A MIXED METHODS INVESTIGATION OF DEVELOPMENTAL MATH STUDENTS' PERSPECTIVES ON SUCCESSES AND CHALLENGES IN MATH AND WITH MYMATHLAB

By

TASHA JEAN WELLS

A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF EDUCATION

UNIVERSITY OF FLORIDA

2014

To Jason

ACKNOWLEDGMENTS

This dissertation represents the culmination of a lifelong dream. Like any dream come true, there are many that encouraged and supported me throughout the years. I would like to take this opportunity to thank them.

To Jason, we did it! I could not have done this without your undying support. You continue to amaze me with your consistent patience and understanding. I could not imagine a more supportive spouse. You began this journey with me years ago and have endured the brunt of this daunting task. I will be forever in your debt. You recognized my love of education when we met as children and have always been my biggest fan. I know I can do anything as long as I have you by my side.

To Chloë and Aubrey, you have never known a mother that was not also a student. You have been there every step of the way, from sleeping quietly in a classroom at only a few months old to patiently waiting for dinner as I finished yet another assignment. You were my driving force and my constant inspiration to follow my dreams. I hope this degree inspires you to pursue and accomplish anything that your heart desires. If I can do it, you can too.

To my parents, Del and Janet, your belief in me has translated into many successes. You have given me the strength to see all my aspirations through to completion. I will continue to dream, knowing that you will always be behind me, with love and support.

To Albert, Swapna, my committee, and all of the wonderful faculty that I have encountered at the University of Florida, thank you for your wisdom, your timely feedback and your inspiration on this endeavor.

Thank you to Mark Wilson for giving me the opportunity to teach college preparatory math on campus. Through this opportunity, I realized my passion for adult education. You supported me from the beginning of this degree to the end. I appreciate your help in orchestrating my project at St. Johns River State College.

Finally, I have the utmost gratitude for every member of my cohort. Each one of you lifted me up and held me to the highest standard. I was a better student and will be a better scholar because of your influence. To those that have graduated, I am thrilled to be joining your ranks. For those that have not graduated, this is an arduous journey that you *will* finish in your own time. Regardless of status, I am proud to call you all colleagues and look forward to working together for years to come.

TABLE OF CONTENTS

APPENDIX

LIST OF TABLES

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Education

A MIXED METHODS INVESTIGATION OF DEVELOPMENTAL MATH STUDENTS' PERSPECTIVES ON SUCCESSES AND CHALLENGES IN MATH AND WITH MYMATHLAB

By

Tasha Jean Wells

May 2014

Chair: Albert Ritzhaupt
Major: Curriculum and Instruction

Math anxiety has been shown to affect students of all ages, regardless of gender, race or income level. While the origins are unique for each student, the detrimental effects are measurable and have been a concern for many researchers in the past forty years. Research on the origin, manifestation and alleviation of math anxiety is ongoing.

Systematic desensitization has been used to effectively treat many anxieties in the past, including math anxiety. Some computer-assisted instruction includes features of systematic desensitization in the immediate feedback delivered by the software. This study investigated the effects of that immediate feedback and the resources available within MyMathLab© while exploring factors that students associated with their successes and challenges in math.

A mixed methods approach was used to explore the student perspective on math and with MyMathLab©. A quasi-experimental pretest-posttest design was conducted to collect quantitative data with the intent to evaluate the effects of MyMathLab© on math anxiety, self-efficacy, and performance of developmental math students. Due to the limited sample size, only descriptive statistics were calculated. Following the study,

semi-structured interviews were performed to explore student history and experience with MyMathLab©. Three themes emerged from qualitative analysis of the interviews. Students associated their successes in math and with MyMathLab© with the following factors: positive feedback, organizational skills and resource availability.

CHAPTER 1
INTRODUCTION

Background

Developmental Students

The American Association of Community and Junior Colleges (AACJC) has defined developmental education as follows:

> [Developmental education programs] teach academically underprepared students the skills they need to be more successful learners. The term includes, but is not limited to, remedial courses… Effective developmental education programs provide educational experiences appropriate to each student's level of ability, ensure standards of academic excellence, and build the academic and personal skills necessary to succeed in subsequent courses or on the job. Developmental programs are comprehensive in that they access and address the variables necessary at each level of the learning continuum. They employ basic skill courses, learning assistance centers, Supplemental Instruction, paired courses and counseling. (AACJC, 1989, p. 115)

Organizations such as National Association for Developmental Education (NADE), National Center for Developmental Education (NCDE) and Developmental Education Initiative (DEI) are dedicated to research and education in the field of developmental education. Contributions from many developmental proponents can be found in the peer-reviewed Journal for Developmental Education (JDE).

According to the National Center for Education (NCES), over one third of all college freshmen require remediation in developmental programs (NCES, 2011). These numbers increase as income level decreases (Developmental Education Initiative, 2013). The majority of these students are placed into developmental mathematics over any other developmental subject area (NCES, 2003) and only a small number ever pass college algebra (Bailey, Jeong, & Cho, 2010). In an interview with the director of NCDE regarding improvements in developmental mathematics, Dr. Paul Nolting purports that one reason for this failure is that "students have anxiety which translates into avoiding math courses” (Boylan, 2011, p.21). Math anxiety limits the future for some developmental students.

Math Anxiety

Math anxiety can cause a student to feel like a failure (Tobias, 1978). For some students, physiological symptoms ensue, such as a sickening feeling rising up from the pit of their stomach at the mere mention of the word math. Other students are inhibited by the psychological symptoms of self-deprecating thoughts along with the flood of negative mathematical memories from their childhood. Tobias (1978) describes this overwhelming feeling:

> Paranoia comes quickly on the heels of the anxiety attack. ‘Everyone knows,’ the victim believes, ‘that I don’t understand this. The teacher knows. Friends know. I’d better not make it worse by asking questions. Then everyone will find out how dumb I really am.’ This paranoid reaction is particularly disabling because fear of exposure keeps us from constructive action. We feel guilty and ashamed, not only because our minds seem to have deserted us, but because we believe that our failure to comprehend this one new idea is proof that we have been ‘faking math’ for years. (p. 51)

Many factors, such as past math performance (Alexander & Cobb, 1984), can contribute to this overwhelming math anxiety. Every math student is distinct, therefore their multi-faceted math anxiety will be distinct as well (Bessant, 1995). Based on previous performance, each math student develops a unique math self-efficacy - a student’s beliefs regarding his or her ability to effectively perform mathematical tasks. Math self-efficacy is an important predictor for future math performance and math anxiety (Hackett & Betz, 1989). According to Hackett and Betz (1989), math anxiety is due to low math self-efficacy. Therefore, if math self-efficacy improves, future math performance should improve and math anxiety should decrease.

Math anxiety can indirectly affect achievement (Ashcraft & Krause, 2007; Hembree, 1990; Ma, 1999; Richardson & Suinn, 1972). Using the Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972), both Betz (1978) and Hembree (1990) determined that students with higher math anxiety levels tend to score lower on mathematics performance tests. The detrimental effects of math anxiety have led researchers to seek methods for math anxiety intervention (Alexander & Cobb, 1984). One example is cognitive modifications that build confidence in order to replace negative thought processes with positive thought processes (Hembree, 1990). According to Hembree (1990), treating the entire class with cognitive modifications did not appear effective; however, individualized cognitive modifications helped build confidence and reduced anxiety, which led to raised ability. Hembree’s (1990) best results were found with behavioral methods of systematic desensitization combined with the cognitive modifications. Systematic desensitization is a psychological intervention that begins with exposing students to simple math tasks that do not invoke math anxiety and gradually exposing them to more difficult math tasks, coupled with positive feedback, until math anxiety is alleviated at every difficulty level. These two components, systematic desensitization and cognitive modification, can be found as an integral part of some math computer-assisted instruction (CAI) software.

Many studies have shown a possible positive correlation between the use of CAI and math learning (e.g., Atkinson, 2003; Livingston, 2001; Mahmud, Ismail & Kiaw, 2009; Quinn, 2003; Spradlin & Ackerman, 2010; Traynor, 2003). CAI has also been shown to have a positive influence on math anxiety, confidence, retention, and future math success in comparison to traditional instruction (Cartnal, 1999; Crumb & Monroe, 1988; Kinney, 2001; Lancaster, 2001; Testone, 2005). According to Speckler (2009), MyMathLab©, a CAI program created by Pearson Education, leads to improvement in achievement, confidence, and participation among math students when it is a required grade component within a math course. Using CAI as an integral, graded part of a math course allows each student to receive individualized and immediate feedback at any time of day or night from any location. This individualized immediate feedback, which is similar in nature to systematic desensitization, may be what is needed to meet the affective needs of students with math anxiety.

When dealing with college students, remediation strategies that place emphasis on providing immediate feedback, individualization, and development of skills and concepts in a non-judgmental environment have proven successful in lowering math anxiety (De Bronac-Meade & Brown, 1982; Mathison, 1978; Wright & Miller, 1981). Another approach that has been effectively used is systematic desensitization (Hembree, 1990). Systematic desensitization involves gradual exposure to math until mathematical tasks become tolerable. Aspects of each of these components can be found as integral parts within MyMathLab©.

MyMathLab©

MyMathLab© is a CAI software accessible from anywhere via a web browser. Within the program, students are able to view how-to videos, step-by-step help with the ability to check their answers as they work (receiving hints that scaffold their understanding of the math topic) and similar example problems - all specific to each problem throughout the assignment.

This is an interactive program that is “modular, self-paced, accessible anywhere with Web access, and adaptable to each student’s learning style” (MyMathLab© Product

Info, 2011). The use of MyMathLab© can provide instruction that is individualized based on the material by providing specific, immediate feedback and applicable resources.

Subjectivity Statement

I began my teaching career as a "non-College of Ed" instructor. My bachelor's degree in computer science was not intended for teaching. Several months after graduating and trying to find a job in the computer science field, I settled for teaching middle school math. This was a high-need position in the county where I lived and the elective math classes I took in college qualified for a temporary teaching certificate in Florida. I began teaching in a school with many at-risk youth in April of 2005 with absolutely no teaching experience. I was the fifth teacher to attempt the position I was filling. The principal told me that if I could make it through those last two months, I could make it through any teaching challenge.

I survived the end of that school year and continued at the same school the following year. Only a few short months into my first full year of teaching, I fell in love with my job. I loved everything about it: the autonomy of the classroom, the children, the math, and, most of all, the opportunity to make a positive impact on children that needed a role model. As a "non-College of Ed" instructor, I was required to attain college credit hours in education courses while teaching in order to secure a permanent teaching certificate. I took this opportunity to return to college for my master's degree in math education.

Over the first five years of my teaching career, I moved between three different counties teaching middle and high school math. Having children of my own, I started to realize that the pressure of being a positive role model all day was affecting my parenting negatively at home. I was exhausted and began to look for another teaching outlet. I did not want to become a teacher that was too burnt out to be effective.

I left the public school system after five years. I began teaching as an adjunct instructor for several different colleges, both online and on campus. I was restricted to teaching only developmental math courses because of my master's degree in math education. I would have needed a master's degree in math to be able to teach higher level courses. After one year, I found that I was making more money than I did in the public school system and I could properly focus on my own children's education and upbringing. I have been teaching adjunct courses ever since.

When I began teaching without any background in education, I found myself taking a behaviorist approach in the classroom. In retrospect, I realize that I took this approach to help manage the classroom behavior issues more than the actual learning that was taking place. As I learned more about education, my approach to teaching took on a combination of behaviorist and cognitivist features. I found that behavioral aspects of my teaching increased the positive experience for my students. Their confidence and self-efficacy seemed to soar with appropriate reinforcement. Alternatively, I found that cognitive aspects of my teaching fit my learning style and understanding of math so that I could effectively teach my students. I provide structured notes and ensure that there is always a connection from one math topic to the next. This cognitive approach to teaching has appeared to increase performance. I still use a combinational approach to my instruction, finding that positive reinforcement seems to help my developmental students combat their math anxiety and that a cognitive teaching approach lends itself to assisting these students in filling any gaps in their math comprehension.

Identification of Need

As a math professor at St. Johns River State College (SJR State), I teach developmental math classes to students that are entering college. These students may have just graduated from high school or they may be returning to school after twenty years. I teach college preparatory courses in pre-algebra and introductory algebra that enable students to properly prepare for college level courses and have a greater chance to earn a college degree. Many of the students in my classes complain of high math anxiety, low math self-efficacy, and low past math performance.

As an instructor for almost a decade, I have taught from fundamentals of sixth grade math through calculus. My students have ranged in age from ten to seventy. During my experience as an instructor, I have witnessed math anxiety with all age groups. I have seen firsthand the debilitating effects that this phenomenon can have over a student. Students that have shown mastery of course topics through various exercises will freeze when a similar but new topic is introduced. During discovery exercises where students work together to determine the mechanics of a problem, entire cooperative groups have shut down feeling utterly helpless. I have seen diligent students give up when faced with a new mathematical challenge. I want to see all of my students succeed. Math anxiety plays a major role in that success.

Having taught as an adjunct instructor for several colleges, both for- and non-profit, I have had the opportunity to teach blended courses at a few colleges that allowed the use of MyMathLab©. I have observed improvements in my students' anxiety towards mathematics in classes where MyMathLab© was used for homework assignments and quizzes. Test scores increased and overall effort improved in classes where MyMathLab© was incorporated as a graded component of the course. These improvements were noted while simultaneously teaching similar level math courses at other institutions without MyMathLab©. It appeared that the noted alleviation of math anxiety was associated with the use of MyMathLab©.

My developmental students have had positive experiences with MyMathLab©. Many have expressed their increase in self-efficacy while exclaiming their unsolicited support aloud in class. The use of this program is supported and suggested by the SJR State Math Department. The adoption of this technology appears to be unanimous at SJR State. The general consensus seems to be that my developmental students like MyMathLab© and feel that it helps them improve in mathematics.

Research Questions

My prior experience and understanding of math anxiety interventions has led to the following research questions:

1. What factors do developmental students attribute their successes and challenges to in mathematics?
2. What factors do developmental students attribute their successes and challenges to with MyMathLab©?
3. What specifiable impact does MyMathLab© have on the math anxiety, self-efficacy and performance of developmental math students?

