most scored incorrectly were deleted to determine the 10 items used for the current study. The limitations section of Chapter 5 will discuss the weakness of this method.

Procedure

During the fourth week of the spring semester 2008, three sections of a first-year mathematics content course at an urban university in the Northeastern United States were requested to participate in this study. All agreed and signed the informed consent form. I gathered background information from participating students as the first part of the study instrument. The information requested included items on sex, age, and ethnicity. The Abbreviated Mathematics Anxiety Scale, the Motivated Strategies for Learning Questionnaire, and the Mathematics Achievement Test were then administered. The participants were asked to complete the AMAS to establish the level of math anxiety. Completing the MSLQ provided information on their self-regulated learning strategies. They completed the mathematics achievement test to measure their mathematics content knowledge. Responses to all instruments were recorded on optically scanned "bubble" sheets for direct assessment and to avoid data entry errors. To preserve anonymity all materials used codes to identify the participants.

The two sections participating in the treatment met with me in the classroom for about 20 minutes on three occasions over a five-week period for training in self-regulated learning strategies. The training sessions were separated from the testing sessions by at least one week. The course instructor was not involved in the treatments. During the twelfth week all participants were posttested on the AMAS, the MSLQ, and the MAT.

I prepared all the treatments. The university professor was only involved as the course instructor. The professor implemented the standard lecture method of instruction, typical of many university mathematics classrooms, throughout the study.

Treatment

I instructed the participants in several self-regulated learning strategies. These treatments included training on time management, organization, test preparation and test taking, reading a mathematics textbook, and estimation. As part of their training the participants were given specific suggestions on how to improve their self-regulated learning skills. Three twenty-minute sessions were conducted in the regular classroom. The sessions were spaced over several weeks during the spring semester. Approximately the same number of students attended each session. To maintain privacy, participants were not identified at the treatment sessions, therefore I cannot state specifically which students attended which sessions. In order to be included in the analysis the participant had to complete the pretest and the posttest.

A set of written materials was prepared for each treatment. The instructor materials included a topic outline for each session, which itemized each of the elements of that lesson (see Appendix H). Participants were given handouts that emphasized the specific elements of the lesson, as well as applications (see appendix I).

Participants were encouraged to work together and to discuss ideas and issues related to self-regulated learning. At the end of each treatment session students were asked to apply the lesson and report on their results in the following session. Participants were reminded of the advantages of self-regulated learning in improving their understanding of mathematics and reducing their math anxiety. Appendix H contains the bullet list that I used to present the treatments. This list was developed from a variety of sources as noted in the literature review (Hofer et al., 1998; Schmitz & Wiese, 2006; VanderStoep & Pintrich, 2003; Zimmerman, Bonner, & Kovach, 1996). The three treatments will be explained in detail below.

The first treatment began with a general introduction to self-regulated learning. The discussion included self-monitoring, setting goals, and attribution of results to strategy use. Results of current research were described to demonstrate the value of self-regulated learning (Schmitz & Wiese, 2006; Zimmerman, 2001; Zusho et al., 2003). I then discussed self-regulated learning strategies related to time management skills and organization (Hofer & Yu, 2003; Zopp, 2000). Topics included creating a to-do list and setting priorities, both long and short term (VanderStoep & Pintrich, 2003). Students should set aside time for studying mathematics on a regular schedule and at a time when they are still fresh (Zimmerman, 2002). Organization skills included where to study to avoid distractions, preparing questions to ask fellow students or the instructor, and what to do when a class is missed (Kiewra, 2002; VanderStoep & Pintrich, 2003). I also looked at dividing the information to be learned into subsets and identifying the relationships among the subsets (Lapan, Kardash, & Turner, 2002).

The second treatment, given the week before the mid-term examination, took advantage of the students' need for test preparation and test taking skills (Miller, 2000). Test preparation looked at using self-questioning techniques and verifying the understanding of the topics on a regular basis (Lapan et al., 2002). The students were encouraged to think of tests as evaluation tools to establish how well their learning strategies are working in advancing their knowledge of mathematics (VanderStoep & Pintrich, 2003). They were advised to analyze and evaluate their testing errors (Pape & Smith, 2002). Time management was tied in with the goal of avoiding cramming for the test. In the area of test taking, students were reminded to look over the whole test first, and then start with the easiest problems, reserving the most difficult ones for later (Hofer et al., 1998). Relaxation techniques were described that could help to reduce test anxiety (Foss & Hadfield, 1993).

The third treatment involved reading a mathematics textbook for understanding and estimation. Topics included skimming a section of the text to gain a general overview of the material (Hofer et al., 1998). The steps in diagramming and outlining were developed (VanderStoep & Pintrich, 2003). Students were encouraged to ask themselves questions as they read in order to monitor comprehension (Hofer et al., 1998). Active reading with the goal of comprehension was emphasized to assist in handling the condensed nature of the material (Pape & Smith, 2002). Pre-reading topics before they are to be covered in class, was also stressed (Foss & Hadfield, 1993). In addition, I described the advantages of estimation in preparing for and evaluating the accuracy of calculations (Alajmi & Reys, 2007; Hanson & Hogan, 2000; Hogan & Palapiano, 2008). The NCTM Standards (2000) recommend that students should use estimation to determine the reasonableness of answers to computation. Students should also know when estimation is the appropriate way to determine the answer to a problem or when paper-and-pencil or a calculator is appropriate (NCTM, 2000). When clarity is more important than precision, an estimate may be used to promote understanding of a numerical value (Usiskin, 1986). For example, the actual number of people in the United States is rarely used when comparing populations among countries. An estimate can be much more helpful in this case. Furthermore, the NCTM advises that estimation skills and the ability to evaluate the reasonableness of an answer are crucial to using calculators effectively (NCTM, 1989).

I was the only one involved in the development and implementation of the treatments. To reduce threats to internal validity, the university professor had no involvement in these treatments.

Data Analysis

The purpose of this study was to determine the effect of training in self-regulated learning strategies on reducing the level of math anxiety and improving the achievement level of preservice teachers taking a first-year course on mathematics concepts appropriate to the elementary curriculum.

The data collection included participants filling out the participant data sheet to obtain background information, and completing the AMAS, MSLQ, and MAT as a pretest and a posttest. The nine-item AMAS was used to measure participants' level of math anxiety. The MSLQ provided information on self-regulated learning skills. The MAT was implemented to measure participants' mathematics content knowledge. All the data from pretest and posttest administrations of the above instruments were analyzed.

The data analysis was designed to answer the research questions. Initially a Pearson correlation was performed to investigate any relationships between the various scales and subscales among all participants. This allowed me to establish the preliminary status before further investigation. Next, the research questions were evaluated.

The first research question asked if training in self-regulated learning strategies reduces math anxiety among preservice teachers in a first-year mathematics course covering the topics appropriate to the elementary school level. Analysis was done using paired samples, two-tailed *t*-tests. In this study, *t*-tests were more appropriate than ANOVA because of the small number of participants. The AMAS pretest scores of both treatment and control groups were compared to verify equality between the groups at the beginning of the study. The AMAS posttest scores of both groups were compared to determine if the groups differed at the end of the treatment period. Also, each group's AMAS scores before the treatment (pretest) were compared to their AMAS scores after the treatment (posttest) to determine if there was any reduction in math anxiety.

The second research question investigated if any reduction in math anxiety corresponded to an increase in achievement among preservice elementary teachers in a first-year mathematics course covering the topics appropriate to the elementary school level. This analysis also used paired samples, two-tailed *t*-tests. To verify equality between the groups at the beginning of the study, the MAT pretest scores of both treatment and control groups were compared. To determine if the groups differed at the end of the treatment period, the MAT posttest scores of both groups were compared. In addition, each group's MAT scores before the treatment (pretest) were compared to their MAT scores after the treatment (posttest) to determine if there was any improvement in mathematics achievement. Finally, correlations were performed to evaluate any relationship between math anxiety (AMAS scores) and mathematics achievement (MAT scores). Pearson correlations were done followed by Spearman correlations due to the small sample sizes involved.

To evaluate the third research question–does training in self-regulated learning strategies increase mathematics achievement among preservice teachers in a first-year mathematics course covering the topics appropriate to the elementary school level–paired samples, two-tailed *t*-tests and correlation analysis were implemented. The MSLQ pretest scores of both treatment and control groups were compared to verify equality between the groups at the beginning of the study. The MSLQ posttest scores of both groups were compared to determine if the groups differed at the end of the treatment period. Each group's MSLQ scores and subscores before the treatment (pretest) were compared to their MSLQ scores and subscores after the treatment (posttest) to determine if there was any improvement in the use of self-regulated learning strategies. Correlation analysis was performed on MSLQ scores and MAT scores to evaluate the relationship of self-regulated learning strategies and mathematics achievement.

Summary

This chapter has described the quantitative research design. A detailed portrayal of the participants gave background on the source of the sample data. The study instruments were illustrated along with a discussion of reliability and validity concerns. A description of the procedure used in the study gave details on how the research was conducted. The treatments in self-regulated learning strategies were based on studies described in the literature review. The techniques of data analysis are related to the research questions. They involve *t*-tests and correlations to investigate the effectiveness of the teaching of self-regulated learning strategies on reducing math anxiety and improving mathematics achievement among preservice teachers.

CHAPTER 4

RESULTS

Introduction

The purpose of this study was to evaluate the efficacy of self-regulated learning strategies in a freshman mathematics concepts class. The focus of this study is on elementary education majors, a group of students who are more likely than other students to have higher levels of math anxiety, as was noted previously. The participants receiving treatment (the treatment group) were compared to participants in a similar class that was taught without such treatments (the control group). The results of the statistical analyses of the data obtained in this study are presented here. The results are presented in the order of the primary research questions: (1) Does training in self-regulated learning strategies reduce math anxiety among preservice teachers? (2) If math anxiety is reduced, is this reduction associated with an increase in mathematics achievement among preservice teachers? (3) Is training in self-regulated learning strategies associated with an increase in mathematics achievement among preservice teachers? Pretest and posttest results of the survey instruments, the Abbreviated Mathematics Anxiety Scale (AMAS), the Motivated Strategies for Learning Questionnaire (MSLQ), and the Praxis-based mathematics achievement test (MAT) are discussed. The chapter ends with a summary of results.

Descriptive statistics for all participants are shown in Table 4.1. AMAS scores have a minimum value of 9 and a maximum value of 45. MSLQ scores have a minimum value of 21 and a maximum value of 105. MAT scores have a minimum value of 0 and a maximum value of 10. Pearson product-moment correlation coefficients were calculated in order to examine the relationships among the scales and subscales for all participants. As shown in Table 4.2, all three scales as well as the MSLQ subscales exhibited significant and strong intercorrelations on a pretest-posttest comparison. This could be expected as the tests used were identical and there was a limited amount of time between administrations. The Test Anxiety subscale was strongly correlated with the AMAS scale, which reflects the relationship between test anxiety and math anxiety discussed in Chapter 2. Another strong relationship was found between the Organization and Reading subscales. These subscales share some common characteristics of self-regulated learning strategies. Some of the Reading items have Organization attributes and some of the Organization items contain Reading attributes. For example, "Before I study new course material thoroughly, I often skim it to see how it is organized" (Pintrich et al., 1991, p. 23) or "When I study the readings for this course, I outline the material to help me organize my thoughts" (Pintrich et al., 1991, p. 21).

Table 4.1. Descriptive Statistics for Participants on All Scales and Subscales (n=29)

Variable	Mean	Standard Deviation
AMAS Pretest	19.83	6.48
AMAS Posttest	19.72	6.94
MAT Pretest	3.62	1.64
MAT Posttest	3.55	1.79
MSLQ Pretest	61.55	8.86
MSLQ Posttest	63.31	10.03
Test Anxiety Pretest	17.14	5.28
Test Anxiety Posttest	16.79	5.51
Organization Pretest	9.14	3.29
Organization Posttest	10.52	3.71
Time Management Pretest	16.38	4.56
Time Management Posttest	17.00	3.78
Reading Pretest	18.90	3.47
Reading Posttest	19.00	3.99

Table 4.2. Pearson Correlations among All Scales and MSLQ Subscales for All Participants (n=29)

Variable	1	2	3	4	5	6
1. AMAS Pretest	-					
2. AMAS Posttest	.841**	-				
3. MAT Pretest	-.303	-.321	-			
4. MAT Posttest	-.276	-.348	.503**	-		
5. MSLQ Pretest	-.227	-.266	-.005	.032	-	
6. MSLQ Posttest	-.044	-.253	.201	-.042	.560**	-
7. Test Anxiety Pretest	-.645**	-.528**	.250	.173	.485**	.133
8. Test Anxiety Posttest	-.560**	-.639**	.391*	.186	.424*	.507**
9. Organization Pretest	.359	.205	-.089	-.086	.547**	.487**
10. Organization Posttest	.359	.199	-.226	-.142	.209	.510**
11. Time Management Pretest	.047	-.048	-.023	-.005	.652**	.331
12. Time Management Posttest	.219	-.039	.191	-.164	.258	.668**
13. Reading Pretest	.000	-.006	-.278	-.094	.438*	.332
14. Reading Posttest	.123	.099	-.005	-.075	.383*	.704**

Note: variables 7 through 14 are MSLQ subscales.
* $p < .05$ (2-tailed). ** $p < .01$ (2-tailed).

Table 4.2. (continued)

Variable	7	8	9	10	11	12	13
1. AMAS Pretest							
2. AMAS Posttest							
3. MAT Pretest							
4. MAT Posttest							
5. MSLQ Pretest							
6. MSLQ Posttest							
7. Test Anxiety Pretest	-						
8. Test Anxiety Posttest	.710**	-					
9. Organization Pretest	-.344	-.164	-				
10. Organization Posttest	-.419*	-.286	.626**	-			
11. Time Management Pretest	.107	.049	.360	.235	-		
12. Time Management Posttest	-.147	.161	.319	.237	.505**	-	
13. Reading Pretest	-.099	.092	.499**	.271	-.155	-.084	-
14. Reading Posttest	-.119	.006	.565**	.524**	.067	.289	.534**

Note: variables 7 through 14 are MSLQ subscales.
* $p < .05$ (2-tailed). ** $p < .01$ (2-tailed).

Analysis of Math Anxiety

The first research question addressed whether training in self-regulated learning strategies could reduce math anxiety among preservice teachers. The 9-item Abbreviated Mathematics Anxiety Scale (AMAS) (Hopko et al., 2003), derived from the Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972), was used to measure the math anxiety of the participants. AMAS scores can range from a minimum of 9 to a maximum of 45. The training in self-regulated learning strategies was intended to reduce the level of math anxiety measured among the treatment group. Any change in level of math anxiety measured among the treatment group was then compared to the change in level of math anxiety measured among the control group. The means of the pretest and posttest AMAS scores for the treatment group and the control group are shown in Table 4.3. The table shows only small differences in the means for each of the groups. A detailed analysis of the importance of this difference will be shown later in this section.

Table 4.3. Descriptive Statistics for AMAS Pretest and Posttest Scores for Treatment and Control Groups

Source	Treatment (n=15)		Control (n=14)	
	Mean	Standard Deviation	Mean	Standard Deviation
Pretest	20.47	6.79	19.14	7.26
Posttest	20.33	5.84	19.07	7.29

Due to the small sample size, I tested the AMAS scores for normality. The Shapiro-Wilk test (Shapiro & Wilk, 1965) calculates a *w* statistic that is used to evaluate whether a sample is likely to have come from a normal distribution. Small values of *w*, typically less than .05, are evidence of departure from normality (see Pearson & Hartley, 1976, Table 16). The Shapiro-Wilk test has done very well in comparison studies with other goodness of fit tests (Iacobucci, 2001; National Institute of Standards and Technology, 2008). The pretest and posttest AMAS scores were analyzed separately. The Shapiro-Wilk significance values measured were greater than .05 for both implementations, $w = .24$ for pretest AMAS scores and $w = .06$ for posttest AMAS scores. These values demonstrate that the AMAS score data was not significantly different from a normal distribution.

An additional analysis was conducted to check for equality between the treatment and control groups' original levels of math anxiety as measured by

AMAS scores. The results of a two-tailed *t*-test comparing the two groups verified that the treatment and control groups did not differ significantly on AMAS scores at the beginning of the study ($t = .543$, $df = 27$, $p = .592$, effect size = .02). Therefore, I concluded that the treatment and control groups were essentially similar in their levels of math anxiety at the beginning of the study.

To test for effects of the treatment in self-regulated learning strategies I conducted an analysis to check for differences between the treatment and control groups' final levels of math anxiety as measured by posttest AMAS scores. The results of a paired samples, two-tailed *t*-test comparing the two groups revealed that the treatment and control groups did not differ significantly on AMAS scores at the completion of the study ($t = .483$, $df = 27$, $p = .633$, effect size = .01). Therefore, I concluded that on the posttest there was no statistically significant difference in the participants' levels of math anxiety.

Further examination of the data in Table 4.3 revealed a small reduction in math anxiety, as measured by mean AMAS scores, for each group on the posttest as compared to the pretest. A paired samples, two-tailed *t*-test was used to evaluate the statistical significance of the difference between the pretest and posttest AMAS scores for each group separately. The results were $t = .106$, $df = 14$, $p = .917$ for the treatment group and $t = .113$, $df = 13$, $p = .912$ for the control group. While the AMAS scores did decline for each group, the large *p* values imply that this reduction was not statistically significant for either group. Therefore, neither the treatment group nor the control group demonstrated any statistically significant change in math anxiety, as measured by the AMAS scores.

Whereas statistical tests of significance tell us the likelihood that experimental results differ from chance expectations, effect-size measurements tell us the relative magnitude of the experimental treatment. They tell us the size of the experimental effect. Effect sizes are especially important because they allow us to compare the magnitude of experimental treatments from one experiment to another. Effect sizes less than .15 are considered negligible, while sizes between .15 and .40 are considered small. An effect size between .40 and .75 is considered large. In this study the effect size of the difference in pretest and posttest means for AMAS treatment scores was .02, a negligible value. The effect size of the difference in pretest and posttest means for AMAS control scores was .01, also a negligible value. This is consistent with the non-significant *t*-test results reported on these measures.

I then performed a more detailed examination of the results of the AMAS instrument. When examined on an individual score level, among the treatment group members ($n = 15$), seven participants' AMAS scores decreased from pretest to posttest, reflecting a decrease in math anxiety. However, at the same time five participants' AMAS scores increased and three participants' AMAS scores did not change. Meanwhile, among the control group ($n = 14$), six participants' AMAS scores decreased, showing improvement. However, at the same time there were six participants whose AMAS scores increased and three participants whose AMAS scores did not change. These findings are discussed in the following chapter.

Analysis of Math Anxiety and Mathematics Achievement

The second research question addressed whether any reduction in math anxiety corresponded to an increase in mathematics achievement. As you may recall, the participants' mathematics achievement was measured using ten multiple-choice items selected from previous Praxis tests. The scores could range from a minimum of 0 to a maximum of 10. The means of the pretest and posttest Mathematics Achievement Test scores for the treatment group and the control group are shown in Table 4.4.

Table 4.4. Descriptive Statistics for MAT Pretest and Posttest Scores for Treatment and Control Groups

Source	Treatment (n=15)		Control (n=14)	
	Mean	*SD*	Mean	*SD*
Pretest	3.40	1.72	3.86	1.56
Posttest	3.53	1.55	3.57	2.06

I next checked for equality between the treatment and control groups' original levels of mathematics achievement as measured by pretest MAT scores. The results of a *t*-test comparing the two groups verified that the treatment and control groups did not differ significantly on MAT scores at the beginning of the study (t = -.747, df = 27, p = .462, effect size = .08). Therefore, I concluded that the treatment and control groups were essentially similar in their levels of mathematics achievement at the beginning of the study.

A test for effects of the treatment with self-regulated learning strategies was conducted to identify differences between the treatment and control groups' final levels of mathematics achievement as measured by posttest MAT scores. The results of a *t*-test comparing the two groups revealed that the treatment and control groups did not differ significantly on MAT scores at the completion of the study (t = -.056, df = 27, p = .955, effect size = .17). Therefore I was unable to conclude that there was any statistically significant difference between the treatment and control groups' levels of mathematics achievement at the posttest.