Methodology

Previously, I conducted a study asking a similar question regarding online college algebra students at a for-profit institution using the computer-assisted instruction software MyMathLab©. I ended with a small sample of 15 students and very contradictory results. Despite the research that claims an indirect relationship between math anxiety and math performance (Hembree, 1990; Ma, 1999; Richardson & Suinn, 1972), the few students that did exhibit improved performance did not present a significantly lower math anxiety level. My results were also contradictory due to the higher performance in students using textbooks versus students using MyMathLab©. CAI students were expected to perform highest based on past research (Atkinson, 2003; Livingston, 2001; Mahmud et al., 2009; Quinn, 2003; Spradlin & Ackerman, 2010; Traynor, 2003). The difference for the study presented here was that the courses were taught at a non-profit community college on campus with developmental math students. The change from a for-profit to a non-profit college, from college algebra to a developmental math course, and from online to on-campus students presented a very different sample. A mixed methods approach was used to further explore the many facets of math anxiety by triangulating the collected data.

Qualitative Method

The qualitative component of this study included interviews conducted after the completion of the course. Five students from the treatment group participated in structured follow-up interviews regarding the use of MyMathLab©. These recorded interviews were conducted over the phone by the researcher. The interviews were then transcribed and coded. Initial codes were created to begin organization of the data (Saldaña, 2009). Code sheets were developed for each unique code. Subcodes were identified while analyzing each code sheet. Finally, codes and subcodes were analyzed with a purposeful approach to identify any emerging themes including comparisons within each interview and between interviews (Boeije, 2002).

Quantitative Method

Due to the indirect relationship between math anxiety and self-efficacy (Hackett & Betz, 1989), math anxiety, self-efficacy, and performance were measured for this study to gain a multi-faceted understanding of math anxiety. The quantitative component of this study followed a quasi-experimental design with a non-randomized control group pretest-posttest design (Gribbons & Herman, 1997). The independent variable in this study was the mode of instruction and the dependent variables were mathematics anxiety, self-efficacy, and performance as measured by pretests and posttests. The null hypotheses were that there was no significant difference in the mathematics anxiety, math self-efficacy, and math performance of students in a MAT0028 Introductory Algebra course using the following modes of instruction: CAI using MyMathLab© and traditional textbook.

At SJR State, MyMathLab© is readily available to students in the bookstore or online at a cost of approximately $80. Due to the budgetary constraints of this project and the systematic desensitization incorporated within most CAI software, MyMathLab© was evaluated and selected as the CAI software for this project. Instructors at SJR State have the option to incorporate MyMathLab© as a part of their course requirements and are able to select and assign problems that directly correlate to textbook problems with different values.

The researcher was the instructor for this study. Two separate sections of the same course, MAT0028, were taught concurrently, meeting twice each week for three hours and ten minutes for seven weeks. Prior to beginning instruction, students were administered a survey including demographics, a question regarding whether or not the student has taken the course previously and failed, the Abbreviated Math Anxiety Scale (AMAS) (Hopko, Mahadevan, Bare & Hunt, 2003) and Math Self-Efficacy Scale (MSES) (Betz & Hackett, 1983). Math performance was also measured prior to instruction using a math performance assessment with 10 multiple-choice questions created by Florida's Department of Education and administered as an exit exam for college preparatory math courses throughout the state college system. For the next seven weeks, students received the same instruction and notes throughout the course. Students in one section of the course completed homework using MyMathLab©. These students received immediate feedback on their responses while the other section of students completed similar homework using a textbook and received written feedback on their responses at the next course meeting. Each group was allowed two attempts at all homework problems. Both sections took the same multiple choice quizzes and tests throughout the course. At the end of the course, students completed another AMAS (Hopko et al., 2003), MSES (Betz & Hackett, 1983), and a similar math performance assessment with 30 multiple-choice questions also created by Florida's Department of Education.

Assumptions

There are several assumptions concerning this study. The first assumption is that participants honestly answered all surveys and interviews throughout this study. Another assumption is that homework is a normal and necessary component of developmental math courses. The last assumption is that participants' performance on the core objectives for the course will improve from pre to post-study.

Limitations

Several limitations affected the design and results of this study: sample, instrumentation choice, time constraints and instructor assignment.

The sample in this study was determined by the individual students that registered for each course. It was not possible to control the enrollment of these courses for this study due to time constraints and the researcher's limited influence as an adjunct instructor. The results of this study are not widely generalizable but still hold value within a community college developmental math course.

Due to the time constraints of this study, the AMAS was chosen over Richardson and Suinn's (1972) MARS. The AMAS consists of only 9 items compared to the full version of MARS, containing 98 items. The AMAS has shown convergent validity with the 24 item version of MARS (Hopko et al., 2003). The brevity of this scale and its proven psychometrics (Ashcraft & Ridley, 2005) make it an appropriate choice for any math anxiety study.

Another factor affected by the time constraints of this study was the length of the study. This study was conducted during a seven week summer semester. Classes were over three hours in length which required covering multiple topics during each course meeting. Results may have differed in a traditional sixteen week course conducted in the fall or spring semester where each course meeting focused on only one new math topic.

The researcher was the instructor for the course. This could have led to a possible experimenter effect and bias in the results According to Rosenthal (2002), it is plausible that the researcher's expectations for this study may have unintentionally affected the responses of participants through nonverbal cues and other means of communication throughout the study. The design of this study included the same instructor for both courses to control for any instructional methodologies or characteristics that were unique to the instructor. The researcher recognizes that the instructor's inherent knowledge of the study may have affected the results.

Delimitations

This study does not explore the effect of adaptive computer-assisted instruction or intelligent tutoring systems on math anxiety. The prolific use of MyMathLab© at SJR State inspired this study. Newer technologies may have a greater effect on math anxiety; however, these technologies are not readily available in the researcher's professional environment. The software, MyMathLab©, was chosen for this study out of convenience. MyMathLab© is the only software readily available to students on campus at the bookstore and currently approved by the math department for inclusion within SJR State developmental math courses. The researcher recognized that other software may be a better fit for this study but chose the current software due to its availability and acceptance at SJR State.

The sample of this study is limited to developmental math students. These are students that are considered ill-prepared for the college environment. Developmental math students are identified by low scores on college placement tests upon enrollment. These students follow a prescribed developmental curriculum that must be mastered in order to proceed into college mathematics courses. Despite the differences between developmental and typical college students, literature surrounding both populations was included in this study. There are a limited number of studies specific to developmental math students, math anxiety, and CAI. Literature was extended to include the typical adult college population to enrich the review within this study.

Though math anxiety has been shown to affect students of all ages, the focus of this study was on developmental math students at a community college. To this purpose, literature regarding the use and effects of CAI on math anxiety and performance in elementary and secondary students was not heavily reviewed. The unique nature of the adult developmental student (discussed further in Chapter 2) requires specific instructional methods and techniques that do not coincide with literature regarding a younger population.

Research Bias

The researcher has been teaching math courses for nine years. Additionally, she has been using MyMathLab© as an integral part of some of those courses for over three years. The researcher chooses to incorporate MyMathLab© as a graded component of her math courses when it is optional. This experience with MyMathLab© gives the researcher a unique view of MyMathLab©, and its effects on math anxiety, self-efficacy, and performance.

Organization of the Study

This study is separated into five chapters. Chapter 1 is an overview of the study, including the problem addressed, purpose, and significance. A literature review of math anxiety, systematic desensitization, feedback and CAI is detailed in Chapter 2. Chapter 3 describes the methodology, including data collection and analysis. The findings from the study are explained in Chapter 4. Chapter 5 finishes with a discussion of the results, implications and suggestions for further research

Summary

Historically, my Introductory Algebra courses have an average completion rate of 60%. Students completing the course with a grade of 70% or lower are required to retake the class. Attrition is a possible challenge for this study and was considered when collecting and analyzing data. An attempt was made to interview students that dropped out of the course in order to determine the cause of withdrawal. Students were informed about the possibility of follow-up interviews when the study began.

The results from this research informed my future teaching methods within my professional practice when working with developmental students on campus. I currently place a major emphasis on the use of MyMathLab© and all of its available assistance components. Dependent upon the results of this research, MyMathLab© may or may not be supported for future use with developmental math students. As an instructor, I have the option to include MyMathLab© as a graded component of my courses. The results of this study directly affect my future instructional practices and implementation with developmental math students.

This study was conducted with the intent to publish the findings. The results from this study may encourage other researchers to conduct similar studies to determine the advantages and disadvantages of the use of MyMathLab©. Answering the above research question, through multiple studies, would allow instructors and administrators to make informed decisions about the inclusion of MyMathLab© in curriculum design. Identifying any relationships between the phenomena of math anxiety and math self-efficacy and the effects on math performance will add to the current body of knowledge surrounding the use of CAI. The results from this study may inform choices at community colleges in regards to the use of a CAI program for homework assignments. The results from this study will mean further inclusion for MyMathLab© in the limited literature regarding CAI, math anxiety, and math performance. As an adjunct instructor at SJR State, I find that one of the most difficult subjects for students is math. Compound that difficulty with the lack of study/organization skills, previous poor experiences in math, or test anxiety and learning math becomes nearly impossible for some students. Those students are overcome with anxiety at the thought of math and begin to experience the effects of math anxiety that can lower their performance ability and overall success in math (Hembree, 1990).

Definition of Terms

COMPUTER-ASSISTED INSTRUCTION-	"drill-and-practice, tutorial, or simulation activities either by themselves or as supplements to traditional, teacher-directed instruction" (Cotton, 1991)
MATH ANXIETY-	negative feeling(s) or reaction(s) associated with math
MATH PERFORMANCE-	student's level of mastery of course objectives
MATH SELF-EFFICACY-	student's beliefs regarding his or her ability to effectively perform mathematical tasks
SYSTEMATIC DESENSITIZATION-	psychological intervention that begins with exposure to increasingly difficult math tasks, coupled with positive feedback

CHAPTER 2
LITERATURE REVIEW

Some students shudder at the thought of math and quickly begin to experience the negative effects of math anxiety that can lower their performance ability and overall success in math (Ashcraft & Kirk, 2001; Hembree, 1990). Math anxiety causes "feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). Students that experience math anxiety are known to avoid math whenever possible (Alexander & Cobb, 1984; Ashcraft, 2002; Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007; Hembree, 1990; Ma, 1999; Turner et al., 2002), including putting off taking math classes until the end of their college degree and, in extreme cases, avoiding college altogether (Ashcraft & Faust, 1994; Ma, 1999). Avoidance of mathematics can influence a student's choice of degree major and possible career paths for life (Ma, 1999; Meece, Wigfield, & Eccles, 1990). Many researchers have reported that students experience a decline in mathematics performance due to feelings of negativity, such as shame or guilt, associated with math anxiety (Ma, 1999). "Highly math-anxious students, even when they attempt to acquire information, may be overwhelmed by their own anxiety reaction" (Ashcraft & Ridley, 2005, p.319). If there is a possibility for intervention and alleviation of math anxiety, this would afford students more opportunities both in school and life. The purpose of this literature review is to explore math anxiety and the use of systematic desensitization through CAI as a math anxiety intervention. The purpose of this literature review is to reveal any relationship between these subjects by drawing on prior research. Math anxiety has previously been alleviated with the use of systematic desensitization

(Crumb & Monroe, 1988; Hembree, 1990; Richardson & Suinn, 1973, Schneider & Nevid, 1993). This chapter will analyze whether computer-assisted instruction delivers components of systematic desensitization to alleviate math anxiety.

Methodology of Review

The research articles selected for this literature review concentrated on computer-assisted instruction, specifically in mathematics, mathematics anxiety, mathematics self-efficacy, meta-analysis in research, and systematic desensitization. To determine relevant research articles, several databases were employed: Education Abstracts Full Text – Wilson, EBSCO, ERIC and Google Scholar. The following journals were also reviewed for research articles: *Journal of Developmental Education* and *Journal for Research in Mathematics Education*. All research appropriate to this topic, regardless of date of publication, was reviewed.

The key terms used while searching these databases included: math anxiety, CAI, intelligent tutoring systems, computer-assisted instruction, systematic desensitization, MyMathLab©, self-efficacy, counter-conditioning, and meta-analysis. These search terms yielded many research articles and the following keyword pairings were used to filter the results farther: CAI and math, CAI and anxiety, math self-efficacy, counter-conditioning and anxiety, and CAI and meta-analysis. This filtering resulted in eighty articles and books that were included in this review.

Math Anxiety

The prevalence of math anxiety and its implications have made it a popular topic of research for educators and psychologists. Alexander and Cobb (1984) presented four areas of study that have emerged surrounding math anxiety: 1) instrumentation for measurement of math anxiety, 2) relationship between math anxiety and other variables, 3) phenomenon of math anxiety and its dimensions and 4) interventions for math anxiety. Each of these areas of research has a significant impact on the comprehensive understanding of math anxiety.