These descriptive data, as seen in Table 4.4, revealed a small improvement in mathematics achievement, as measured by MAT scores, for the treatment group by comparing the posttest mean scores to the pretest mean scores. The control group data, however, demonstrated a slight decline in MAT scores.

I used a paired samples *t*-test to evaluate the statistical significance of the difference between the pretest and posttest Mathematics Achievement Test scores for each group separately. The results were t = -.307, df = 14, p = .764 for the treatment group and t = .603, df = 13, p = .557 for the control group. While this demonstrates that the Mathematics Achievement Test scores did change for each group, the large p values imply that this change was not statistically significant for either group. Therefore, neither the treatment group nor the control group demonstrated any statistically significant improvement in mathematics achievement, as measured by the Mathematics Achievement Test scores. The effect size of the difference in pretest and posttest means for MAT treatment scores was .08, a negligible value. The effect size of the difference in pretest and posttest means for MAT control scores was .19, a small value. This is consistent with the non-significant *t*-test results reported on these measures.

I would also like to note that the MAT scores are rather low (between 30 and 35 percent of the items correctly answered) for a set of questions taken from former Praxis I examination items. Elementary education students are usually expected to be able to pass the Praxis I examination before being accepted into the elementary education major. For comparison, the mean MAT score (using 20 questions) in the pilot study (at a different university) was about 50 percent correct.

For the purpose of improving the reliability of the MAT, I performed an analysis after dropping items 3 and 4. Item-total correlation analysis identified these items for removal to improve the Cronbach's alpha value of the instrument. This resulted in an improvement in Cronbach's alpha from .61 on the pretest to .70 and from .48 on the posttest to .54. While the posttest reliability was still low, the pretest reliability was now acceptable. The issue of low reliability for this instrument will be discussed in the Chapter 5. The *t*-test was run again using the remaining eight items. For the treatment group the revised *t*-test calculations were $t = -.59$, $p = .57$, with an effect size of a negligible .14. The control group results for the revised item list were $t = 0$, $p = 1$, with an effect size of 0, since the pretest and posttest scores were identical. This shows a slight improvement in treatment scores, but this modified result was still not significant. Thus, while the reliability of the treatment scores was improved by analyzing a selected subset of the original ten items, the result was still a lack of significant difference in mathematics achievement as measured by the MAT.

Pearson correlation analysis revealed that for the treatment group the AMAS pretest score was negatively correlated at a medium level to the mathematics achievement pretest score, as shown in Table 4.5. Similarly, for this group the AMAS posttest score was negatively correlated at a medium level to the mathematics achievement posttest score. This is consistent with prior research (Ashcraft & Krause, 2007; Donlan, 1998; Dwinell & Higbee, 1991) showing increased math anxiety is associated with lower mathematics achievement. Among the control group these correlations were weaker, but not significantly so.

Table 4.5. Pearson Correlations between AMAS Score and MAT Score for Treatment and Control Groups

Variable	Treatment (n=15)		Control (n=14)	
	MAT Pretest	MAT Posttest	MAT Pretest	MAT Posttest
AMAS Pretest	-.410		-.188	
AMAS Posttest		-.452		-.274

Due to the small sample size, I performed a Spearman correlation analysis on the above measures. The Spearman correlation ranks both sets of data before making the comparison. This analysis, as shown in Table 4.6, revealed similar results to the Pearson correlation and provided no further insight into the relationship of these variables.

Table 4.6. Spearman Correlation between AMAS Score and MAT Score for Treatment and Control Groups

Variable	Treatment (n=15)		Control (n=14)	
	MAT Pretest	MAT Posttest	MAT Pretest	MAT Posttest
AMAS Pretest	-.415		-.137	
AMAS Posttest		-.471		-.264

Analysis of Self-regulated Learning and Mathematics Achievement

The third research question addressed whether training in self-regulated learning strategies corresponded to an increase in mathematics achievement among preservice teachers. I used the Motivated Strategies for Learning Questionnaire (MSLQ) to measure the use of self-regulated learning strategies. As noted previously, the 21 items selected for this study included items intended to measure test anxiety, organization skills, effective reading, and time management. The MSLQ scores ranged from a minimum of 21 to a maximum of 105. The means and standard deviations of the pretest and posttest MSLQ scores for the treatment group and the control group are shown in Table 4.7. The results show a small increase in means for the treatment group and a negligible increase for the control group. The MSLQ Test Anxiety subscores range from a minimum of 5 to a maximum of 25, the Organization subscores range from 4 to 20, the Reading subscores range from 7 to 35, and the Time Management subscores range from 5 to 25. Table 4.8 shows the means and standard deviations of the pretest and posttest scores for the four subscales. The treatment group means increased slightly from pretest to posttest for the Test

Anxiety, Reading, and Time Management subscales. However, the Organization subscale mean was up sharply. For the control group, the Test Anxiety and Reading subscale means were down somewhat, while the Organization and Time Management subscale means were moderately higher.

Table 4.7. Descriptive Statistics for MSLQ Pretest and Posttest Scores for Treatment and Control Groups

Source	Treatment (n=15)		Control (n=14)	
	Mean	*SD*	Mean	*SD*
Pretest	61.60	8.82	61.50	9.23
Posttest	64.60	10.24	61.93	9.98

Table 4.8. Descriptive Statistics for MSLQ Subscales Pretest and Posttest Scores for Treatment and Control Groups

Source	Subscale	Treatment (n=15)		Control (n=14)	
		Mean	*SD*	Mean	*SD*
Pretest	Test Anxiety	15.47	5.60	18.93	4.43
	Organization	10.07	3.53	8.14	2.80
	Reading	19.33	3.39	18.43	3.61
	Time Management	16.73	3.33	16.00	5.71
Posttest	Test Anxiety	15.67	5.02	18.00	5.94
	Organization	12.00	3.18	8.93	3.67
	Reading	19.93	4.38	18.00	3.96
	Time Management	17.00	3.74	17.00	3.96

MSLQ scores measured the original levels of the use of self-regulated learning strategies by the treatment and control groups. The results of a *t*-test comparing the two groups verified that the treatment and control groups did not differ significantly on MSLQ scores at the beginning of the study (t = .030, df = 27, p = .976, effect size = .31). Therefore, I concluded that the treatment and control groups were essentially similar in their levels of the use of self-regulated learning strategies at the beginning of the study.

To test for effects of the training, an analysis was conducted to check for differences between the treatment and control groups' final levels of their use of self-regulated learning strategies as measured by posttest MSLQ scores. The results of a two-tailed *t*-test comparing the two groups revealed that the treatment and control groups did not differ significantly on MSLQ scores at the completion of the study (t = .711, df = 27, p = .483, effect size = .04). Therefore, it cannot be concluded that there was any statistically significant difference between the groups in their use of self-regulated learning strategies at the time of the posttest.

A group-by-group analysis of *t*-test results on the pretest and posttest scores of the MSLQ and each of the subscales (Table 4.9) revealed only one statistically significant outcome, a *p* value of less than .05 for the Organization subscale for the treatment group. The other treatment group *p* values exceeded the significance level of .05 for the MSLQ (effect size = .34), Test Anxiety subscale (effect size = .04), Reading subscale (effect size = .18), and Time Management subscale (effect size = .08). For the control group, the MSLQ (effect size = .04), Test Anxiety subscale (effect size = .21), Organization subscale (effect size = .28), Reading subscale (effect size = .12), and Time Management subscale (effect size = .18) showed no significant change. However, as shown in Table 4.8, the pretest mean for the Organization subscale for the treatment group was 10.07, whereas the posttest mean was 12.00. This improvement was statistically significant (t = -2.266, df = 14, p = .040, effect size = .55, a moderate value). This implies that there may have been some effect due to the treatment. It is possible that the organization skills of the participants in the treatment group were improved due to the treatment. However, there were reliability issues related to the Organization subscale, which will be discussed later.

Table 4.9. Paired Samples *t*-tests on Pretest/Posttest Scores of MSLQ and its Subscales for Treatment and Control Groups

Source	Treatment (n=15)			Control (n=14)		
	t	*df*	*p*	*t*	*df*	*p*
MSLQ	-1.145	14	.271	-.213	13	.834
Test Anxiety	-.161	14	.874	1.055	13	.311
Organization	-2.266	14	.040*	-1.069	13	.305
Reading	-.212	14	.835	-1.073	13	.303
Time Management	-.592	14	.563	.479	13	.640

* $p < .05$ (2-tailed).

For the purpose of improving the reliability of the MSLQ, an analysis was performed after dropping items 2, 9, and 14. Item-total correlation analysis identified these items for removal to improve the Cronbach's alpha value of the instrument. This resulted in an increase in Cronbach's alpha from .63 on the pretest to .71 and a slight decrease on the posttest from .73 to .72. This reduction in items resulted in acceptable reliability on both pretest and posttest. The revised descriptive statistics for MSLQ treatment group pretest were mean = 54.60 and *SD* = 10.05. The posttest mean was 56.87 with *SD* = 9.61. For the control group, the pretest mean was 55.93 with *SD* = 8.81 and the posttest mean was 50.50 with *SD* = 8.79. The *t*-test was run again using the remaining 18 items. For the treatment group the revised *t*-test calculations were $t = -.81$, $p = .432$, with a small effect size of .23. The control group results for the revised item list were $t = 2.88$, $p = .013$ (note: $p < .05$), with a medium effect size of .62. This shows a slight improvement for the treatment group, but a statistically significant decrease for the control group. Thus, when the reliability of the treatment group scores was improved by analyzing a selected subset of the original 21 items, the result was still a lack of significant improvement in self-regulated learning strategy use. However, there was a significant reduction in self-regulated learning strategy use on the part of the control group. This finding will be discussed in Chapter 5.

Next, I attempted to improve the reliability of the Organization subscale. Item-total correlation analysis suggested dropping item 4. This resulted in an improvement in Cronbach's alpha from .64 on the pretest to .85 and from .75 on the posttest to .79. The remaining 3 items resulted in acceptable reliability on both pretest and posttest. The revised descriptive statistics for Organization subscale treatment group pretest were mean = 7.07 and *SD* = 3.65. The posttest mean was 8.33 with *SD* = 2.66. For the control group, the pretest mean was 4.93 with *SD* = 2.20 and the posttest mean was 5.71 with *SD* = 2.92. The *t*-test was run again using the remaining 3 items. For the treatment group the revised *t*-test calculations were $t = -1.55$, $p = .144$, with a small effect size of .35. The control group results for the revised item list were $t = -1.08$, $p = .300$, with a small effect size of .36. This shows a slight improvement in both treatment and control mean scores. Thus, when the reliability of the treatment scores was improved by analyzing a selected subset of the original 3 items, the result was a lack of a significant difference in the Organization subscale results from pretest to posttest on the part of the either group. Also, the significant difference that was found for the treatment group using all 4 items did not hold up in this reduced set. Chapter 5 will provide a further discussion on this issue.

For the purpose of improving the reliability of the Reading subscale, an analysis was performed after dropping items 3, 9, 10 and 12. This resulted in an improvement in Cronbach's alpha from .32 on the pretest to .65 and from .45 on the posttest to .43. This reduction in items did not improve the reliability of this measure to an acceptable level on either pretest or posttest. The revised descriptive statistics for Reading subscale treatment group pretest were mean = 6.80 and *SD* = 3.14. The posttest mean was 7.47 with *SD* = 2.90. For the control group, the pretest mean was 5.93 with *SD* = 1.49 and the posttest mean was 5.79 with *SD* = 1.31. The *t*-test was run again using the remaining 3 items. For the treatment group the revised *t*-test calculations were $t = -.90$, $p = .384$, with a small effect size of .21. The control group results for the revised item list were $t = .35$, $p = .729$, with a negligible effect size of .10. This shows a slight improvement in both treatment mean scores and a modest reduction in control mean scores. Due to the low reliability of this revised measure, these findings must be interpreted carefully. The possibility that this subscale may be too fragmented to be useful will be discussed in Chapter 5.

The results of a Spearman correlation of MSLQ and MAT scores are shown in Table 4.10. The training in self-regulated learning strategies was not shown to be related to improvement in mathematics achievement. Specifically, there was no statistically significant correlation between the MSLQ scores and the MAT scores at the posttest for the treatment group. The control group also reported no statistically significant correlation. The training in self-regulated learning strategies had no measurable effect on mathematics achievement.

Table 4.10. Spearman Correlation between MSLQ Score and MAT Score for Treatment and Control Groups

Variable	Treatment (n=15)		Control (n=14)	
	MAT Pretest	MAT Posttest	MAT Pretest	MAT Posttest
MSLQ Pretest	-.153		.153	
MSLQ Posttest		-.016		.035

Training in Self-Regulated Learning Strategies and Math Anxiety

No significant relationship was found between the training in self-regulated learning strategies and math anxiety scores. In this case, there was no statistically significant correlation between the MSLQ scores and the AMAS scores at the posttest for the treatment group. Similarly, the control group reported no statistically significant correlation. Table 4.11 shows this Spearman correlation. Thus, the training in self-regulated learning strategies had no measurable effect on math anxiety. This finding will also be discussed in Chapter 5.

Table 4.11. Spearman Correlation between MSLQ Score and AMAS Score for Treatment and Control Groups

Variable	Treatment (n=15)		Control (n=14)	
	AMAS Pretest	AMAS Posttest	AMAS Pretest	AMAS Posttest
MSLQ Pretest	-.312		-.123	
MSLQ Posttest		-.092		-.206

Summary

The research data have been presented and analyzed in this chapter. The quantitative analyses revealed no statistically significant relationship of training in self-regulated learning strategies with math anxiety. Math anxiety was not shown to be related to mathematics achievement. Finally, the training in self-regulated learning strategies was not shown to be associated with the level of mathematics achievement.

Only the organization subscale of the MSLQ revealed any statistically significant posttest improvement for the treatment group and none for the control group. However, even this result may be mitigated due to the low reliability of the measure. A thorough discussion of these results is presented in Chapter 5. Also, strengths and weaknesses of the research study with implications for future investigation are presented.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

Introduction

The purpose of this research study was to examine the effect of training in self-regulated learning strategies on math anxiety and mathematics achievement among preservice teachers in a course on mathematical concepts appropriate to the elementary education curriculum. In the following sections, the findings relative to the quantitative analyses described in Chapter 4 are discussed. In addition, limitations based on the constraints of the research design are explored. Implications and recommendations for future studies complete the discussion in this chapter.

This study implemented a pretest/posttest quasi-experimental control group design. Two groups of education majors were involved in the study. The treatment group received several in-class presentations on self-regulated learning strategies including reading a mathematics textbook for understanding, time management, organization, test taking and preparation, and estimation. The control group did not receive any training. I conducted all training sessions. The research study took place within a standard college classroom setting where the same university professor taught the same lessons on mathematics content and gave the same examinations to all participants. Three instruments were used for pretesting and posttesting the participants. Math anxiety was investigated using the Abbreviated Mathematics Anxiety Scale (AMAS). Data on the use of self-regulated learning strategies were obtained from the Motivated Strategies for

Learning Questionnaire (MSLQ). The level of mathematics achievement was measured using the Mathematics Achievement Test (MAT), which was based on Praxis questions. The results of this analysis and its relationship to previous research are presented below.

Research Findings

One of the major findings of this research study was that there were no significant differences between the pretest and posttest scores for the treatment group in their level of math anxiety as a result of the training sessions. By comparison, the control group also showed no significant differences in these scores. This analysis examined the results of a *t*-test on the pretest and posttest scores of the AMAS for the treatment group. The *p* values all exceeded .05. Thus, the training did not produce any measurable reduction in math anxiety for the treatment group. Also worth noting, the pretest and posttest Cronbach's alpha values were very good for the AMAS, confirming the high reliability stated by Hopko et al. (2003).

A more detailed analysis of individual participant math anxiety scores produced mixed results. While 47 percent (seven out of fifteen) of the participants in the treatment group showed improvement through lower math anxiety scores, 43 percent (six out of fourteen) of the participants in the control group showed similar improvement. Thus, there was no clear advantage for the treatment group. However, only one-third of the treatment group reported higher levels of math anxiety, while 43 percent of the control group's math anxiety scores increased. Thus, while there was no significant finding here, it is informative to note that fewer participants in the treatment group reported increased math anxiety at the end of the treatment period compared to the control group.

In related research, Zopp (2000) reported success among college students using a treatment program of three two-hour sessions held at the beginning of the semester. Zopp's treatment was designed to reduce the math anxiety of non-traditional aged students at a community college. The treatment sessions ran concurrently with a required mathematics class and among other things offered study skills and training in time management. Some advantages of Zopp's study included longer treatment sessions and positioning the sessions at the start of the semester. Training students in study skills such as organization, test preparation, and time management produced improvement in math anxiety in several studies (Cox, 2002; Foss & Hadfield, 1993; Miller, 2000). The Miller (2000) and Cox (2002) studies incorporated the training into regular class lessons on basic or intermediate college algebra throughout the semester. Foss and Hadfield (1993) reported successful results from independent math anxiety clinics for new students that extended over five weeks during the fall semester. Norwood (1994) reported success in reducing math anxiety through a semester-long concept-oriented relational approach to teaching mathematics that included organization, test preparation, and test-taking skills. The range of training time among these other studies was several hours to a whole semester. The current study included a total of 60 minutes of training. Thus, it may be that the current research study detected no significant improvement in participants' math anxiety due in part to these two factors: the limited time for training participants and the delay in beginning the treatments until several weeks after the start of the semester.

A second finding of this research study was that there were no significant differences between the pretest and posttest scores for the treatment group in their level of mathematics achievement as a result of the training sessions. Similarly, the control group showed no differences. The second research question addressed whether any reduction in math anxiety corresponded to an increase in mathematics achievement. Since no significant change in math anxiety was found, nor was there a significant change in mathematics achievement, the current study was unable to conclude that a reduction in math anxiety relates to a change in mathematics achievement. Other studies have found relationships between math anxiety and mathematics achievement. The Cox (2002) and Miller (2000) studies described above measured significant increases in mathematics achievement for students with reduced levels of math anxiety.

Item-total correlation analysis determined that the reliability of the MAT instrument could be improved through the removal of items 3 and 4 (requiring calculations using fractions and percents). The revised set of items at pretest improved to an acceptable level of reliability, but the same reduced set of items at posttest still had poor reliability. Moreover, the revised *t*-test values still did not show a significant difference between pretest and posttest MAT scores for the treatment group. The *t*-test on the control group revised data did not show significant results either.

I also looked at the relationship of math anxiety and mathematics achievement. A correlation analysis of the AMAS and MAT data revealed that math anxiety was negatively related to mathematics achievement at a moderate level for the treatment group. I also found a similar negative relationship in the results of a pilot study of 304 elementary education majors at a different university taking a similar course on mathematics concepts. Furthermore, the findings of the current research study concur with the results of other studies that have found that people with lower levels of math anxiety tend to score higher on mathematics achievement evaluations and people with higher levels of math anxiety tend to have lower scores on mathematics achievement evaluations (Betz, 1978; Brockman, 2007; Husni, 2007; Ma, 1999; Zakaria & Nordin, 2008).

The low mathematics achievement scores recorded by the participants in this study should concern teacher educators at this institution. The items chosen reflect the type of questions found on the Praxis I examination, which is required by many colleges before allowing students to enter the elementary education major. Furthermore, these low scores may reflect conceptual weaknesses. Developing a deep conceptual understanding of mathematics is a necessary part of the preparation of preservice elementary teachers (Ball et al., 2001; Stevens & Wenner, 1996). The NCTM (1991) has suggested that teachers should be confident in their knowledge of mathematics, since this will affect how they teach the subject. Weakness in the topics of elementary school mathematics may lead to lower achievement among their students (Ball, 1990; Hill et al., 2005; Ma, 1999). These preservice teachers will need strong mathematical content knowledge to prepare effective classroom activities, plan useful student evaluations, and develop appropriate homework assignments (Ball et al., 2001). If, as teachers, they are uncomfortable with these basic concepts and procedures, they will find it difficult to encourage their students and get them excited about mathematics (Hill et al., 2005).