Instrumentation for Math Anxiety

Richardson and Suinn introduced the MARS in 1972. Elevated scores on the MARS test translate to high math anxiety. The authors presented the normative data, including a mean score of 215.38 with a standard deviation of 65.29, collected from 397 students that replied to an advertisement for behavior therapy treatment for math anxiety (Richardson & Suinn, 1972). For test-retest reliability, the Pearson product-moment coefficient was used and a score of 0.85 was calculated, which was favorable and comparable to scores found on other anxiety tests. Richardson and Suinn validated the construct of this test by sharing previous results from three other studies that were very similar to the results achieved in this study. They also administered the Differential Aptitude Test, a 10 minute math test including simple to complex problems. Calculation of the Pearson product-moment correlation coefficient between the MARS test and Differential Aptitude Test scores was -0.64 ($p < .01$), indicating that higher MARS scores relate to lower math test scores and “since high anxiety interferes with performance, and poor performance produces anxiety, this result provides evidence that the MARS does measure mathematics anxiety” (Richardson & Suinn, 1972, p. 553). This test was intended for use in diagnosing math anxiety, testing efficacy of different math anxiety treatment approaches and possibly designing an anxiety hierarchy to be used in desensitization treatments (Richardson & Suinn, 1972). The MARS test is of interest to those in counseling psychology (McLeod, 1994) and the test is used profusely in math anxiety research (e.g., Alexander & Cobb, 1984; Capraro, Capraro, &

Henson, 2001; Crumb & Monroe, 1988; Hembree, 1990; Norwood, 1994). It is available in several versions of varying length (Capraro et al., 2001) and is considered psychometrically sound (Alexander & Cobb, 1984). Other tests are often given to measure different dimensionalities of math anxiety, such as the Fennema-Sherman Mathematics Attitudes Scales (FSMAS) (see Table 2-1). The FSMAS evaluates nine

Table 2-1.Table of instrumentation taken from Ma's (1999) meta-analysis on math anxiety and performance

Summary of Instruments Measuring Anxiety Toward Mathematics (in Chronological Order)

Description of items	Number of items	Scale
Mathematics Anxiety Rating Scales (MARS) (Richardson &Suinn, 1972) Measure students' anxious reactions when they do mathematics in ordinary life and in academic situations	98	5-point Likert
Mathematics Attitude Inventory (MAI) (Sandman, 1974) Contains six scales, one of which is Anxiety Toward Mathematics, which measures students' mathematics anxiety in general academic situations	6	4-point Likert
Mathematics Anxiety Scale (MAS) (Fennema& Sherman, 1976) Measures students' feelings of anxiety and nervousness as well as associated somatic symptoms when students use mathematics	10	5-point Likert
Mathematics Anxiety Questionnaire (MAQ) (Meece, 1981) Measures cognitive and affective components of mathematics anxiety parallel to those of text anxiety: dislike, lack of confidence, discomfort, worry, fear and dread, and confusion and frustration	22	7-point Likert
Second International Mathematics Study Anxiety Scale (SIMS-AS) Measures the extent to which students feel afraid and scared of mathematics or feel calm and relaxed when they perform mathematical tasks	5	5-point Likert
Mathematics Anxiety Scale for Children (MASC) (Chiu & Henry, 1990) Describes various situations that can arouse mathematics anxiety – from getting a new mathematics textbook to taking an important test in a mathematics class	22	4-point Likert

specific domains using Likert-type scales: attitude toward success, mathematics as a male domain, mother's attitude, father's attitude, teacher's attitude, confidence in learning mathematics, mathematics anxiety, affectance motivation and mathematics usefulness (Fennema & Sherman, 1976). Despite the introduction of newer instrumentation, the use of the MARS test appeared to be the educational standard for measuring math anxiety due to its specificity and prolific use for many years (Ma, 1999).

In 2003, Hopko et al. introduced the Abbreviated Math Anxiety Scale (AMAS) which was intended for diagnosing math anxiety. This scale was composed of nine anxiety-related items answered on a 5-point Likert scale from *low anxiety (1) to high anxiety (5)*. These items included issues such as "having to use the tables in the back of a math book" and "thinking about an upcoming math test one day before" (Hopko et al., 2003, p. 180). Elevated scores on the AMAS test translate to high math anxiety. With a large sample size of N = 1239, internal consistency ($\alpha = .90$) and two-week test-retest reliability ($r = .85$) within the AMAS were excellent (Hopko et al., 2003). The strong association between the AMAS and the original MARS-R (a 24-item version of the original Math Anxiety Rating Scale) indicated convergent validity (Hopko et al., 2003), including replication of the finding concerning the pervasiveness of math anxiety in females (Hembree, 1990). When comparing AMAS total and subscale scores, moderate associations were found (r = .20-.54) indicating that the scale has some divergent validity with these measures (Hopko et al., 2003). Considering the brevity of the scale and reliability of the results, the "AMAS appears to be the test of choice for future work on math anxiety" (Ashcraft & Ridley, 2005).

Relationship Between Math Anxiety and Other Variables

Math anxiety indirectly affects achievement (Ashcraft, 2002; Ashcraft & Kirk, 2001; Hembree, 1990; Ma, 1999; Richardson & Suinn, 1972). Using the MARS test, Hembree (1990) determined that students with higher math anxiety levels tend to score lower on mathematics performance tests. Many factors, such as past math performance (Alexander & Cobb, 1984; Ashcraft & Kirk, 2001), can contribute to a student's math anxiety. While every mathematics student is unique, their multi-faceted math anxiety will be unique as well. Alexander and Cobb (1984) conducted a study to determine the various dimensions of math anxiety determined by the MARS test and to establish whether these variables can possibly serve as predictors for math anxiety in college students. Based on the analysis of MARS test results administered to 197 college students, the authors concluded that performance in high school math seemed to affect the level of math anxiety in college students. According to analysis of variance (ANOVA), students that completed Algebra II and those who scored well in Algebra I and Geometry exhibited less anxiety. The researchers suggested that high school grades be monitored carefully and that early intervention be offered as a means to reduce math anxiety in college students (Alexander & Cobb, 1984).

Past mathematics experiences, such as instructor interaction, earned grades, and available resources, create a student's math history. Based on previous performance, each math student develops a unique math self-efficacy. Self-efficacy is a person's beliefs regarding his or her ability to effectively perform particular tasks or behaviors. This type of self-awareness has been associated with a person's choice to attempt a task and their effort and persistence to see the task through to completion (Bandura, 1977). This perceived ability may affect students' choices in course enrollment and career choice (Hall & Ponton, 2005). Self-efficacy is very cyclical in nature. Past performance affects current self-efficacy levels, which then influences future performance (Bandura, 1977). Math self-efficacy is an important predictor for future math performance and math anxiety (Hackett & Betz, 1989). It is reasonable to assume that poor math performance will result in a low level of math self-efficacy. According to social learning theory, math anxiety is due to low math self-efficacy (Hackett & Betz, 1989). If math self-efficacy improves, future math performance should improve and math anxiety should decrease.

Beyond previous performance, other uncontrollable factors, such as gender, ethnicity and race, may also play a role in math anxiety. Hembree (1990) found that females experienced higher math anxiety than their male classmates but that there was no difference in the level of performance or avoidance between the two genders. Ho et al. (2000) found similar results in a cross-national study including the United States, Taiwan and China. However, the researchers did not find a difference in math anxiety levels between genders in China. This could be explained by effects of the People's Republic of China's one-child policy, implying that parents have high expectations for their only child, regardless of gender (Ho et al., 2000). Hembree (1990) found a higher rate of anxiety in Hispanic students whereas Tobias (1978) found that women and black males avoid mathematics due to beliefs that it is for white males. These are many variables that can play a role in a student's development of math anxiety.

Phenomena of Math Anxiety and Its Dimensions

Bessant (1995) presented the multidimensionality of math anxiety through an in-depth look at the results of the MARS test given along with the Study Process Questionnaire (SPQ). The SPQ determines a student's likelihood to utilize different types of study methods. These results are coupled to analyze any relation between math anxiety, learning approach, cognitive processes and attitudes towards math. The aspects of anxiety, attitude and instructional preference are detailed in Table 2-2 were measured within each category. The findings of this study confirmed that a student's learning orientation was directly related to specific types of anxiety. Bessant (1995) found that math test anxiety was a component of math anxiety but that other variables also factored strongly into high anxiety levels.

Table 2-2. Table of measured multidimensionality created from Bessant's (1995) findings.

Anxiety	**Attitude**	**Instructional Preference**
• General evaluation • Everyday numerical • Passive observation • Performance anxiety • Math test anxiety • Problem-solving anxiety	• Mathematics enjoyment • Scientific value • Educational value • Problem-solving enjoyment • Social	• Guided learning • Group-based learning • Weak study habits • Detailed learning • Textbook study

Test anxiety differs from math anxiety but is a major component of math anxiety (Alexander & Cobb, 1984; Bessant, 1995; Dew, Galassi & Galassi, 1984; Hembree, 1990; Ho et al., 2000; Ma, 1999). Test anxiety refers to the anxious symptoms aroused when a student is in a test-taking environment. This anxiety can manifest during a math test but is not unique to the type of material covered by the test. Test anxiety may occur during any test from language arts to martial arts. Math anxiety can encompass these same anxious symptoms but is not limited to the test-taking environment (Alexander & Cobb, 1984; Bessant, 1995). Test anxiety is triggered by a test where math anxiety is triggered by math.

Alexander and Cobb (1984) conducted a study with 197 Introduction to Psychology students, with differing majors and mathematical backgrounds to explore the multidimensionality of math anxiety. After administering the 98 item MARS test, Alexander and Cobb used the Mingeigen criterion which yielded 21 separate factors within the test. Within the MARS test, 34 questions were related to taking tests in math or courses related to mathematics and seven questions were related to fear and apprehension with regards to doing mathematical calculations. Over 40 questions from the MARS test fit within these two significant sub-constructs: math test/course anxiety and numerical task anxiety. These two components were also isolated by Rounds and Hendel (1980) and Brush (1978). Analysis of the scores showed that math test/course anxiety stimulated more anxiety than numerical task anxiety. These results showed that test anxiety was a strong component of math anxiety but that other factors were also involved (Alexander & Cobb, 1984).

Ho et al. (2000) presented two different manifestations of test anxiety: interference and deficit. Interference caused by test anxiety refers to the emotive effects of anxiety interfering with a student's ability to perform on a test. The deficit perspective refers to poor performance causing the test anxiety. The deficit manifestation implies that study or test-taking skills that are lacking lead to increased anxiety. These two different forms of test anxiety can be better categorized behaviorally into affective test anxiety, emotionality that causes interference, and cognitive anxiety, worry that is displayed through negative thoughts about performance or ability. Ho et al. found that affective test anxiety only showed a slight but significant negative correlation with test performance. However, this correlation was minimal in comparison to the strong negative relationship between cognitive anxiety and test performance (Ho et al., 2000). Math anxiety can also be evaluated with respect to these two factors: affective versus cognitive. For math anxiety, the affective emotionality component has a stronger negative relationship with math performance than the cognitive factor (Wigfield & Meece, 1988). This difference helps separate the studies of test anxiety and math anxiety. The stronger affective component of math anxiety will affect the choices of intervention for math anxiety.

Interventions for Math Anxiety

The prevalence of math anxiety, along with its detrimental effects, has researchers, psychologists, and educators seeking interventions to alleviate the symptoms. Multiple intervention methods have been attempted. Norwood (1994) found that developmental math students who experience math anxiety do not trust their mathematical or problem-solving instincts and do not feel comfortable in a learning environment created with the discovery-type approach. She presented a study of 123 developmental mathematics students placed in two groups: highly-structured/expository and conceptual/interrogative learning environments. Students that were determined to have high anxiety expressed more comfort in the highly-structured. Both teaching methods were comparable in improving mathematical achievement; however, only the highly-structured environment made an impact on reducing math anxiety (Norwood, 1994).

Beyond instructional changes, researchers have identified intervention methods for individual students, such as systematic desensitization. Systematic desensitization involves gradual introduction to math until mathematical tasks become tolerable. Students are exposed to simple math tasks and provided either positive reinforcement, such as “Great job!” for correct answers or encouraging scaffolding, such as “Great effort! Remember: a problem is not complete until you simplify your fraction,” for incorrect answers. Upon mastery of simpler tasks, students are gradually exposed to more difficult problems while provided with the same positive reinforcement and scaffolding.

Schneider and Nevid (1993) conducted a study on systematic desensitization and stress inoculation training used to treat math anxiety. They had three experimental groups: systematic desensitization, stress management training, and control. Schneider and Nevid's (1993) results indicated that both systematic desensitization and stress management training significantly reduced mathematics anxiety in college students. There was no significant difference between the two methods indicating that systematic desensitization and stress inoculation training would both be effective treatment methods. The control group did not show any reduction in math anxiety. The researchers noted no significant change in mathematics performance on an aptitude test (Schneider &Nevid, 1993).

Within a study that integrated the results of 151 studies surrounding math anxiety, Hembree (1990) attempted to identify four aspects of math anxiety: 1) correlating variables, 2) dimensionality of math anxiety, 3) a relationship between math anxiety and performance and 4) effective treatment for math anxiety. Hembree (1990) concluded that when math anxiety is reduced there is a consistent improvement in achievement. He presented the results of using various interventions in an effort to relieve math anxiety. Hembree measured the effects of each treatment by comparing post treatment scores of control versus experimental groups. One method that was tested included changes in instructional methods: introduction of microcomputers, small group work, and self-paced materials. This method and whole class cognitive treatment did not appear effective with mean effect sizes of -0.04 and -0.10, respectively. Amongst the 151 studies analyzed, systematic desensitization was often coupled with behavioral treatment, such as anger management and relaxation techniques. This method of treatment conducted outside of the classroom was highly successful with a mean effect size of -1.04 ($p < .01$). Relaxation techniques alone did not foster the same results with a mean effect size of -0.48. Another method that Hembree (1990) analyzed was cognitive modifications that build confidence by replacing negative thought processes with positive thought processes. Cognitive training using restructuring to help students build confidence and correct defective beliefs was moderately effective with a mean effect size of -0.51. Individualized cognitive modifications helped build confidence and reduced anxiety, which led to raised ability. Combination of cognitive restructuring with systematic desensitization resulted in a mean effect size of -1.15, comparable to the effects of systematic desensitization alone. The best results were found with behavioral methods of systematic desensitization combined with cognitive modifications (Hembree, 1990).

According to Leder and Grootenboer (2005), there are few studies that explore the connection between affective factors and mathematics learning and achievement. Hembree's (1990) results coupled with the evidence that math anxiety is more affective in nature than cognitive, tending towards emotionality rather than worry, suggests that a behavioral technique may be best suited to alleviate math anxiety symptoms. Because math anxiety manifests behaviorally and systematic desensitization is a behavioral psychological intervention, more research on this possible connection may be timely.

Systematic Desensitization

In a review of articles published by the *Journal for Research in Mathematics Research* from 1970 through 1994, McLeod (1994) found that results from numerous studies suggest that systematic desensitization can reduce mathematics anxiety. The dual-process theory of avoidance behavior describes the learning involved when a threatening stimulus evokes emotional responses and a person’s autonomic and central responses assert control over the avoidance response (Bandura, 1969). Essentially, a person is likely to avoid an aversive situation that has previously caused an emotional response. In an effort to reduce avoidance behavior, the therapeutic method of systematic desensitization was created to lower anxiety.

Systematic desensitization was introduced by Wolpe (1958) as reciprocal inhibition with this basic principle:

> If a response antagonistic to anxiety can be made to occur in the presence of anxiety-evoking stimuli so that it is accompanied by a complete or partial suppression of the anxiety responses, the bond between these stimuli and the anxiety responses will be weakened. (p.71)

Wolpe described the procedure of systematic desensitization in which a person is in a deeply relaxed state and instructed to picture images from a hierarchy of stimuli that provoke anxiety. Beginning with the weakest image in the hierarchy that does not trigger an emotional response, the treated person slowly graduates through the hierarchy of images until desensitized to the most aversive stimuli (Davison, 1968). This method was similar to Guthrie’s (1952) notion of counterconditioning where the stimulus is present but other more desirable responses shut out the aversive response. In counterconditioning, the stimulus becomes a conditioner of the more desirable responses and an inhibitor of the aversive response (Guthrie, 1952). Despite the widely acknowledged efficacy of systematic desensitization (Kazdin & Wilcoxon, 1976), there has been debate about whether systematic desensitization stems from an authentic counterconditioning procedure (Davison, 1968; Kazdin & Wilcoxon, 1976).