The third finding of this research study was that there were no significant differences between the pretest and posttest scores for the treatment group in their use of self-regulated learning strategies as a result of the training sessions. Similarly, the control group showed no differences. The third research question of this study addressed whether training in self-regulated learning strategies corresponded to an increase in mathematics achievement among preservice teachers. While no significant change in the use of self-regulated learning strategies was found using the MSLQ, item-total correlation analysis determined that the reliability of the MSLQ instrument could be improved through the removal of items 2, 9, and 14 (all elements of the problematic Reading subscale). At pretest the reduced set of MSLQ items showed an acceptable level of reliability. The same reduced set of items at posttest had similarly acceptable reliability. It must be noted that reducing the number of items on the MSLQ may impact the validity of the instrument. This may be a limitation related to my use of selected items rather than the entire 82-item MSLQ. The treatment group's pretest and posttest revised MSLQ scores still did not show a significant difference on *t*-test. However, the *t*-test on the control group revised data did show statistically significant results. The revised control group mean was statistically significantly lower at posttest than at pretest. The control group participants' self-regulated learning strategy use declined during the study period. This group did not receive any training; therefore it is possible that this exposure to a mathematics course may have led them to fall back on a reduced set of strategies that they had employed in previous mathematics class experiences. In studies, weaker students found mathematics classes less anxiety-producing when they were taught in a highly structured, rule-based class environment (Christou, Phillipou, & Menon, 2001; Clute, 1984).

Initially, the current research showed some minor level of excitement in studying one of the MSLQ subscales. Analysis of the use of organization strategies by the treatment group appeared to show dramatic improvement. That is, all four items from the Organization subscale of the MSLQ, showed statistically significant improvement for the treatment group. The *t*-tests on this MSLQ subscale revealed that the use of organization strategies by participants showed statistically significant improvement from pretest to posttest. However, reliability analysis revealed deficiencies in this subscale. Cronbach's alpha for the 4-item Organization subscale pretest was somewhat low at .64. Using Item-total correlation analysis, one item was removed to yield a revised alpha of .85. A new *t*-test was run. It revealed a non-significant value ($p = .14$) for the treatment group's revised 3-item Organization subscale. Thus, while the original Organization subscale results may be interesting, they must be looked at in light of this low reliability. The data could reflect a positive change, in the direction of improved use of organizational skills related to self-regulated learning strategies.

Organization was the topic of the first presentation on self-regulated learning strategies that I gave during this study. Perhaps this additional time gave the treatment group participants more opportunities to apply this new knowledge. Students who are strong on organizational skills have shown significantly better mathematics achievement scores (Nota et al., 2004). College Learning to Learn programs that emphasize aspects of self-regulated learning, list organizing as one of the most important skills (McKeachie, Pintrich, & Lin, 1985; VanderStoep & Pintrich, 2003). However, in the current study there was no correlation of the Organization subscale with a significant change in mathematics achievement, the focus of this research question.

Next, we look at another MSLQ subscale. The reliability of the Reading subscale of the MSLQ is problematic. This subscale was made up of a subset of seven items that pertained to reading issues taken from the 12-item Metacognition subscale of the MSLQ. The Cronbach's alpha values were low at both pretest and posttest. Removing items failed to improve the reliability to an acceptable level. Neither the original scale, nor a reduced version produced any significant *t*-test results for either the treatment or control group. It may be that this scale cannot be used to measure reading skills in the way that was originally intended for this study. Furthermore, even the findings of non-significance must be interpreted carefully in light of this low reliability.

In a similar manner, the Time Management subscale faced reliability issues. This subscale was made up of a subset of five items that pertained to time management issues taken from the 8-item Time and Study Environment subscale of the MSLQ. The posttest had high reliability, while the pretest reliability was somewhat low. Item-total correlation analysis was unsuccessful in determining any items that could be dropped so as to improve the reliability of the pretest. For this reason, the findings of non-significance of the Time Management subscale must be interpreted carefully in light of its low reliability.

On a more positive note, the Test Anxiety subscale of the MSLQ had very good reliability at pretest and posttest. While the *t*-test findings of non-significant results was unsatisfying, the Test Anxiety subscale items correlated well with the test anxiety items found in the AMAS instrument.

For comparison, the literature describes several successful interventions. Studies have found that training in self-regulated learning can improve mathematics problem solving skills (Perels et al., 2005), as well as encourage students' use of self-regulated academic achievement behaviors (Talbot, 1992). The Perels (2005) study lasted 4 weeks, with six 90-minute sessions per week. Talbot (1992) embedded about 5 to 10 minutes of training in self-regulated learning into each class over an entire semester. Pape (2003) was successful at improving mathematics achievement by embedding SRL strategies into a seventh grade mathematics course that lasted the full year. A four-month program to reduce math anxiety and improve learning strategies for university students in Italy was successful for students in a mathematics concepts course (Zan, 2000). Zan's study taught self-regulated learning skills such as time management and test preparation in weekly four-hour sessions. Camahalan (2006) taught self-regulated learning skills over a six-week period using one-hour sessions, five days a week for six weeks. These students performed significantly better on a mathematics achievement test than a control group. The self-regulated learning strategies taught included self-evaluation, planning, organization, maintaining records of their work, and self-monitoring.

Limitations

The limitations of the current study relate to the structure of the intervention, how the treatments were implemented, and the lack of random sampling. Other limitations include the use of self-report instruments, the choice of instruments, the reliability of the instruments, the sample size, the restructuring of the mathematics achievement test, and the lack of qualitative data sources.

One weakness of this research study was that there was insufficient time to establish each self-regulated learning strategy. The technique of scaffolding is appropriate for teaching strategies. It is best to present one strategy at a time, introducing new strategies only after earlier ones are successfully implemented by the students (Hofer et al., 1998; Zimmerman et al., 1994). This type of implementation may have given the students a stronger background in the self-regulated learning strategies that I presented. The present study was limited by the available time in the university professor's busy class schedule where there was a required syllabus and a fixed departmental exam schedule. As noted above, Perels (2005), Zan (2000), and Camahalan (2006) used four weeks to four months of daily or weekly sessions to accomplish successful self-regulated learning strategy training results. Talbot (1992) and Pape (2003) were successful at embedding the strategies into the course content, possibly the best choice. To improve this study, using fixed-length, in-class training sessions, a minimum of 20-minute weekly sessions through most of the semester would probably be advisable.

Another difficulty related to my inability to embed the self-regulated learning strategies into the course content. This is a recommended approach to improve the effectiveness of the instruction (Kiewra, 2002). It involves describing and modeling the strategy, explaining why it works, telling where else it is useful, and providing practice in using the strategy (Kiewra, 2002). For best results, the strategies would be built into the course schedule from the beginning of the semester.

A common limitation of educational studies is how participants are selected and grouped for experimentation. In the case of this study, students' placement in mathematics class sections was predetermined. Thus, I was not able to randomly assign students to treatment and control groups. This non-random design and the limited sample size may have had an effect on the outcomes of the study. A larger sample tends to be statistically more representative of the population, and less likely to be influenced by a few extreme values.

A major difficulty in using self-report instruments is whether a participant can accurately report his/her feelings or emotions. Participants were not trained or given any guidance on how to rate their responses to the items in the instruments. In addition, the individual's frame of mind at the time of the evaluation may influence his/her responses. Furthermore, the responses may have been affected by the fact that an outsider was watching as they completed the instruments.

All the same, other researchers have used the instruments chosen for this study and found them useful. Numerous studies have incorporated the Mathematics Anxiety Rating Scale (Austin et al., 1992; Brady & Bowd, 2005; Brush, 1981) and its variants, the Revised Mathematics Anxiety Rating Scale (RMARS) (Baloglu & Koçak, 2006; Kazelskis, 1998; Preston, 1987), the Mathematics Anxiety Rating Scale Revised (MARS-R) (Malinsky et al., 2006), the Abbreviated Mathematics Anxiety Rating Scale (AMARS) (Alsup, 2004), the Mathematics Anxiety Rating Scale - Short (MARS-S) (Ashcraft & Kirk, 2001), the Mathematics Anxiety Rating Scale - Adult (MARS-A) (Tooke & Lindstrom, 1998), and the Abbreviated Mathematics Anxiety Scale (AMAS) (Hopko et al., 2003) – the measure chosen for this study. The instrument for measuring levels of self-regulated learning, the MSLQ, has been employed by several researchers studying college students, with acceptable results (Moore, 2007; VanderStoep & Pintrich, 1996; Wolters, 1998). The Praxis I® test, the source of this study's mathematics achievement test questions, is used by many states to evaluate the mathematics preparation of future elementary teachers. The Educational Testing Service (ETS) (2006), the creators of the Praxis test, warns that it cannot guarantee that the results are representative of actual student achievement. However, the decision to use only 10 items may have been ill formed. The 20-item MAT, that had been pilot-tested, would have been a better choice.

The small sample size, 15 in the treatment group and 14 in the control group, had the effect of reducing the power of any statistical analysis. It also restricted the use of ANOVA-type statistical analysis. The pilot study offered a larger number of participants, but the environment was not conducive to presenting the treatments in the classroom, so none decided to participate in the intervention.

Reliability issues plagued some of the instruments involved in the current study. The low value of Cronbach's alpha for several of the analyses detracted from the usefulness of the study's findings. The use of test-item correlation analysis reduced the number of items available for study when it was successful at improving the reliability. This may have affected the validity of the results by removing important items. The reliability issues related specifically to the MAT, MSLQ, and the Organization, Reading, and Time Management subscales of the MSLQ.

The MAT was another issue. The restructuring of the mathematics achievement test from the pilot's 20 items to the current study's 10 items could have been done more carefully. Instead of choosing the 10 items from the 20 used in the pilot study, the 80-20 rule (which requires selecting items whose standard deviation is either in the top 80% or the lower 20% of all items) could have been used to create a more representative subset of the original set of questions. As noted previously, the pilot study's 20 questions had an acceptable reliability, while the current study's 10 questions did not. Some of the validity of the original set of items may have been lost also. In retrospect, it would probably have been better to keep all 20 questions for the current analysis, even though there were time constraints.