If systematic desensitization were not counterconditioning in nature, the pairing of relaxation with the hierarchical images that cause aversive responses would be deemed unnecessary (Kazdin & Wilcoxon, 1976). Davison (1968) compared the results of four experimental groups: systematic desensitization paired with relaxation, relaxation paired with irrelevant stimuli, exposure to aversive stimuli without relaxation, and a control group. Within-group changes evaluated by *t* tests for correlated means showed that systematic desensitization was the only method that resulted in significant lowering of avoidance behavior with $t = 4.20$ ($p < .005$). Davison's methodology showed that systematic desensitization stems from counterconditioning. Theoretical speculations surrounding the mechanisms behind counterconditioning are largely disputed (Bandura, 1969). However, many well-designed experiments have shown that systematic desensitization reduces avoidance behavior by lowering anxiety levels (Bandura, Blanchard & Ritter, 1969).

Bandura (1977) conducted a study that explored four aspects of self-efficacy: performance accomplishments, vicarious experience, verbal persuasion and emotional response. Of those components, emotional arousal was associated with fear and anxiety. Within this study, Bandura explored several modes of inducing emotional arousal in an effort to find an effective treatment method: attribution; relaxation, biofeedback; systematic desensitization and symbolic exposure. According to Bandura's findings, systematic desensitization can alter anxious behavior by manipulating efficacy expectations. Bandura found that the higher the self-efficacy following systematic desensitization, the less avoidance behavior was observed. If self-efficacy improves, future performance should improve and anxiety should decrease. Different treatments were deemed appropriate for each of the four aspects of self-efficacy. Systematic desensitization was shown to effectively treat the emotional arousal associated with anxiety (Bandura, 1977).

Kazdin and Wilcoxon (1976) reviewed 74 studies to find overwhelming data to support systematic desensitization as an effective strategy for an extensive range of anxiety-based problems. Systematic desensitization is an accepted behavioral therapy for anxiety. The challenge is providing people afflicted with anxiety disorders with the appropriate therapy.

Many people do not get the therapy that they need because of a lack of finances, a negative attitude towards psychiatry, or no access to therapy (Wright & Wright, 1997). Wright and Wright (1997) explain that computer-assisted psychotherapy provides patients with systematic feedback and promotes self-monitoring. Each of these components is central to cognitive and behavioral therapies. Since cognitive and behavioral therapeutic (CBT) methods do not usually require a relationship with a therapist, CBT psychotherapy is possibly more suitable for computers than other techniques (Wright & Wright, 1997). The benefits of providing computer-assisted psychotherapy are that it is cost-effective, available at the patient's leisure, and maintains consistent support without fatigue. This type of psychotherapy that utilizes CAI for systematic desensitization has effectively treated phobias (Wright & Wright, 1997). Wright and Wright analyzed studies on therapeutic software created to treat phobias between 1966 and 1997. The outcomes of the studies showed that computer-assisted therapy is effective. The researchers noted that this area of research is limited by small sample sizes and difficulty in using a control but, overall, computer-assisted psychotherapy seems promising based on lowered anxiety levels and patient satisfaction (Wright & Wright, 1997).

Feedback. Feedback has been considered an integral part of learning in both behaviorism and social cognitivism. In behaviorism, feedback is considered a type of reinforcement (Skinner, 1968). Positive feedback leads to continued behavior and negative feedback leads to aversive behavior in behavioral theory. Feedback plays a similar role in social cognitive theory, increasing and decreasing the likelihood of certain behaviors. However, according to social cognitive theory, feedback is a method for learners to identify errors in understanding and to make corrections in comprehension based on that feedback (Bandura, 1991). Both theories agree that feedback plays a role in performance.

While feedback has been shown to impact performance (Bandura, 1991), the method in which feedback is delivered is still under debate (Cole & Todd, 2003). Kulhavy and Stock (1989) suggest that delayed feedback is most effective. Delayed feedback allows the learner's misunderstanding indicated by a wrong answer to weaken where immediate feedback may be met with interference by a persevering incorrect answer. Kulik and Kulik found contrary results in a meta-analysis of 53 studies comparing immediate and delayed feedback (1988). Following the review, Kulik and Kulik theorized that immediate feedback is the most effective. Overall, whether delayed or immediate, feedback has been shown to result in increased performance and retention (Cole & Todd, 2003).

Feedback is a main component of systematic desensitization that has been shown effective in significantly reducing avoidance behavior associated with anxiety

(Bandura, 1977; Bandura et al., 1969; Davison, 1968; Kazdin & Wilcoxon, 1976; Wright & Wright, 1997). While it is not practical or probable for every student that experiences math anxiety to seek psychological help, it is plausible to employ certain cognitive and behavioral components of computer-assisted psychotherapy feedback that could work as intervention techniques.

Computer-Assisted Instruction

Instructional approach has a significant impact on developmental students' math anxiety and self-efficacy (Norwood, 1994). An instructional approach focused on memorization of math facts rather than understanding of deeper concepts has been associated with elevating levels of math anxiety (Greenwood, 1984). Finding an intervention method that can impact instructional approach on both an individualized and behavioral level would be ideal.

In a society infiltrated with technology, computers have made their way into instructional methods. The use of computers in education has been labeled many different ways:

- Computer-based education, training or instruction,
- Computer-assisted instruction,
- Computer-managed instruction,
- Computer-enriched instruction and
- Intelligent tutoring systems.

The most generic of these terms is computer-based education, which can broadly be defined as any type of computer use in education (Cotton, 1991). The terms following computer-based education above are more specific in nature, detailing the qualities or components of the computer use. CAI has been associated with drill and practice since the 1960s (Wenglinsky, 1998). It usually refers to "drill-and-practice, tutorial, or simulation activities either by themselves or as supplements to traditional, teacher-directed instruction" (Cotton, 1991). Computer-assisted instruction software may be similar to intelligent tutoring systems (ITS) but an ITS includes a mechanism for analyzing a student's abilities and providing appropriate scaffolding and feedback (Stern, Beck &Woolf, 1996). CAI contains behavioral characteristics (Koç, 2005) contrary to ITS which include constructivist concepts, such as Vygotsky's scaffolding (Stern, Beck and Woolf, 1996). Because most research on the relationship between math anxiety and computer use has been done with CAI, the definition of CAI above will be used for the remainder of this literature review.

Hundreds of studies have been done on CAI and the effects of its use on performance, motivation, self-efficacy and anxiety. Describing these individual studies in a chronological order will not adequately reveal the accumulated knowledge (Glass, 1977). Gathering the data found during these studies to analyze it in an organized, technical and statistical manner can be referred to as meta-analysis, a term coined by Glass (1976). Meta-analysis helps synthesize results from many researchers. This idea of research integration allows one study to be viewed with respect to many other similar studies to determine the collective findings. Meta-analysis provides researchers with a method to review hundreds of data points simultaneously, in an effort to identify patterns that may not be evident within a single study.

Looking at individual studies to analyze results can give some insight into possible correlations in any field of study (Glass, 1977). However, looking at many similar studies in comparison to each other can offer a stronger effect size and a broader view of the impact of the results as a whole (Glass, 1977). Several meta-analyses on CAI have been conducted in the past several decades. Each of these meta-analyses has amassed data from many researchers to determine the effects of CAI within education. The most notable meta-analyses have been conducted by Kulik and colleagues (Kulik, Bangert & Williams, 1983; Kulik, Kulik & Bangert-Drowns, 1984; Kulik, Kulik & Cohen, 1980; Kulik & Kulik, 1991).

Clark (1985) presented an analysis of Kulik and colleague's meta-analyses at the college level (Kulik et al., 1980), the secondary school level (Kulik et al., 1983) and the elementary school level (Kulik et al., 1984), in which average achievement gains of 4/10 of a standard deviation were reported on average for CAI over traditional instruction (Clark, 1985). These results were promising for CAI. Clark's recalculation, for 40 of the randomly chosen studies, produced a similar effect size of 0.49 (Clark, 1985). However, the main purpose for Clark's analysis was to identify serious flaws within CAI research methodologies. Clark is well-known for arguments in favor of instructional methods rather than media delivery (Clark, 1983). In this analysis, he was able to identify two specific effects confounding CAI research: "same teacher" and "John Henry" (Clark, 1985). The "same teacher" effect refers to research methods where the same teacher delivered the CAI and traditional instruction to experimental and control groups. This method allowed for the greatest control of instructional method within a study. For studies that were identified to have the "same teacher" effect, Clark presented a recalculated effect size of 0.09. The "John Henry" effect describes the impact that teachers of the control group can have on the study when they put forth remarkable effort to "defeat" the technology instruction. This effect could explain results from studies indicating traditional instruction is more effective than CAI. The main issue found with CAI research is “the emphasis on *whether* things worked rather than why things worked” (Clark, 1985). According to Clark, identifying the instructional method that would cause an increase in performance is more important than the vehicle of delivery for that instructional method (Clark, 1994).

The combination of data from multiple weak studies can combine to form a strong conclusion (Glass, 1977). According to Glass (1977), “respect for parsimony and good sense demands an acceptance of the notion that imperfect studies can converge on a true conclusion.” Noting multiple defects can easily transform into a conspiracy theory (Glass, 1977). The best use of the possible confounding effects would be to inform researchers on better practices for internal, external, and construct validity in meta-analysis research.

Kulik and Kulik (1991) performed another meta-analysis of 254 studies comparing student learning in courses taught with and without CAI. This meta-analysis supported the “same teacher” effect reporting a larger effect size in studies where different teachers taught control and experimental courses (Kulik & Kulik, 1991). Overall, this analysis reported that the average effect size of 0.36 for studies conducted in the years 1974 to 1984 surpassed the average effect size of 0.24 for studies conducted in the previous years 1966 to 1974 (Kulik & Kulik, 1991). This increase in effect size may be due to the increased capabilities of technology (Kulik & Kulik, 1991). On average, Kulik and Kulik (1991) found that CAI increased student test scores by 0.30 standard deviations. They also noted small positive changes in student attitudes towards computers and teaching. More recent studies on the effects of CAI and student performance indicate a similar overall positive effect (Christmann & Badgett, 1999;

Cohen & Dacanay, 1992; Fletcher-Flinn & Gravatt, 1995; Liao, 2007; Timmerman & Kruepke, 2006).

Many studies have shown a possible positive correlation between the use of CAI and math learning (e.g. Atkinson, 2003; Livingston, 2001; Mahmud et al., 2010; Quinn, 2003; Traynor, 2003). CAI has also been shown to have a positive influence on math anxiety, confidence, retention, and future math success in comparison to traditional instruction (Cartnal, 1999; Crumb & Monroe, 1988; Kinney, 2001; Lancaster, 2001; Testone, 2005). According to Speckler (2009), MyMathLab©, a CAI program created by Pearson Education, leads to improvement in achievement, confidence, and participation among math students when MyMathLab© is a required grade component within a math course. Aside from the benefit of not having to grade individual homework assignments, using CAI as an integral, graded part of a math course allows each student to receive individualized immediate feedback at any time of day or night wherever a student may be. This individualized immediate feedback, which is similar in nature to systematic desensitization, may be what is needed to meet the affective needs of students with math anxiety.

CAI and Math Anxiety

CAI software used in mathematics has many characteristics of systematic desensitization. MyMathLab© is a computer-assisted instruction software accessible from anywhere via a web browser. Within the program, students are able to view how-to videos, step-by-step help checking the answers as they work and similar example problems all specific to each problem as they work. Created by Pearson Education, MyMathLab© is "modular, self-paced, accessible anywhere with Web access, and adaptable to each student's learning style" (MyMathLab© Product Info, 2011).

According to recent studies, MyMathLab© has been shown to increase retention, passing rates and performance (Burch & Kuo, 2010; Buzzetto-More & Ukoha, 2009; Kodippili & Senaratne, 2008).

As students work through assignments in MyMathLab©, they receive immediate feedback upon completion of a problem. If the answer is correct, a positive “Nice job!” or “Well done!” is presented on the screen. If the answer is incorrect, students receive an encouraging comment and a hint related to the mistake they made when trying the problem, such as “Subtract the same quantity from both sides of the inequality.” Students have the ability to interact with the material and receive immediate feedback with the use of CAI. The immediate feedback and supportive interaction are qualities of systematic desensitization.

Considering the strength of the research regarding the positive effects of systematic desensitization in alleviating anxiety symptoms (Kazdin & Wilcoxon, 1976) and the purported ease of use with math CAI (MyMathLab© Product Info, 2011), there were surprisingly few studies where CAI was examined with math anxiety. McLeod (1994) reported many studies that supported the use of systematic desensitization to improve math anxiety; however, only two studies were found concerning the use of CAI as systematic desensitization to treat mathematics anxiety.

In the first study, Mevarech and Ben-Artzi (1987) performed a study with 245 sixth-grade mathematics students. They divided the students into three groups: CAI with fixed feedback, CAI with adaptive feedback, and a control. Students from all groups participated in traditional instruction. CAI students received three traditional lessons each week and two 20 minute sessions with CAI. Control students received four traditional lessons with no CAI use. The difference between the fixed and adaptive CAI groups was the form of feedback they received within the CAI software. For both groups, students had three attempts for each math problem. In the fixed CAI group, students received standardized responses of “very good,” “good,” and “correct” for each attempt, respectively (Mevarech& Ben-Artzi, 1987). For incorrect responses, fixed CAI students received the following message “You made a mistake. This was your first (second, or third) try. Please try again” (Mevarech & Ben-Artzi, 1987). For adaptive CAI students, the CAI software was programmed to respond differently for problems that were identified as raising mathematics anxiety, such as word problems and fractions (Tobias, 1978), with more positive comments: “Superb job, David!” “Very fine work!” and “You got it!” for each of the three attempts, respectively (Mevarech & Ben-Artzi, 1987). For other types of problems, adaptive CAI students received the same responses as fixed CAI students. Also for this group, incorrect responses simply received the messages “Think again” or “Try again” (Mevarech & Ben-Artzi, 1987). Prior to and after the treatment, students took a modified combination version of the MARS test, Mathematics Attitude Scale, and Test Anxiety Scale, testing six different factors. Students also took an achievement test after one year of instruction within their group. The analysis of the study results, using a two-way multivariate analysis of covariance (MANCOVA) then a separate ANCOVA for each factor plus achievement, showed that students in both CAI treatment groups tended to show lower anxiety levels for the “worries about learning mathematics” and “attitudes toward learning mathematics with computers” (Mevarech & Ben-Artzi, 1987). There was no significant difference between the fixed and adaptive CAI groups. Mevarech and Ben-Artzi’s (1987) study showed that math anxiety is lowered with the repeated use of CAI but that mathematical achievement was not affected.

Subsequently, Crumb and Monroe (1988) analyzed the use of CAI by seventeen developmental mathematics students with two groups. Both groups used CAI. However, only the experimental group used CAI that was specifically individualized to their needs. Crumb and Monroe did not give many details beyond the title of the individualized CAI, Computer Curriculum Corporation Math Skills (CCC-MS), and the company name that created the commercial software package used for the control group, Minnesota Educational Computing Consortium (Crumb & Monroe, 1988). Based on the results of this study, individualized CAI reduced math anxiety after 40 hours of instruction during one semester. Both groups showed improvement in computation; however, only the experimental group had reduced anxiety. The authors of this article called for a revision of the instructional strategy within the course and a larger group study (Crumb & Monroe, 1988).

Both of these studies presented convincing data for the support of CAI to systematically desensitize students with mathematics anxiety. Considering the age of these studies and the advancement of technology in general, CAI for mathematics (as seen with MyMathLab©) has grown exponentially. Further research on the effects of CAI on math anxiety would be opportune.

Summary

Based on the previous literature, the individualized components of CAI and the immediate neutral feedback may serve to systematically desensitize students to math. However, the effects of CAI on math anxiety have not been well substantiated empirically. Even though most studies regarding CAI and math do not evaluate the effects of CAI on math anxiety, it would be expected that positive gains in achievement or self-efficacy due to the use of CAI would be related to a possible connection between CAI and math anxiety. Consequently, the purpose of this literature review was to identify the possible direct correlation between math anxiety and CAI and demonstrate the need for more research in the area of effects of CAI on math anxiety.

In line with Clark's (1985) arguments regarding the flaws within CAI meta-analyses results that have been reported, the question is not whether CAI can reduce math anxiety. The more appropriate question would be whether CAI can effectively deliver the systematic desensitization treatment that has already been shown to reduce math anxiety. If CAI can serve as a form of systematic desensitization, this would be an affordable and easily-accessible treatment for students suffering from the negative effects of mathematics anxiety.

Previous research has explored the negative factors that create each student's unique math anxiety. Figure 2.1 shows the relationship between a student's math history and their math anxiety, self-efficacy, and performance. This figure also highlights the area where CAI may have an effect. The purpose of this literature review was to recognize what has been learned from previous studies and to emphasize the need for more research regarding CAI and math anxiety.

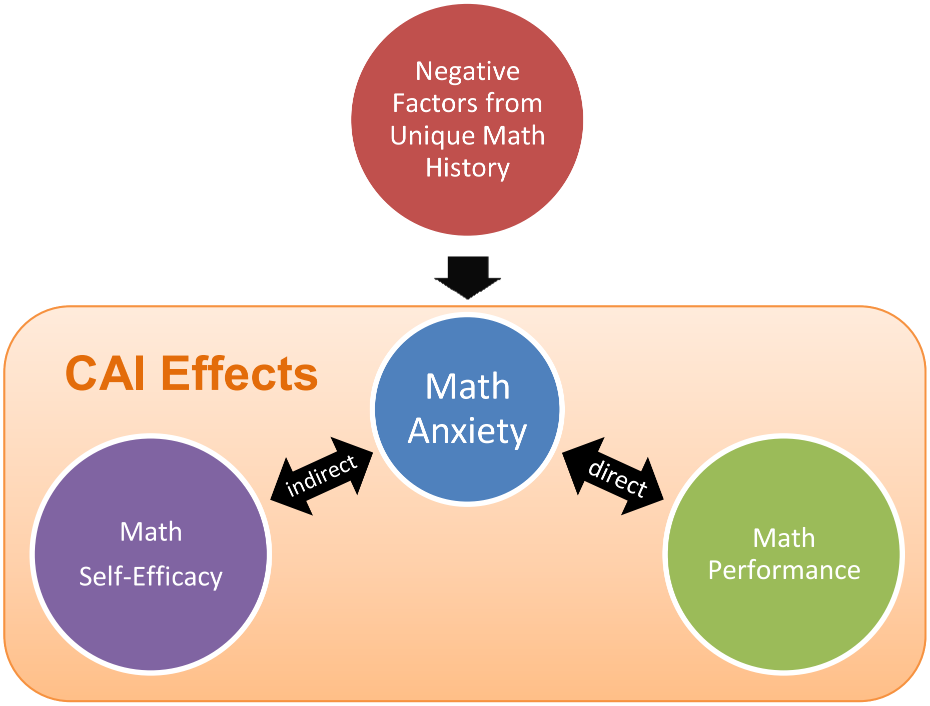

Figure 2-1. Illustration of Relationships Between Math History, Anxiety, Self-Efficacy, Performance, and CAI

CHAPTER 3
METHOD

This chapter details the procedures and methodologies used to conduct this study. The sample and setting are described in detail. Explanations of both the qualitative and quantitative components used in this mixed methods study are supported by prior published research and literature surrounding the nature of the data collected.

Purpose

The purpose of this study is to investigate the student perspective of personal successes and challenges in math. The following research questions framed this study:

4. What factors do developmental students attribute their successes and challenges to in mathematics?
5. What factors do developmental students attribute their successes and challenges to with MyMathLab©?
6. What specifiable impact does MyMathLab© have on the math anxiety, self-efficacy and performance of developmental math students?

Problem

Developmental mathematics students enter college lacking the mathematical skills necessary to graduate. Developmental mathematics intersect both K-12 and undergraduate mathematical skills; however, there are unique phenomena specific to this population that are under investigated (Mesa et al., 2012). Amongst these phenomena are high math anxiety and low self-efficacy, both leading to probable poor math performance. Many researchers have found that math anxiety can lead to math avoidance (Alexander & Cobb, 1984; Ashcraft, 2002; Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007; Hembree, 1990; Ma, 1999; Turner et al., 2002) which can be exhibited as behaviors such as postponing math classes until the end of a degree program to avoiding college completely (Ashcraft & Faust, 1994; Ma, 1999). Occasionally, math anxiety can result in a completely different choice in career path (Ma, 1999; Meece, Wigfield & Eccles, 1990). The role of the developmental instructor is to identify tools available to help these students become successful in math and, eventually, successful in college and life.

Earlier studies have shown that CAI may alleviate math anxiety (Crumb & Monrose, 1988; Mevarech & Ben-Artzi, 1987). Lower math anxiety levels have been shown to have a direct correlation with increased performance (Crumb & Monroe, 1988; Hembree, 1990; Richardson & Suinn, 1973, Schneider & Nevid, 1993). Ultimately, increasing performance will lead to greater success for developmental mathematics students.

Technology is rapidly changing and education is evolving with it. As new technologies emerge and are introduced into the developmental mathematics classroom, a deeper understanding of how that technology impacts student success is needed. The purpose of this study is to determine the impact of MyMathLab© on math anxiety, self-efficacy, and performance in developmental students while exploring how students' describe their successes and challenges with math and MyMathLab©.

Research Methodology

The problem of math anxiety addressed by this study is very complex. Both the origin of math anxiety and continued effects are intricately interwoven. In an effort to provide robust results regarding this topic, a mixed methods design was utilized (Creswell, 2009). Appropriate mixed methods research elicits the best that both qualitative and quantitative research has to offer (Creswell, 2009).

Quantitative methods are generally used to measure and quantify a "known" phenomena while qualitative methods tend to uncover the why and how surrounding a phenomena (Pasick et al., 2009). A mixed methods approach was used for this study to measure students' math anxiety, self-efficacy and performance while attempting to uncover the factors that students' associate with their unique successes and challenges with math. Recognizing that past events cannot be effectively described with quantitative data, a qualitative approach was selected to elicit student's perspectives on their experiences with math and MyMathLab©. A quantitative approach was selected to measure math anxiety, self-efficacy, and performance to build upon past research using tools that have previously been validated. Through triangulation of quantitative and qualitative data, this study was conducted to explore the 'what' and the 'why' behind students' experiences with mathematics (Johnson & Onwuegbuzie, 2004; Johnstone, 2007). A partially mixed sequential dominant status design was used with greater emphasis placed on the qualitative interview data collected after treatment (Leech & Onwuegbuzie, 2009).

Design

This section focuses on how the study was designed, including participant selection, data collection, instrumentation, data analysis and ethical considerations.

Participants

The sample for this study included developmental math students enrolled in two sections of MAT0028 Introductory Algebra at SJR State. This sample consisted of females and males between the ages of 18 and 64, with more than half of the sample over the typical college age (23+). The sample of this study consisted of students that remained in the course for the duration of this study and completed all scales and assessments both at the beginning and the end of this study.

Established classes were used for grouping. Students were registered for the courses by their academic advisor and could not be randomly assigned to the control or treatment groups. Courses are typically filled first with students requiring MAT0028 Introductory Algebra as the next course in their program of study, followed by students retaking the course having previously failed. Students in the first section of the course were assigned to the treatment group and students in the second section of the course were assigned to the control group.

Data Collection

The study began with an administration of math anxiety and self-efficacy scales and a performance pretest to garner initial levels of math anxiety, self-efficacy, and performance before the study. The final stage of the study concluded with the administration of the same math anxiety and self-efficacy scales and a performance posttest to determine any changes in levels of math anxiety, self-efficacy, and performance. Interviews were conducted with members of the treatment group. All data were then analyzed through triangulation to seek corroboration between the qualitative and quantitative data (Bryman, 2006).

Parallel lesson plans were created to keep both classes on the same track throughout the study. Every effort was made to deliver the same lesson to each class throughout the study; however, many unexpected events can affect the course of a lesson, from fire drills to health emergencies. A journal was maintained by the researcher in an effort to capture any differences between class meetings. The purpose of this journal was to make memos following each class meeting to chronicle the study.

Qualitative method. Upon completion of the course, all students from the treatment group were invited to do a follow-up interview. Interview questions were developed with the goal of drawing out each student's math history, from their earliest memory to their most recent experience with MyMathLab©. Five students participated in semi-structured telephone interviews with the researcher regarding their experiences in math and with MyMathLab©. Students were interviewed with the following probes as a guide:

1. How do you feel about math in general? Why do you think you feel that way?
2. Tell me about your earliest math experience.
3. What about your experiences taking math in high school?
    a. Did you take algebra?
    b. Describe a typical day in your math class.
4. Would you say you typically had more positive or more negative experiences taking math in secondary school? Could you give me an example of each?
5. Can you tell me about the last math class you took before our class together?
6. Compare that class to our class together. Any similarities or differences?
7. Tell me about how you did your homework for this class. Walk me through how you finished an assignment.
8. What did you think of MyMathLab©?
    a. Did you like doing homework in MyMathLab©? Why or why not?
    b. Would you take another course that required MyMathLab? Why or why not?

Quantitative method. The quantitative component of the study was quasi-experimental using the non-randomized control group pretest-posttest design (Gribbons & Herman, 1997). The independent variable in this study was the mode of instruction and the dependent variables were mathematics anxiety, self-efficacy, and performance as measured by the pretests and posttests. The null hypotheses were that there was no significant difference in the mathematics anxiety, math self-efficacy, and math performance of students in a MAT0028 Introductory Algebra course using the following modes of instruction: computer-assisted instruction using MyMathLab© and traditional textbook.

For all groups in this study, the course textbook, learning objectives, materials, and lecture notes were identical. The researcher taught both sections. One course was conducted as usual, using textbook problems for homework assignments graded by the instructor with formative feedback, as the control group. The other course was conducted substituting MyMathLab© assignments with similar practice problems in place of the textbook homework assignments as the treatment group. All individual assignments for the control and treatment groups consisted of the same number of problems. Identical multiple choice quizzes and tests were used for both courses.

Instrumentation

Math anxiety, self-efficacy, and performance were measured for this study to identify any relationships between the three. Math anxiety was measured using the AMAS, discussed in detail in Chapter 2, in original form so that this study's results could be compared with normative data acquired during previous use. Math self-efficacy was measured using the Mathematics Self-Efficacy Scale (MSES) developed by Betz and Hackett (1983). The MSES is made up of 52-items aimed at identifying a student's confidence level with varying mathematical tasks on a 10-point continuum scale from *no confidence at all (0)* to *complete confidence (9)*. Elevated scores on the MSES test translate to high math self-efficacy. The MSES was combined with the AMAS into a 61 question survey.

Math performance was measured using two similar math performance assessments with 30 multiple-choice questions (see Appendices A and B), created by Florida's Department of Education and administered as an exit exam for college preparatory math courses throughout the state college system. These tests were given during class in written form. Answers were recorded on Scantron sheets and submitted when complete. Below is a sample problem taken from the pretest:

Solve for x: $5w + 4x = 7k$

A. $x = \frac{7k+5w}{4}$

B. $x = 3kw$

C. $x = \frac{7k-5w}{4}$

D. $x = 7k - 5w$

The following is a similar problem found on the posttest:

Solve for y: $3x + 4y = 12$

A. $y = 12 - 3x$

B. $y = \frac{3x-12}{4}$

C. $y = 3 - 3x$

D. $y = \frac{12-3x}{4}$

Both problems test students for the ability to solve literal equations. Constants and variables are different between the two problems; however, the skill and level of the problems remain the same. Students in the Florida state college system were previously required to earn a 60% (18 out of 30) to pass this exit exam.

All students were instructed to participate in the online pretests and posttests and in class performance tests for participatory grades. To maintain anonymity and confidentiality, students were given an eight digit identifier consisting of their last four digits of their social security number followed by the last four digits of their phone number, such as 0444-5729. If the student did not have a phone number, 0000 was used for that portion of the identifier.