Qualitative data collection was not a part of this quantitative quasi-experimental design. A different design might have included interviews with several students at the beginning and completion of the study. Another possibility would have been having the students complete journals of their behaviors on a regular basis. Open-ended questions as part of the survey instrument may also have proven useful in providing more explanations of student interpretations of strategy use and their understanding of self-regulated learning as a result of the training. However, these qualitative areas were not explored during this study.

Finally, any conclusions drawn from this study are limited to populations similar to the one on which this research is based. Caution must be used in generalizing these results to other populations.

Implications for Practice

This study provides some insight into the relationship of aspects of self-regulated learning strategies to math anxiety. In my correlation analysis (r = -.64, Table 4.2), test anxiety was related to math anxiety and, therefore, should be considered in efforts to improve how students approach mathematics test preparation and test taking. Organization skills may also be amenable to improvement through classroom intervention. Although the current study's data was tainted by low reliability of the instruments, it is possible that the intervention had beneficial results on students' organizational and other self-regulated learning behaviors.

The literature suggests that training in self-regulated learning strategies holds the potential for reducing math anxiety and improving mathematics achievement among preservice teachers. If this training proves beneficial to these future teachers, it can be expected that they will be more likely to create a positive learning environment for their students. As a result these preservice teachers may use their improved learning skills to become more effective and successful teachers of mathematics.

While this research study did not find statistically significant results in favor of the self-regulated learning strategies in reducing math anxiety among preservice teachers, there is substantial literature in favor of this approach (Cox, 2002; Miller, 2000; Norwood, 1994). Future studies will need to investigate this area further while implementing the strategies from the beginning of the semester and embedding them as much as possible into the content of the course.

The choice of testing instruments may have impacted the results of the study. Versions of the instruments exist that include substantially more items. A longer version of the mathematics achievement test, for example, may have elicited more variation in the test results. However, any lengthening of the instruments has the detrimental effect of making the pretest and posttest administrations longer, thus interfering with limited class time. Twice as many items were used during pilot testing of the MAT. However, the extra time needed to complete the entire test drew negative responses from many of the faculty members involved in the pilot study. Upon reflection, it may have been an inappropriate choice to reduce the number of items. The convenience of a shorter testing time goes against the goal of validity and reliability in the use of testing instruments. Therefore, I would not recommend this practice in the future. According to the Educational Testing Service, the Praxis questions are appropriate for evaluating preservice elementary teachers. All the same, the items I chose may not have sufficiently reflected the mathematics content of this course. A more detailed analysis of the syllabus of the mathematics content of this course may have provided a higher correspondence to specific items used in the MAT. The other instruments used offer similar room for discussion. The 98-item MARS may have provided a different result than the 9-item AMAS, although studies have shown the AMAS to be a valid replacement (Hopko et al., 2003). Alternatives to the MSLQ exist, however the items chosen from the MSLQ appeared to reflect well on the self-regulated learning strategies being investigated, that is, they had face validity, although the reliability of some of the subscales turned out to be inadequate.

The current study looked at mathematics achievement among preservice teachers. The training in self-regulated learning strategies combined with traditional instruction was, at the least, found to be no less effective than traditional instruction alone. While it is likely that training in the use of these strategies would prove beneficial to the treatment group participants, the results of the study revealed no clear benefits to participants' mathematics achievement. By contrast, other studies have supported the use of self-regulated learning strategies to improve mathematics achievement (Betz, 1978; Hofer et al., 1998; McKeachie et al., 1985; Zimmerman et al., 1996; Zimmerman, 2001). No significant improvement in mathematics achievement may also be the result of the fact that both groups learned similar material using a consistent instructional method from the same professor. This may have tended to hide any changes in achievement. However, it is also interesting to note that the training sessions reduced class instruction time for the treatment group. This reduction did not have any negative effect on their achievement.

Conclusion

The results of this study are that this method of training in self-regulated learning strategies among preservice teachers produced no significant difference between pretest and posttest scores for the treatment group on any of the three test scales. Finding no difference suggests that the strategies were not effective in reducing math anxiety or improving mathematics achievement. However, the finding that there was no difference in MSLQ scores suggests that the training may not have been effective in encouraging the participants' use of self-regulated learning strategies. Therefore, it may be that the training approach was inadequate. Given a more effective training regimen, such as embedding the strategies into the syllabus, implementing training sessions at regular intervals beginning in the first week of the course, and frequently checking on student progress, the math anxiety and mathematics achievement levels of the participants may have improved.

Among research studies, most of the successful efforts at training students in self-regulated learning strategies involved a more in-depth approach. Learning to Learn courses for incoming freshman have shown improvement in these strategies through semester-long interventions (Hofer et al., 1998; Hofer & Yu, 2003; VanderStoep & Pintrich, 2003). While these Learning to Learn courses were not focused specifically on mathematics, the principles could be applied to a mathematics class. The faculty of the mathematics content classes should be made more aware of these strategies and their favorable outcomes in other courses. They would then be more likely to model these strategies for the future teachers under their influence. Embedding these strategies in the classroom content, building on prior knowledge and implementing the skills as the students are ready has been shown to be successful (Cox, 2002; Miller, 2000; Norwood, 1994).

The fact that the Organization subscale of the MSLQ showed statistically significant differences in the posttest scores suggests that the training had some effect, although there is a reliability issue here. It is possible that more time spent in training these students would be worth the trade-off in class time if the students are better able to prepare for class and for their tests. It would be fairly easy to integrate these strategies into a college mathematics education curriculum. Instructors could use the following strategies: (1) start with an overview of self-regulated learning at the beginning of the semester; (2) explore different strategies as mathematics topics warrant, highlighting test preparation as the first test approaches; (3) as students take more control of their own learning, the faculty could be more focused on the mathematical topics, rather than the routine questions concerning the minimum requirements needed to pass the class.

In conclusion, there exists very little research on the use of self-regulated learning strategies to reduce math anxiety. This study is an important step in adding to that knowledge. It shows that there is at least no detrimental effect in this training. Further research in this area would be beneficial.

Recommendations

The results of this study indicate that further research into training in self-regulated learning strategies is warranted. Such research may serve to provide further insights and to illuminate the advantages of this training. Some of the following recommendations refer to specific areas that were not thoroughly examined by this study.

1. A replication of this study should be performed with a larger sample of preservice elementary education students using a random assignment method to improve the statistical value of the results.
2. The self-regulated learning strategies should be embedded into the structure of the mathematics content course. Students should be taught self-regulated learning using scaffolding to develop deeper understanding of the individual strategies. The strategies should be introduced in the beginning of the course and developed throughout the semester. Training and follow-up at regular intervals, say once a week for 15 to 20 minutes over the course of a semester, would allow students the chance to learn and apply these strategies while the instructor and other students provide feedback.

3. Mathematics Achievement Test items should be closely matched to the requirements of the preservice elementary teachers mathematics content needs and related as much as possible to the syllabus of the mathematics content course.
4. The issue of student motivation may be related to math anxiety and mathematics achievement (Byrnes, 2003; Jones & Byrnes, 2006; Shores & Shannon, 2007; Zakaria & Nordin, 2008). The current study did not look at this area through any testing instruments, and is therefore unable to add to the discussion on this topic. However, it is an important area for further research.
5. Self-efficacy may be related to math anxiety and mathematics achievement (Bursal & Paznokas, 2006; Cooper & Robinson, 1991; Finney & Schraw, 2003; Pajares, 2005). This was not examined in the current study through any testing instruments, and I was therefore unable to add to the discussion on this topic. However, it is another important area for further research.

The use of self-regulated learning strategies was not shown to reduce math anxiety among preservice teachers in this study due to the various limitations mentioned above. However, future research should investigate if, without these limitations, self-regulated learning strategies can reduce math anxiety and improve the learning of mathematics concepts, leading to more effective mathematics teaching in the elementary classrooms.

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APPENDIX A

INFORMED CONSENT FORM

************* INFORMED CONSENT FORM *************

This project has been reviewed and approved by the Temple University Institutional Review Board. The IRB believes that the research procedures adequately safeguard the subject's privacy, welfare, civil liberties, and rights.

Project Title: <u>The effect of training in self-regulated learning on math anxiety and achievement among preservice elementary teachers in a freshman course in mathematics concepts</u>

Principal Investigator, address, phone: <u>Dr. Jacqueline Leonard, Dissertation Chair, Temple University, CITE Department (Math Education), (215) 204-8042; Charles Kimber, Doctoral Candidate, College of Education, (610) 269-1503</u>

I understand that the purpose of this study/project is <u>to determine if training in self-regulated learning will reduce the level of math anxiety of preservice elementary teachers taking a first-year course on mathematics concepts appropriate to the elementary education curriculum. Furthermore, does any reduction in math anxiety correspond to improved achievement in mathematics content knowledge?</u>

** I confirm that my participation is entirely voluntary. No coercion of any kind has been used to obtain my cooperation.
** I understand that I may withdraw my consent and terminate my participation at any time during the project.
** I have been informed of the procedures that will be used in the project and understand what will be required of me as a subject.
** I understand that all of my responses, written/oral/task, will remain completely anonymous.
** I understand that a summary of the results of the project will be made available to me at the completion of the study if I so request.

I wish to give my voluntary cooperation as a participant.

_______________________________________   ________________________
Subject Signature   Date

____
Print Name

APPENDIX B

ABBREVIATED MATH ANXIETY SCALE

Mathematics anxiety can be defined as the negative feelings or behaviors associated with the learning of mathematical concepts, solving mathematical problems, or performing everyday mathematical tasks. The Items in this questionnaire refer to things that may make you feel some amount of mathematics anxiety. Use the following scale to describe the level of mathematics anxiety that the statement makes you feel:

A = Low Anxiety, B = Some Anxiety, C = Moderate Anxiety, D = Quite a Bit of Anxiety, E = High Anxiety.

Remember there are no right or wrong answers; just answer as accurately as possible. Please do not write on this paper, put all answers on you Scantron form.