Procedures

During the first week of the course, students in the treatment group were given the graded assignment to complete three tasks before the second course meeting: math anxiety and self-efficacy combined scale, registration for a MyMathLab© account, and familiarization with the program. Students in the control group were given the graded assignment to complete one task before the second course meeting: math anxiety and self-efficacy combined scale. Both groups were administered the math performance pretest during the first course meeting with the instructions to answer to the best of their ability and to leave any answers blank for problems that they did not know how to solve. Students that completed each required task were awarded a participation grade of 100%.

For the remainder of the course, students in all sections of the MAT0028 course received the same lecture material/notes and took the same assessments. With the exception of homework assignments submitted throughout the course, students participated in all the same activities in the treatment and control groups. Homework assignments during the course were completed using MyMathLab© for the treatment group. Homework assignments during the course were completed without the use of CAI for the control group. All students were allowed two attempts at each problem. Students in the treatment group were allowed to try each homework problem twice through MyMathLab© with immediate feedback on the problem. Students in the control group were required to submit homework at the next class meeting. These students received formative feedback at the next class meeting with the opportunity to rework the homework problems and submit them a second time. The problems below demonstrate the differences between a similar problem given to the treatment and control groups.

Treatment problem (MyMathLab©, 2011):

Multiply. Leave your answer in exponential form.

12. $(9z^2)(8z^3)$

Control problem taken from the textbook (Martin-Gay, 2010):

Multiply. Leave your answer in exponential form.

12. $(3x)(-2x^5)$

Every type and level of problem presented in the textbook assignments was programmed into MyMathLab© for the treatment group. All students, both treatment and control, completed the same number of problems within the homework assignments throughout the course.

During the last week of the course, students in both the treatment and control groups were given the graded assignment to complete the math anxiety and self-efficacy combined for a participation grade. Completion of this task resulted in a participation grade of 100% for students in all courses. Students in all courses also completed the math performance posttest in class for a final exam grade. All scales and exams were due by the last day of the course.

MyMathLab©

When a student is working on a problem in MyMathLab©, various features are available to the student with a simple click on the button to the right of the computer screen. Five features were available to students in MyMathLab© throughout this study. These features are outlined in Table 3-1. Descriptions with further details follow.

Table 3-1. Description of Features in MyMathLab©

Feature	Step-by-Step Instruction	Auditory Component	Interactive	Creates New Problem	Available for Every Problem
View An Example	Yes	No	No	No	Yes
Help Me Solve This	Yes	No	Yes	Yes	Yes
Video	Yes	Yes	No	No	No
Text	Yes	No	No	No	Yes
Animation	Yes	Yes	Yes	No	No

View an Example. This feature is available for every problem that students encounter in MyMathLab©. MyMathLab© presents a similar problem with different numbers that is worked out already. Students click Continue to move through each step of the problem with descriptions of the method used for solving. This option is very similar to looking at a sample problem from the textbook. After viewing this sample problem, students are able to complete the original problem they encountered when starting the problem.

Help Me Solve This. Like View an Example, this feature is also available for every problem that students encounter in MyMathLab©. MyMathLab© presents the actual homework problem that the student must complete along with interactive steps provided as a guide. Throughout the guide, the student enters answers to parts of the problem and clicks Check Answer to determine whether it is correct. This helps students learn whether they comprehend the steps that are being given. If a student gets part of the sample problem incorrect, they are able to try again. After missing the answer twice, the guide will give the appropriate answer and move along to the next step. Upon completing the guide, a new problem is created for the homework assignment. Students must then complete a different problem for credit on the assignment.

Video. This feature is only available on select problems in MyMathLab©. Students are able to watch a video with a similar problem being worked on a white board with an instructor. This option is similar to watching a lesson in math class. After viewing the video, students are able to complete the original problem they encountered when starting the problem.

Text. This feature is available for all problems in MyMathLab©. This feature directly links students to the page in the book that gives details on how to complete the current homework problem. This option is similar to looking in the textbook itself. After viewing the text excerpt, students are able to complete the original problem they encountered when starting the problem.

Animation. This feature is only available on select problems in MyMathLab©. Students are able to view a slide show with a similar problem worked out using steps. The steps and problem are both written on the screen. There is an auditory component to this slide show instructing the student on how to complete the problem. Students must click on the “Next” button throughout the slide show to continue through the Animation. Hyperlinks are available within the slide show for vocabulary terms. Clicking on the link triggers a pop-up with the definition of the term. After viewing the animation, students are able to complete the original problem they encountered when starting the problem.

Data Analysis

Qualitative data. Each post-instruction interview was transcribed. Initially, each transcription was coded using descriptive codes to identify recurring topics and tabulate the content while trying to reveal each student's unique anxiety level, history with mathematics and experience with MyMathLab©. Initial codes were created to begin categorization in an effort to organize the data (Saldaña, 2009). Code sheets were then established using data from all five interviews for each unique code. After analyzing the code sheets, subcodes were created based on the relationships between the data. Finally, each code was analyzed with respect to any subcodes to look for causal relationships identified by the student. Each comparison allowed the researcher to enrich the complete picture (Boeije, 2002) regarding students success and failures in math and with MyMathLab©.

Quantitative data. Pretest and posttest scores for each student were collected. The sample size, mean, and standard deviation were organized by group and gender. Scores were omitted for students who did not complete any portion of the pretests or posttests.

Fourteen students were enrolled in the two courses for this study (6 in the treatment group and 8 in the control group). During the study, no students withdrew from either course. A total of twelve students participated in either both of the pre and post math anxiety scales or both of the pre and post math performance assessments, with five students in the treatment group and seven students in the control group. Nine were female and 1 was male. The distribution of the 10 students by group and gender is shown in Table 3-2.

Table 3-2. Distribution of Sample

	Male	Female	Total
Control	1	6	7
Treatment	1	4	5
Total	2	9	12

Ethical Considerations

Every effort was made to protect the participants in this study. Numerical identifiers were used in place of names and all data collected from participants were secured from the researcher until the completion of the course and grades were posted. Participation in the study posed minimal risk considering the instructional methods for both the treatment and control groups are currently used at the college. This study posed no physical or psychological harm to participants. Prior to beginning the study, participants were explained the nature of the study and that participation was voluntary. Confidentiality of data was and will be maintained at all times and participants' identification was not available during the study and will not be made available after the study. All participants signed an informed consent agreement prior to the start of this study.

Limitations

There were multiple limitations within this study including setting, data collection, and researcher's subjectivity. A description of these limitations follows.

Setting

This study took place at the St. Augustine, Florida campus of St. Johns River State College (SJR State). SJR State is accredited at a Level II by the Southern Association of Colleges and Schools Commission on Colleges. SJR State offers technical programs and two year degrees to students from ages 16 to 60. The college began offering a limited number of four year baccalaureate degrees in 2010. The college spans several cities with three campuses in Orange Park, Palatka, and St. Augustine, Florida. The purpose of this college is to meet both the educational and workforce needs of Northeast Florida. The St. Augustine campus sits in the heart of St. Johns County, a small county with a population of approximately 200,000. According to 2011 census data, 89.8% of the population is white with less than 10% of the population below the poverty level. 92.5% of St. Johns County residents over the age of 25 graduated from high school but only 39.3% hold a bachelor's degree or higher. The results from this study may not be generalizable in a different school setting.

Data Collection

Due to the low enrollment in developmental classes over the summer semester, this study was limited by the number of students enrolled in each course section which resulted in a small sample size. Participation in the study was voluntary; however, all students elected to participate. Participants may have been interested in the subject and apt to share more details.

Each of the post-instruction interviews was performed over the phone after grades had been submitted for the course. Phone interviews can have limitations because there is no opportunity for body language and the setting is unnatural, which can lead to less thoughtful answers (Shuy, 2003). Other limitations are interviewer effects such as the inability to see the interviewee (Rogers, 1976). Overall, the participants' responses were assumed to be true recollections.

Researcher's Subjectivity

The researcher served as the instructor for both courses within this study. In a typical class taught by the researcher, MyMathLab© is used for homework submission. The researcher's propensity towards using MyMathLab© as an integral part of each course may lead to subjectivism and possibly skewing qualitative data collected during this study (Johnson & Onwuegbuzie, 2004). A peer reviewer was introduced to validate codes and themes derived from qualitative data. Quantitative measurements were collected in an effort to preclude any bias, allowing for comparison between all data.

Summary

The purpose of this chapter was to detail the methods and design of this study with a focus on determining the impact of MyMathLab© on students' successes and challenges in mathematics. Participant selection, data collection, instrumentation, data analysis, ethical considerations, and limitations were described.

CHAPTER 4
RESULTS

This chapter will discuss emergent themes related to the three research questions: what factors students attribute their successes and challenges to in math, what factors students attribute their successes and challenges to with MyMathLab© and what specifiable impact MyMathLab© has on math anxiety, self-efficacy, and performance. A thorough description of how the qualitative data was organized and analyzed will be followed by detailed descriptions of the themes that emerged through the data analysis. Descriptive statistics will be presented for the quantitative data collected during this study along with qualitative data regarding math anxiety.

For this study, students elected to participate following a convenience sampling. Students enrolled in two sections of the course MAT0028 Intermediate Algebra during the summer term of 2013. Participants in one section of the course completed traditional homework using a textbook and participants in the other section of the course completed homework using MyMathLab©. All students elected to participate in the study, completing a pre and post math anxiety/self-efficacy scale and performance test. Each student in the study had previously taken the College Placement Test and was determined to be a developmental math student that required college preparatory courses in order to be successful in college level math classes.

Students in the MyMathLab© section of the course were invited to participate in semi-structured interviews following the completion of the course. Five students chose to complete the interview process. After grades were posted for the course, phone interviews were scheduled with the five students that chose to participate. A free and recorded conference line was used.

After the last interview, all interviews were transcribed. Following transcription, every interview was input into a protocol spreadsheet using Microsoft Excel. This allowed the researcher to view the interviews piece by piece. Originally, the protocol sheet was separated using the types of questions asked. Each answer was placed into a separate cell. Then, the researcher took a bottom-up approach to analyzing the data (Saldaña, 2009). Beginning at the bottom of the protocol sheet, each cell was read out of context to determine if notes about the question being asked needed to be added. For instance, "yes it was" would need clarification to determine what the interviewee was answering. Notes were added to cells where this clarification was necessary. While adding notes, initial codes were also determined based on each individual cell. Where necessary, cells were separated into two or more cells when more than one idea fell within the original cell.

After the initial organization and codes, a separate document was created with all cells alphabetized by code. Separate code sheets were then created for each different code. Unique codes with only one or two cells were not moved to a new code sheet. For instance, only one student commented that the material in the study course was harder than the student's previous course. This code remained on the alphabetized code sheet until all other code sheets were created. After all of the code sheets were created, the comments remaining on the alphabetized code sheet were reanalyzed for fit in the new code sheets. Codes that did not fit a specific code sheet were marked N/A.

All of the initial codes were written on index cards. These cards were manipulated to explore causal relationships. Following this exploration, code sheets were then recoded and any subcodes were identified. Three major themes were identified throughout: interviewees valued feedback, maintaining organization was a positive influence on success, and resources also lead to greater success. Themes and subthemes will be illustrated and described within the discussion of each research question that follows.

Due to the small sample size of this study, descriptive statistics were used to address the question regarding the impact of MyMathLab© on math anxiety, self-efficacy, and performance. Performing research in practice is unpredictable, including participation levels and unforeseen circumstances. Therefore, analysis of quantitative data for this study was limited. Subsequently, qualitative data was also analyzed in respect to the presence of math anxiety amongst participants and will be discussed later in the chapter.

RQ#1: What factors do students attribute their successes and challenges to in math?

The five students interviewed for this study described their successes and challenges in math by discussing the root causes of the problems they encountered. During each interview, participants were asked to give details about their personal experiences in math class from as early as they could remember through the last class they were enrolled in as part of the study. While each experience and recollection was unique, three themes emerged from the interviews as factors for successes and challenges in math: feedback, organization and resources. Figure 4-1 portrays these themes. Each factor will be described in further detail below.

Feedback

Feedback was a common theme across all the interviews. The importance that participants placed on interactions between student and teacher was prevalent, whether in person or in writing. Interviewees wanted to ask questions and get answers that improved their understanding of math. Questions were not an option for those

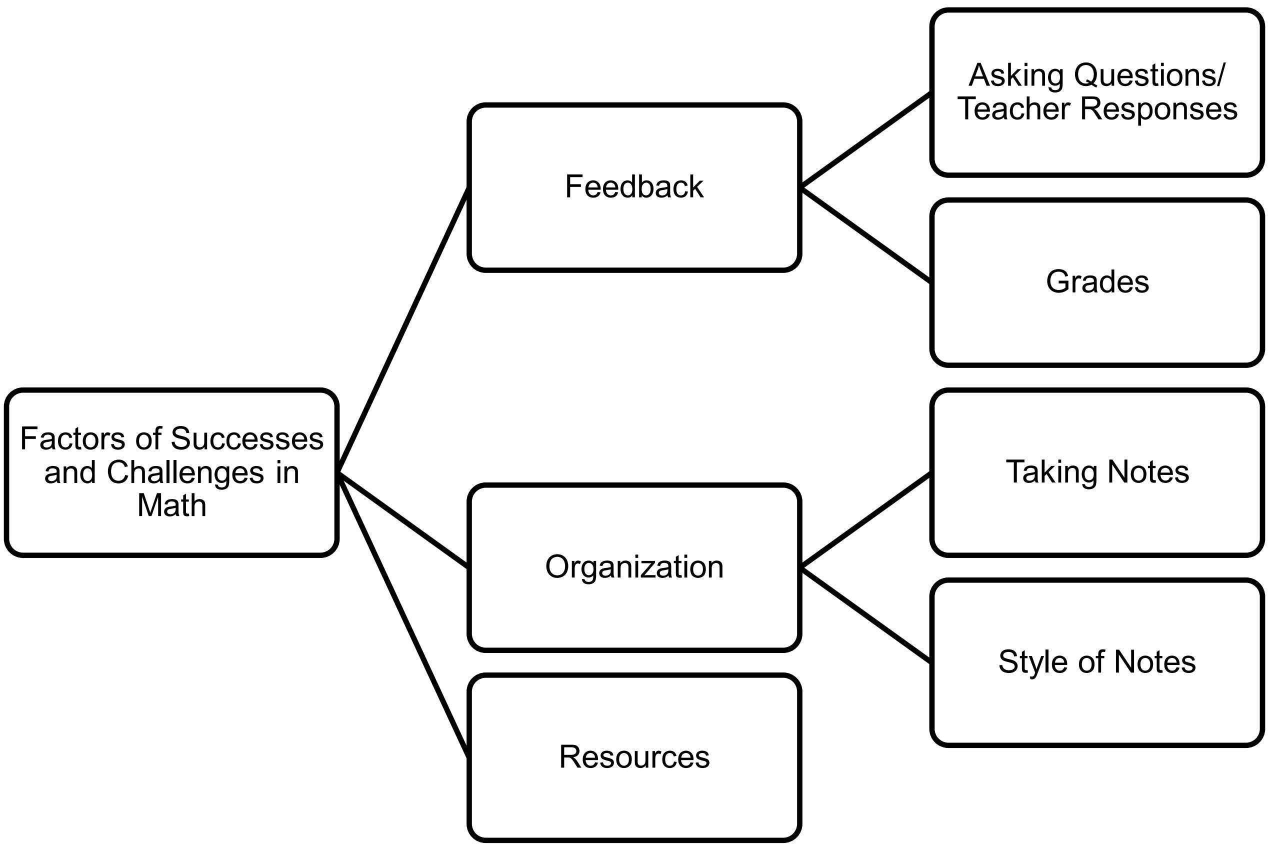

Figure 4-1. Factors of Successes and Challenges in Math

participants that had dealt with embarrassment or frustration during past experiences in math class. Some participants felt that the importance of asking questions overrode the fear of being uncomfortable and were uninhibited in the quantity or quality of their questions in math class. Interviewees also mentioned the value they placed on getting graded feedback while taking a math class. Earning a good grade was important to some interviewees but earning a passing grade was important to all of them. Participants discussed their experiences asking questions of teachers, including the teachers' responses, and receiving grades in math class. Figure 4-2 illustrates this relationship.