Low Anxiety	Some Anxiety	Moderate Anxiety	Quite a Bit of Anxiety	High Anxiety
A	B	C	D	E

1. Having to use the tables in the back of a math book.

2. Thinking about an upcoming math test the day before you take it.

3. Watching a teacher work an algebraic equation on the blackboard.

4. Taking an examination in a math class.

5. Being given a homework assignment of many difficult problems which is due the next class meeting.

6. Listening to a lecture in math class.

7. Listening to another student explain a math formula.

8. Being given a "pop" quiz in a math class.

9. Starting a new chapter in a math book.

APPENDIX C

PERMISSION TO USE ABBREVIATED MATH ANXIETY SCALE

Date: Wed 18 Jul 11:22:14 EDT 2007
From: dhopko@utk.edu Add To Address Book | This is Spam
Subject: Re: Math anxiety scale usage
To: Charles Kimber <ckimber@temple.edu>

Hi Charles:

You research sounds very interesting. May I suggest using my Abbreviated Math Anxiety Scale (AMAS) instead? The psychometric properties are much stronger and it's about the same length. I've attached the measure and you can read all about it's psychometric properties in a 2003 volume of the journal "Assessment." (I'd send you a pdf but don't have one). Best in your research.

Dr. Hopko

Derek R. Hopko, Ph.D.
The University of Tennessee
Department of Psychology
307 Austin Peay Building
Knoxville, TN 37996-0900
Phone: (865) 974-3368
Fax: (865) 974-3330

APPENDIX D

MOTIVATED STRATEGIES FOR LEARNING QUESTIONNAIRE

The Items in this questionnaire refer to your attitudes about this mathematics class. Use the following scale to describe how closely the statement reflects your attitude:

A = Not at All True of Me, B = A Little True of Me, C = Moderately True of Me,
D = Greatly True of Me, E = Very True of Me.

Remember there are no right or wrong answers; just answer as accurately as possible. Please do not write on this paper, put all answers on you Scantron form.

Not at All True of Me	A Little True of Me	Moderately True of Me	Greatly True of Me	Very True of Me
A	B	C	D	E

1. When I study the readings for this course, I outline the material to help me organize my thoughts.

2. When reading for this course, I make up questions to help focus my reading.

3. When I become confused about something I'm reading, I go back and try to figure it out.

4. When I study for this course, I go through the readings and my class notes and try to find the most important ideas.

5. I make good use of my study time for this course.

6. If course materials are difficult to understand, I change the way I read the material.

7. I make simple charts, diagrams, or tables to help me organize course material.

8. I find it hard to stick to a study schedule.

9. Before I study new material thoroughly, I often skim it to see how it is organized.

10. I ask myself questions to make sure I understand the material I have been studying.

Not at All True of Me	A Little True of Me	Moderately True of Me	Greatly True of Me	Very True of Me
A	B	C	D	E

11. When I take a mathematics test I think about how poorly I am doing.

12. I often find that I have been reading for this class but don't know what it was all about.

13. When I take a mathematics test I think about items on other parts of the test I can't answer.

14. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.

15. When I take a mathematics test I think of the consequences of failing.

16. When I study for this course, I go over my class notes and make an outline of important concepts.

17. I make sure I keep up with the weekly readings and assignments for this course.

18. I have an uneasy, upset feeling when I take a mathematics test.

19. I often find that I don't spend very much time on this course because of other activities.

20. I feel my heart beating fast when I take a mathematics test.

21. I rarely find time to review my notes or readings before a mathematics test.

APPENDIX E

PERMISSION TO USE MOTIVATED STRATEGIES FOR LEARNING QUESTIONNAIRE

Date: Tue 29 May 07:34:16 EDT 2007
From: Marie Bien <mabien@umich.edu>
Subject: Re: Permission to use MSLQ for research
To: Charles Kimber <ckimber@temple.edu>

I do not see that I mailed you a MSLQ but if you
have one then disregard the message below. I
have read your statement of use for the MSLQ and
you can use it in your project as you stated just
making sure the authors get credit for their work.

>I mail out the MSLQ for a fee of $20. Make your check payable to the
>University of Michigan. With this payment, you are allowed to use
>the MSLQ for your needs but making sure you give the authors
>credit.   You can copy the MSLQ for your needs
>and also put it on a password protected website
>for your people but do not distribute it outside
>of your group.

>Also, I am willing to send it out before I receive your
>check so you can get it as soon as possible. Please send me back
>your complete address and I will use that as my label. ...Marie
>
>____
>
>Marie-Anne Bien, Secretary
>The University of Michigan
>Combined Program in Education & Psychology (CPEP)
>610 East University, 1413 School of Education
>Ann Arbor, MI 48109-1259
>PH (734)647-0626; FAX (734) 615-2164
>mabien@umich.edu
>http://www.soe.umich.edu

APPENDIX F

MATHEMATICS ACHIEVEMENT TEST

Educational Testing Service guidelines forbid the release of testing materials to University Microfilms, Inc.

APPENDIX G

PERMISSION TO USE PRAXIS QUESTIONS

Date: Mon 11 Jun 10:42:00 EDT 2007
From: "HED Data Requests" <HEDDataRequests@ETS.ORG>
Subject: RE: Request for Praxis Test Questions
To: "Charles Kimber" <ckimber@temple.edu>

Dear Mr. Kimber,
I am pleased to inform you that your request to use Praxis test prep questions in your project has been approved. I will be forwarding your information to our permissions administrator in order to have a letter of agreement drawn up. Once you have reviewed and signed the agreement, please fax a copy to my attention before returning the original to ETS. We must receive a signed copy of this agreement prior to your use of the questions. I have included my contact information below. Best wishes on your project.

Sincerely,
Sharon Wagg

Ms. Sharon Wagg
Client Relations Specialist
Higher Education Division
ETS
Room L289O, Mail Stop 40L
Rosedale Road
Princeton, NJ 08541

(609) 683-2277 - fax

HEDDataRequests@ets.org
www.ets.org

APPENDIX H

LESSON OUTLINES ON SELF-REGULATED LEARNING STRATEGIES

Introduction to Self-regulated Learning.

- Presented overview on self-regulated learning with regard to setting goals, selecting strategies, monitoring effectiveness of strategies, adjusting strategies and goals, and attribution of results of strategy use.
- Provided information on the current research in self-regulated learning and its effects on student learning.
- Discussed three important types of cognitive strategies. These types of strategies include "(1) rehearsal, a surface level strategy, where students focus on memorizing and recall of facts; (2) elaboration, a deeper processing strategy, where students focus on extracting meaning, summarizing, or paraphrasing; and (3) organization, another deeper processing strategy, where students focus on organizing material through the use of outlines or drawing maps" (Zusho et al., 2003, p. 1084).

Reading a mathematics textbook for understanding.

- A mathematics text is not like an English or history text - the material is much more condensed.
- Set a goal of comprehension (requires active reading)
- Skim first. Pay special attention to overviews and summaries. Note any new words or topics. Note topics with which you are familiar;

this will allow you to activate your prior knowledge. Use this information to prepare questions for your reading.

- Ask yourself questions as you read to check your understanding of the material.
- Write a summary as you go through the reading. List steps or processes that you will need to remember. Write down any keywords and your own definitions. Develop mental images whenever possible. This will provide an alternative method of retrieving the information when you need it later.
- When material is difficult to understand, modify your reading approach.
- Use a concept map or other diagram to help you organize the ideas from the reading.
- Create an outline of the section. You can start with the subheadings from the text, but add your own descriptions and details.
- Consider general questions about the reading. What are the important points? How does this section fit with other sections? How does the reading relate to the lecture notes? Are there any topics that you still don't understand?
- Read the section before it will be covered in class so that you will be able to ask any troubling questions then. You will also feel more comfortable participating in class discussions.

Time management.

- Use an appointment book, either a handheld device or a paper booklet. Keeping track of your projects, meetings and other activities allows you to follow through on your goals. Research shows that organized students are more successful.
- Make a weekly schedule of classes and study times. Be sure to include part-time work and extra-curricular activities. Allow time for meals, sleep, and exercise, as well as the occasional party.
- Be flexible with your schedule. Allow for changes in your schedule, such as doing your mathematics studying in the morning, if it works out better that way. Errors in estimating how long different activities will take also may require adjusting your schedule. But don't give up.
- Prioritize your daily schedule. Identify what areas are of most immediate concern. Make a list that will allow time for all the necessary activities of the day. Be sure to schedule time for studying mathematics every day.
- Long-term assignments and mathematics exams need organized preparation. You can avoid cramming by preparing on a continuing basis.

Organization

- Organization involves establishing the right study area.
- Avoid distractions such as television or talking with friends when you are trying to study. Your cognitive system can get overloaded if you try to do too many things at once. Your brain will not be able to process all the information, so your learning will suffer.
- Set aside a specific place to study that is not used for other activities. This study area should not be confused with a place to eat, sleep, or socialize. Keep it reserved for study only so that when you go there your concentration will be focused on that one activity.
- Turn off the cell phone and the iPod during study time. Avoid updating your blog when you are using the computer to complete an assignment.
- Identify your strengths and weaknesses. Where needed get help. Be an adaptive help-seeker. Don't ask for answers. Ask how to do the problem. This should be a learning situation where you end up understanding how to do something rather than getting the answer to one exercise.
- Seek help from faculty members when you are having difficulty with the course material. Always prepare a specific question or topic that you wish to discuss. Try talking to him/her after class. Find out their office hours and go and visit at that time. Use email to ask a question.

- Use your peers as a learning resource. Identify one or two students in your class with whom you would be willing to share notes and discuss problems. That way if you miss a class you can easily get the notes and any assignments.

Test preparation and test taking

- Think of tests as an evaluation tool to determine what you have learned in the course. They also help you to evaluate your learning strategies, to determine which strategies are working and which need to be modified. Consider testing yourself in between teacher-given tests. Remember, this is a chance to evaluate your learning. Knowledge of your progress improves your likelihood of improvement.
- Avoid cramming. Stick to a schedule to prepare for the test. Remember to plan your time.
- When you receive the test, look over all the questions to determine the scope of the test and identify the easiest questions.
- Divide up your time for each question. If all questions carry the same weight, allow equal time for each question. Otherwise, allow more time for questions worth more points.
- Allow enough time to review your answers before the end of the allotted time span.
- Begin the test by doing the easiest questions first.

- Use the last few minutes to review your answers.
- Test anxiety may interfere with your ability to perform at your best.
- While some anxiety (or arousal) about a test is normal, too low a level of anxiety shows a lack of interest and would likely lead to poor performance. Similarly, high anxiety can affect performance due to interference with normal cognitive function.
- Research has shown that negative physical responses to stress can decrease your performance. Learn to relax. Plan to sit quietly for a short time before entering the testing room, or take a minute at the beginning of the test to relax. If necessary, stop and relax repeatedly as you continue with the test.
- Think about how you treat stress in other parts of your life, athletics, public speaking, theatrical performance, etc. If you have found ways to relax in these situations, apply them to test taking.
- Alternatives that may not always be available include asking the instructor for more time, to reduce the time pressure, and asking to take the test in a quiet area, such as a learning center or academic support center.

Estimation

- The NCTM Standards (2000) suggest that fluency in computation should be combined with the ability to make reasonable estimates. Estimation activities are recommended to encourage students to make connections among the mathematics concepts they are learning and the skills they are developing.

- Before attempting any complicated or lengthy mathematics problem, stop and estimate the final result. This will give you a point of reference when you complete your computations. This will also focus your attention on the method that must be used to solve the problem.
- Estimation still requires you to perform the same calculations that would be required if you were computing with the original numbers.
- The most common use of estimation for a class on elementary level mathematics content is to estimate the answers to numerical computations.
- A comfort level with computational estimation may make it easier for you to work with fractions, decimals, and percents, for example.
- Try to estimate answers before you do any real calculation. Estimation will not give you the exact answer to a computation, but it will help you determine if the answer is reasonable.
- Even with calculators mistakes can be made. Your skill at estimation will allow you to catch those "obvious" mistakes, such as too many zeros, or dropped digits in the computation.
- The basic idea with estimation is to trade some level of accuracy for doing a lot less work. Part of learning to estimate is learning when using estimation is appropriate, and when it's not.

- Like other strategies the effective use of estimation requires constant monitoring and reevaluation.
- Remember, an estimate is not a wild guess. It is a reasonable calculation using rounding to make the calculation easier.
- Estimation helps you build number sense by making you aware of the key elements of the problem.

APPENDIX I

STUDENT HANDOUTS

Constructing a To-Do List and Setting Priorities

Step 1. Make a list of all the courses you are taking.

Step 2. Under each of these courses, list the assignments, papers, and exams for each one. Attach a date to these, or sort them into short-term (such as this week) and long-term (such as last week of semester) tasks.

Step 3. List other general categories of things you have to do, such as Work, Social Activities, Community Service, Household Chores, etc.

Step 4. Under each of these areas, list things you have to do this week or this semester, and where possible attach a date to them.

Step 5. Now that you have a general list of all the things you have to do this week and this term, go through the list and think about your priorities. For example, if you have an exam this Friday, that will have priority over a final paper that is not due until the end of the term. Also, set priorities in the other categories, such as household chores. For example, if you need to go food shopping because you have no food in your apartment, that should be a higher priority than cleaning the bathroom.

Step 6. Now that you have established some priorities, take out your weekly calendar and start to put the higher priority items in appropriate places in your weekly calendar. For example, for the exam on Friday, you can study for it during one or two of your prime study times. You can go shopping for food Monday night, since you need to get food in the house for the rest of the week.

From VanderStoep and Pintrich (2003). *Learning to Learn,* p. 67.

Weekly time schedule

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
7 A.M.							
8 A.M.							
9 A.M.							
10 A.M.							
11 A.M.							
Noon							
1 P.M.							
2 P.M.							
3 P.M.							
4 P.M.							
5 P.M.							
6 P.M.							
7 P.M.							
8 P.M.							
9 P.M.							
10 P.M.							
11 P.M.							

Adapted from VanderStoep and Pintrich (2003). *Learning to Learn,* p. 62.

Organization

1. Your Study Area

- Beyond time management, organization also involves where you study.
- Set aside a specific place to study that is not used for other activities. This study area should not be confused with a place to eat, sleep, or socialize. Keep it reserved for study only so that when you go there your concentration will be focused on that one activity.
- Avoid distractions such as television or talking with friends when you are trying to study. Your cognitive system can get overloaded if you try to do too many things at once. Your brain will not be able to process all the information, so your learning will suffer.
- Turn off the cell phone and the iPod during study time. Avoid updating your blog or checking facebook when you are using the computer to complete an assignment.

2. Seeking help

- Identify your strengths and weaknesses. As you need it, get help.
- Be an adaptive help-seeker. Don't ask for answers. Ask how to do the problem. This should be a learning situation where you end up understanding how to do something rather than getting the answer to one exercise.
- Seek help from faculty members when you are having difficulty with the course material.
    a. Always prepare a specific question or topic that you wish to discuss.
    b. Try talking to him/her after class.
    c. Find out their office hours and go and visit at that time.
    d. Use email to ask a question.
- Use your peers as a learning resource. Identify one or two students in your class with whom you would be willing to share notes and discuss problems. That way if you miss a class you can easily get the notes and any assignments.

3. Scheduling

- Discuss the differences between college freedom and the prescriptive and tightly scheduled nature of high school. Request opinions and experiences about effective studying -- when they study best, where they study best, etc.

Time management

1. Ask students, individually or in groups, if they have ever taken an academic task and broken it down into weekly goals or steps. (Perhaps in previous school classes the teacher broke down a major project into a series of weekly tasks) Have you ever done such a task breakdown without teacher assistance?

2. Ask if any students have experiences with conditioning related to athletic performances or therapy while recovering from an injury. Using their examples, explain how such preparation or therapy has an ultimate or long-term goal which is achieved only when the long-term goal is broken down into a series of sub-goals or proximal goals.

Checklist for time and organization

1. Using appointment book or calendar or Palm - type device.
2. Using weekly schedule for classes and studying time
3. Scheduling other activities, such as eating, work, exercising.
4. Realizing the need to maintain a weekly schedule, yet be flexible.
5. Keeping a "To Do" list (weekly or daily).
6. Identifying a study space supportive of studying.
7. Knowing when to seek help and what to do when you are afraid to seek help.
8. Seeking help in adaptive ways.
9. Seeking help from faculty members.
10. Understanding and using peers as resources.
11. Developing and using peer study groups.

Test Preparation and Test-taking

1. Test preparation
   - Think of tests as an evaluation tool to determine what you have learned in the course.
   - Tests help you to evaluate your learning strategies, to determine which strategies are working and which need to be modified.
   - Knowledge of your progress improves your likelihood of improvement.
   - Consider testing yourself in between teacher-given tests.
   - Avoid cramming. Stick to a schedule to prepare for the test. Remember to plan your time.

2. Test-taking
   - When you receive the test, look over all the questions to determine the scope of the test and identify the easiest questions.
   - Divide up your time for each question. If all questions carry the same weight, allow equal time for each question. Otherwise, allow more time for questions worth more points.
   - Allow enough time to review your answers before the end of the allotted time span.
   - Begin the test by doing the easiest questions first.
   - Use the last few minutes to review your answers.

3. Test anxiety
   - Test anxiety may interfere with your ability to perform at your best.
   - While some anxiety (or arousal) about a test is normal, too low a level of anxiety shows a lack of interest and would likely lead to poor performance. Similarly, high anxiety can affect performance due to interference with normal cognitive function.

4. Relaxation
   - Research has shown that negative physical responses to stress can decrease your performance. Learn to relax. Plan to sit quietly for a short time before entering the testing room, or take a minute at the beginning of the test to relax. If necessary, stop and relax repeatedly as you continue with the test.
   - Think about how you treat stress in other parts of your life, athletics, public speaking, theatrical performance, etc. If you have found ways to relax in these situations, apply them to test taking.

Reading a Mathematics Textbook for Understanding

1. A mathematics text is not like an English or history text - the material is much more condensed.
2. Set a goal of comprehension (requires active reading)
3. Skim first.
   - Pay special attention to overviews and summaries.
   - Note any new words or topics.
   - Note topics with which you are familiar; this will allow you to activate your prior knowledge.
   - Use this information to prepare questions for your reading.
4. Ask yourself questions as you read to check your understanding of the material.
5. Write a summary as you go through the reading.
   - List steps or processes that you will need to remember.
   - Write down any keywords and your own definitions.
   - Develop mental images whenever possible. This will provide an alternative method of retrieving the information when you need it later.
6. When material is difficult to understand, modify your reading approach.
7. Use a concept map or other diagram to help you organize the ideas from the reading.
8. Create an outline of the section. You can start with the subheadings from the text, but add your own descriptions and details.
9. Consider general questions about the reading.
   - What are the important points?
   - How does this section fit with other sections?
   - How does the reading relate to the lecture notes?
   - Are there any topics that you still don't understand?
10. Read the section before it will be covered in class so that you will be able to ask any troubling questions then. You will also feel more comfortable participating in class discussions.

Estimation

1. The NCTM Standards (2000) suggest that fluency in computation should be combined with the ability to make reasonable estimates. Estimation activities are recommended to encourage students to make connections among the mathematics concepts they are learning and the skills they are developing.
2. Before attempting any complicated or lengthy mathematics problem, stop and estimate the final result. This will give you a point of reference when you complete your computations. This will also focus your attention on the method that must be used to solve the problem.
3. Estimation still requires you to perform the same calculations that would be required if you were computing with the original numbers.
4. The most common use of estimation for a class on elementary level mathematics content is to estimate the answers to numerical computations.
5. A comfort level with computational estimation may make it easier for you to work with fractions, decimals, and percents, for example.
6. Try to estimate answers before you do any real calculation. Estimation will not give you the exact answer to a computation, but it will help you determine if the answer is reasonable.
7. Even with calculators mistakes can be made. Your skill at estimation will allow you to catch those "obvious" mistakes, such as too many zeros, or dropped digits in the computation.
8. The basic idea with estimation is to trade some level of accuracy for doing a lot less work. Part of learning to estimate is learning when using estimation is appropriate, and when it's not.
9. Like other strategies the effective use of estimation requires constant monitoring and reevaluation.
10. Remember, an estimate is not a wild guess. It is a reasonable calculation using rounding to make the calculation easier.
11. Estimation helps you build number sense by making you aware of the key elements of the problem.