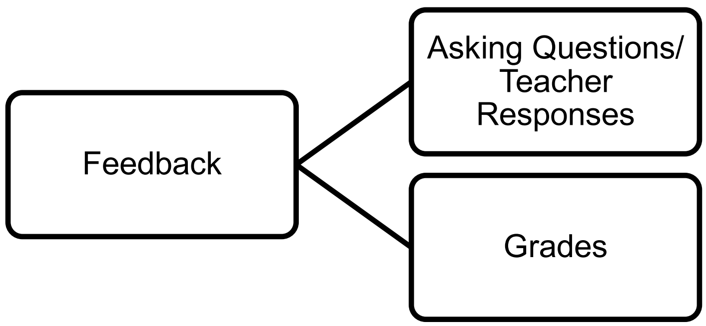

Figure 4-2. Feedback Subthemes for Math History

Asking questions. Throughout the interview process, participants recognized the importance of asking questions for clarification in math class. Gaining a better understanding through more explicit explanations would help participants in their comprehension. Participants also believed that questions asked in class could provide further clarification for classmates as well. Asking questions in class was a topic mentioned by students in every interview conducted for this study.

One participant stated, "I have to ask questions. I noticed at a very, very early time that in math if you don't ask questions … if you don't get it right away, then you're just going to be lost even more down the line because everything is a step for the next step." Another participant agreed, "Oh, yeah. I don't have a problem asking questions." In regards to aiding classmates by seeking further clarification, one interviewee stated "In my perfect mind … in my perfect world, I'm doing everybody a favor by asking so many questions."

Not all participants reported positive experiences asking questions in class though. Some participants chose not to ask questions in math class in the future based on the type of responses they had received from teachers in the past. Some teachers did not take the time necessary to make sure the participant understood. Other teachers had showed annoyance or disrespect to the participant for interrupting class with a question. Other interviewees were embarrassed to look ignorant in front of their peers or to waste their classmates' time with explanations.

One participant stated, "I felt like I was put on the backburner because I didn't really understand it. If I did ask for help, I did get it but it wasn't explained quite as well." Other teachers were described as "burned out" or "annoyed every time you would ask questions and propose a problem." Another interviewee asserted that "I think they cared a little bit about their students succeeding but it wasn't like they felt that they had to teach them well." Participants were met with unpleasant responses, as described here:

> Teachers … I can't think of one specific example, but it happened a few times, repetitively. I would ask questions and they would roll their eyes because I ask a lot of questions. That's what I need to do in order to learn the material. They'd get frustrated at me asking so many questions because a lot of the times it was just me asking those questions. Nobody else would. With the other students as well. They would get frustrated, because they'd see my hand go up in the air and I was that kid asking a lot of questions. They would just … they'd get irritated with me. Honestly, if I was in their shoes I'd probably feel the same way, but it was just … it was what I needed to do in order to pass the class and I'll do whatever I can.

One interviewee said the teacher "wouldn't write out steps. She would just do it and then just ask the class, 'Do you get it?' Since it was such a big class, everyone was like, 'Yeah, okay', and she would just go on." One instructor mentioned during the interviews was described as "hard of hearing so it was hard to understand for him and it was hard for us to understand him because he didn't know the right way to explain things. It's hard to understand what he was trying to say. It was just unclear when he tried to explain it." After many attempts to ask questions in past math classes, interviewees seemed exasperated with their efforts and were less inclined to ask questions in future classes.

Overall, the students interviewed realized the importance of asking questions to get the help that they need in math class. Some were conditioned by their past experiences to avoid asking questions in class. Others felt the end result of having a better understanding of a math topic was worth putting themselves at risk of embarrassment by the teacher or isolation from classmates. The act of asking questions that resulted in helpful responses was valued by all students interviewed for this study.

Feedback through grades. Another form of feedback that surfaced during the interviews was receiving grades. Participants were interested in their progress and to learn their level of mastery. Every participant wanted to earn a passing grade. Others earned higher grades in other subjects and were determined to work hard in math to earn similar grades. The grade itself represented feedback on mastery to each participant. A good grade translated to a good understanding of the material covered in math class.

After having a very difficult time passing math classes in high school, one interviewee exclaimed, "I felt like I won the lottery when I graduated." Another interviewee stated "I just threw myself into this class to get a good grade, I really tried hard at this" indicating the importance of earning a good grade in math class. The student went on to tell a story about having a grade of 107% in class and completing an extra credit assignment with hopes of increasing her grade even higher. She said, “I did it and I got a 100 on it, but if I had paid attention to the math I would have realized that that would bring my grade down, so it did.” Other participants expressed their relief that they were “just able to pass, just be done, just get through it and just pass” math class. Earning a passing grade and being able to comprehend the material was important to all students interviewed for this study.

Organization

Along with feedback on their performance and understanding, interviewees indicated that organization was another factor in their successes and challenges with math. Taking notes and different styles of notes were mentioned throughout the interviews. Participants discussed how teachers delivered notes and how they managed the notes. They were most interested in having notes as a go-to resource outside of the classroom when completing math assignments on their own. Figure 4-3 displays this relationship.

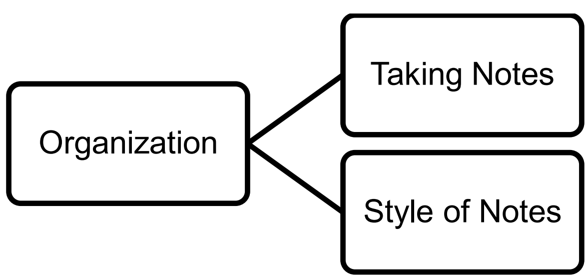

Figure 4-3. Organization Subthemes for Math History

Taking notes. Interviewees made many references to taking notes throughout their math career. They discussed note-taking as a common part of every math class. Teachers would work out problems on the board or on a projector while participants copied. Participants discussed their efforts to capture as much information as possible in order to have a great resource to go back to. Sometimes interviewees were unclear on what was important and what was not so they attempted to write down everything they could. They found it challenging when teachers did not provide them with notes in an organized or clear manner. Keeping these math notes organized in a notebook was also important to participants. A well-organized notebook was mentioned as an aid in interviewees' successes with math.

Participants described the note-taking process in detail. When discussing a past teacher, one participant recalled, "I know she tried, and she would actually do the problem and tell us the steps, but … She would just tell them to you." Another participant expounded that the teacher "did take it step by step. She wouldn't write the steps out but she would do the math." Interviewees preferred when teachers would write out the actual steps for the math problems, not just solve them. Upon comparison between the last class taken before this study and the class taught by the researcher, one participant said to the researcher during the interview that she was not as apprehensive about math class "because you did really good notes, and you write out the steps."

Not knowing what information was most important in class, one participant tried to capture every detail she could and stated, "I'm writing down everything he tells us and everything that he writes down." When a teacher would write the chapter and section numbers on the board, this student stated that "it helped keep it organized in my notes, so that I would be able to look back in the textbook later on if I was having any problems." Because of their uncertainty and unfamiliarity with the math topics, interviewees were not sure exactly what they would need as a reference for later so they attempted to write down everything they could.

Three of the students interviewed felt that note-taking was a key factor in their math successes. An organized notebook became a sought after tool when conquering math problems away from school without the aid of the teacher. When teachers did not teach math topics in an organized, step-by-step manner, participants struggled with what to capture from the lesson.

Style of notes. Throughout the interviews, students mentioned a preference for solving mathematical problems using a step-by-step approach. Participants stated that they preferred the notes given by the researcher which were typically formatted using a step-by-step approach. One participant mentioned using the Cornell method for taking notes as well. This method allowed students the spacing on their paper to copy the lesson as it was taught with additional room to reflect on these notes. Students could use the additional room to write questions that were still unanswered, to reword the notes that were taken in class or to list additional resources for the topic. Interviewees continuously noted the significance of taking notes and having a step-by-step method for each topic to use as a reference when solving math problems on their own.

A participant, indicating the importance of taking notes, stated, "I think I'm the type that I need to see the steps and actually write it down for my notes step by step. I can't just be told." The student that mentioned the Cornell method stated that this process helped when teachers did not write the steps out on the board saying, "On the side of my notes, I would write step by step or try to do step by step from what I understood." This student described the Cornell method in detail:

> It's got a two inch margin on the left hand side of your paper. You fold it in half or draw a line down the side of it, whichever you please. It left room for questions or extra help or just anything you really needed over there. On the other half of the paper you'd write the notes or whatever was being taught. Towards the end you would write a summary of what you understood and what not.

The ability to create organized notes was valued by several of the students interviewed for this study. Notes became a valuable resource when participants worked on math assignments outside of the classroom, away from the aid of the teacher.

Resources

During the interviews, students made it clear that they desire access to many resources to ensure their success. As indicated in the section above regarding asking questions, interviewees felt that teachers were their main source of information. After all, the teacher's expectations are the ones that the students were trying to meet. Participants want to be able to ask teachers questions and to receive helpful guidance in return. A secondary resource mentioned by several participants was family. Parents, siblings and others that were skilled in math helped interviewees complete math assignments at home. Several challenges arose regarding family members, such as inexperience with mathematics, inability to explain mathematics and apparent lack of interest in student's mathematical success. Only one participant brought up the use of a tutor. This student mentioned that a tutor was desirable during high school but outside of the family's budget. Ultimately, participants favored resources that did not impose on others, such as notes, textbooks or technology. MyMathLab© was also considered a beneficial resource when completing math outside of school.

One participant described the difficulty of using her parents as a math resource by stating:

> I think also with Algebra the problem is, too… when my mom went to high school, she did not have to have Algebra to graduate. She didn't know it either. We were learning together. My dad, he did, but he's not really a good teacher, and he couldn't really explain it very well. He knew it, but I don't think he could tell me really good how to do it.

Another interviewee indicated the difficulty of family as a math resource when she stated, “My parents didn't care one way or another what happened to my education.” These two students found that their family was not a reliable source of math assistance.

Overall, interviewees placed the blame for their challenges in math on outside factors. Throughout the interviews, the blame appeared to be aimed at former teachers. Interviewees seemed to believe that the teacher alone could determine their success in a course. There was little evidence that participants took responsibility for their past challenges in math. Other than admitting the need for organized notes, interviewees felt that the teacher’s feedback and organization was the main factor in their success or failure.

RQ#2: What factors do students attribute their successes and challenges to with MyMathLab©?

Interviewees described their successes and challenges with MyMathLab© by discussing the features that did and did not help them with math class. Participants were asked about their personal experiences with MyMathLab© previously and during the course for this study. While every student’s experience was different, three similar themes emerged for this research question as factors for successes and challenges with MyMathLab©: feedback, organization and resources. Figure 4-4 illustrates these themes. Each theme will be described in greater detail below.

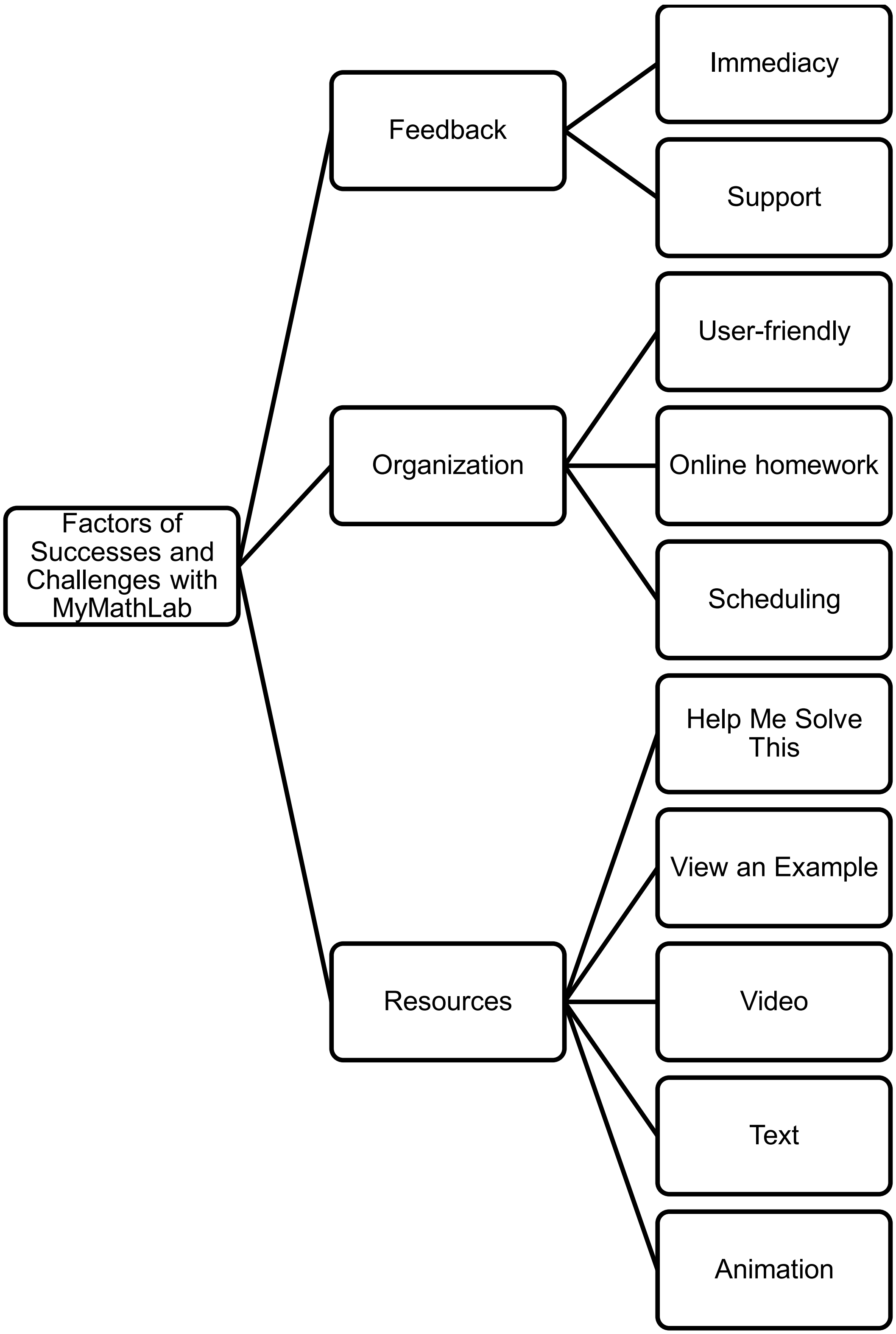

Figure 4-4. Factors of Successes and Challenges with MyMathLab©

Feedback

The feedback provided by the software within MyMathLab© was a common theme across the interviews. Participants raved about the immediacy of the grade and support offered when checking the answers to each problem in their homework. After completing a problem in MyMathLab©, students click on "Check Answer" before proceeding to the next problem. If the answer is correct, MyMathLab© displays a positive response on the screen, such as "Great job!" If the answer is incorrect, MyMathLab© displays a positive response with support, such as "Nice try! Be sure to simplify your answer by dividing out any common factors from the numerator and denominator." Immediately, students are able to determine if they are on the right track with their comprehension. Participants enjoyed knowing whether or not they got an answer correct before moving on to the next problem. They also liked the feature within MyMathLab© that allowed them to check their grade in the course at any time. Feedback allowed participants to gauge their understanding and constantly check their progress in the course. Figure 4-5 portrays this relationship.

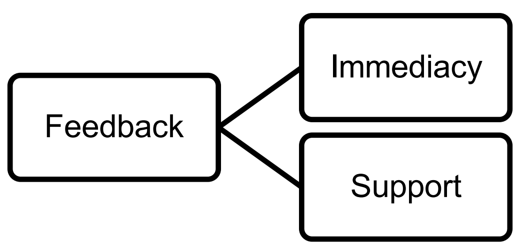

Figure 4-5. Feedback Subthemes for MyMathLab©

Immediacy. The immediate feedback within MyMathLab© appealed to all students interviewed for this study. Participants liked knowing whether or not they were getting answers correct as they went through the homework. Some felt better prepared returning to class knowing they had mastered the previous lesson's homework assignment. The timeliness of the feedback was very popular with participants.

One interviewee stated, "I feel good. I feel like I like it a lot better because that way I know how I'm doing immediately. I don't have to wait for it to be graded. I actually know if I'm doing it right or if I'm doing it wrong or if I'm in the middle, if I'm not getting it." Others agreed with statements such as, "you're going to be checking your answer every time so you know that you're getting a good grade," and "I liked that I could submit it and automatically get results." In regards to returning to class with mastery of the current topic, one participant stated, "I definitely do like seeing the grades right away so I definitely know how I'm doing in the class. Then I can be a little bit more prepared for the next class we have." Immediate feedback gave interviewees the reassurance that they were completing the homework correctly and mastering the current math topic.

Immediate feedback was mentioned in every interview within this study. All participants spoke positively about this feature within MyMathLab©. They were happy to know they were getting answers right and comprehending the material.

Support. When a student entered an incorrect answer on the homework, MyMathLab© would present a note of positive encouragement with a suggestion to improve the answer. Participants were generally pleased with the support provided when an incorrect answer was entered. This supportive feedback helped participants to determine whether they were doing the problems correctly in a timely manner so that they did not continuously practice doing problems the wrong way. According to the interviewees, this feature helped them develop good habits while completing their homework. Overall, the support provided helped interviewees stay on track with their homework.

One participant described the feedback by saying “on MyMathLab©, they tell you right away: ‘Not only did you get this wrong but here’s why. Here’s how to do it the right way before you make a habit out of it.’” In regards to the support presented after getting a problem wrong, another participant stated, “I liked that, because it would actually ... If it was wrong, it would kind of tell you, like, ‘Now remember. Did you do this?’ It would try and help you see where you went wrong in your problem.” Interviewees enjoyed the immediate feedback, including the support to redo problems that they had missed. They also appreciated knowing if they comprehended the material covered by the homework. When comparing MyMathLab© with traditional homework, a participant said, “I think that it is so much different than trying to do these problems on paper because there’s nobody there to tell you if you’re wrong or right. Next thing you know you’ve made a habit out of completing these problems the wrong way and nobody was there to tell you otherwise.” Interviewees felt that the immediate support kept them from repeating mistakes and helped them measure their level of comprehension.

Overall, the feedback provided with MyMathLab© was well-received by all students interviewed for this study. Participants felt encouraged knowing their grades at all times. They valued the support provided within MyMathLab© when they made mistakes as well. The immediate feedback was a tool for participants to gauge their understanding while measuring their success. There were no challenges mentioned with regard to feedback during the interviews.

Organization

MyMathLab© is an online program that can be accessed anywhere through a web browser. Homework assignments are listed in order by due date. Students using MyMathLab© for math homework do not have to write down the page and problem numbers in class, open their textbook to find the problems, or remember to bring their completed homework to class for submission. The entire assignment is accessed, completed, submitted, and graded online. Students interviewed for this study found that MyMathLab© was easy to use and helped them stay organized. They also noted their preference for frequent and applicable homework assignments. Figure 4-6 represents these subthemes.

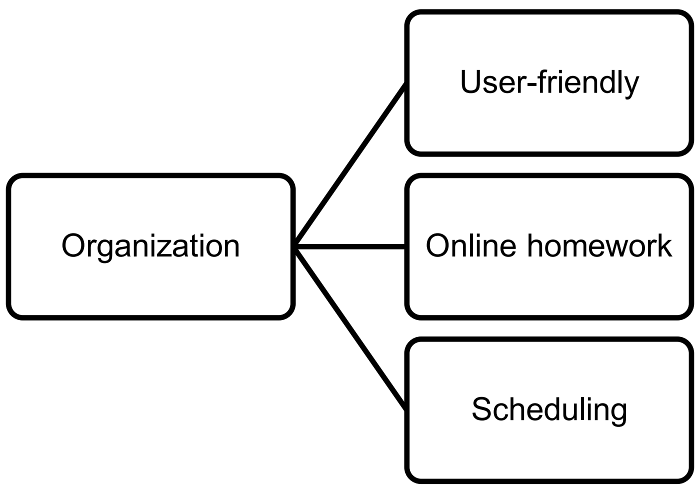

Figure 4-6. Organization Subthemes for MyMathLab©

User-friendly. According to participants, MyMathLab© was user-friendly. Interviewees were able to find the homework, access the necessary resources and view their grades online. They were able to view due dates and times for online homework via the calendar feature within MyMathLab©. Participants felt that the organization of

MyMathLab© helped them determine which assignments to complete and the order in which to complete them.

One participant described MyMathLab© stating, “I think it's a very good tool. I like it a lot. It's not very difficult. It's actually pretty easy and organized and the way it works is nice … It shows you step-by-step what you need to do and what days to do it.” Other participants agreed saying, “It was easy” and “I just log on and open a problem.” When asking another participant why they liked MyMathLab©, the answer was, “It was online. I guess, you know, the generation now, we just love good technology and the computer.” The ease of use and accessibility was appealing to most interviewees.

Online homework. Aside from the user-friendly aspect of MyMathLab©, participants liked that homework was completed online. They did not have to pull out their unwieldy textbook unless they wanted to use it as a resource. Notebook paper and legible handwriting were not necessary. Grades were immediately submitted to the instructor so participants were not at risk of forgetting to bring or submit an assignment. Interviewees found the online homework convenient and neat.

Two participants mentioned not having to use the textbook for homework. One participant said, “It was portable so I didn’t have to constantly bring my huge textbook around with me.” The other said, “I really like it a lot. I love it, because I don't have to sit there with a book.” The same student also addressed the issue of submitting legible homework by saying, “I'm not writing out a whole bunch of problems. I get a little nervous when I have to turn in written homework. It's not like neat enough.” The fear of submitting sloppy homework was a common issue described by another participant as well. The other participant said, “I love it. I mean, it's so much easier to do the homework instead of writing it on paper because I write so sloppy. Sometimes, I can't even read my own problems." Interviewees seemed thrilled that online homework did not require textbook or notebook paper.

Participants also enjoyed the ability to submit the assignments online. There was no chance of completing an assignment and leaving it at home or in the car. Participants were guaranteed to get credit on their work as long as they clicked on "Check Answer" after each problem. One participant declared, "I like it because it was that way, and I didn't have to remember it to bring homework to class and everything." Another participant expressed their relief in saying, "I don't have to worry with papers and writing, making sure things are neat and remembering, because if I get up, it's like I have to make sure, 'Don't forget your homework.'" Interviewees were happy with the remote submission.

Overall, online homework avoided challenges that have caused participants grief in the past, such as forgetting homework or a textbook and not copying down homework assignments from the board. Interviewees were able to complete their homework without fear of missing a problem because the teacher could not read their answer due to sloppy handwriting. Online homework helped participants succeed with organization.

Scheduling. Within MyMathLab©, instructors have the ability to choose the type, number and frequency of homework problems. Instructors also choose the due date and time for each assignment. Those participants that had previous experience with MyMathLab© noted the differences between how instructors programmed homework in MyMathLab©, with a preference for frequent assignments with problems similar to the lessons taught in class. These students felt this scheduling made a difference in their successful mastery of the subject matter. Frequent practice with material that closely resembled the lessons presented in class aided in interviewees' success with math.

One participant described the difference between a previous course and the course for this study stating, "You seemed to understand that practice was good. He only had one or two problems for a certain topic and then we would move on. The practice really helped with our class and his class was just the two problems were not good or maybe because I needed to understand them and I didn't really understand them with just two." The previous instructor had not programmed many practice problems for each topic. This student felt that more practice helped with comprehension. Another participant explained that a previous instructor created only four assignments for the entire course due before each test. Comparing the homework for this study with the previous course, this student stated, "Yours would take maybe 40 minutes each and it would be every couple of days. His homework was easier, but I would say your homework was more beneficial to me. I felt like I learned it better because there were more detailed examples. It helped it stick in my mind just a little bit better." When the researcher asked which type of homework the participant preferred, this student elaborated further, "I would say that the way that you did homework … There were more questions in his. I felt like his questions in MyMathLab© were broader. They were not as detailed as your questions were." These two participants preferred homework assignments that closely related to the lessons learned in class scheduled frequently throughout the course.

Each interviewee stated that they were satisfied with the online homework. For various reasons, the online nature of the homework appealed to each. Participants liked the portability, the ease of use, the online submission and the organization of MyMathLab©. Two participants with previous MyMathLab© experience preferred the frequent homework assignments within this study over longer, less frequent homework assigned in past courses. According to all students interviewed for this study, the organization of online homework was a tool that aided their math success.

Resources

Along with the immediate feedback and organization that MyMathLab© offers, interviewees valued some of the resources available within the software itself. With this software, participants did not feel the same need to ask the teacher questions or rely on the assistance of family members. Instead, participants relied heavily on the resources available within MyMathLab©. Interviewees were asked to describe the most and the least useful aspects of MyMathLab©. These questions resulted in a detailed description of which features they preferred to use with a tendency towards View an Example and Help Me Solve This. In general, interviewees preferred step-by-step assistance, whether visual, auditory, or both, and solving the original problem presented within the homework. Figure 4-7 portrays this relationship.

View an Example. All of the students interviewed used this feature on a regular basis. One of the advantages to using the View an Example feature was that students would be able to work through a sample problem for assistance without MyMathLab© creating a new problem for the student to solve. Participants were pleased with the step-by-step explanations that were offered with this feature. However, one participant mentioned frustration when the sample problem for this feature used a method that did not appear to be the same method learned during class from the teacher. This made

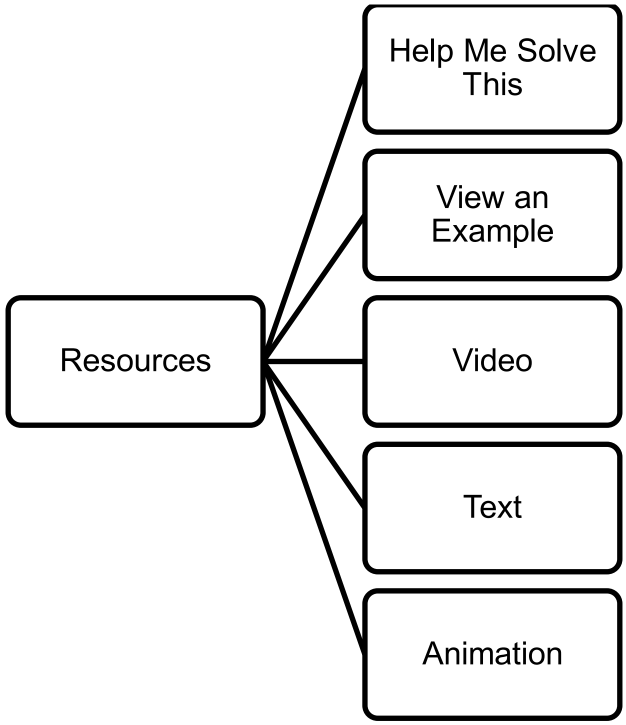

Figure 4-7. Resources Subthemes for MyMathLab©

the student feel confused as if relearning the material. When interviewees were looking for an example problem for guidance but wanted to work the original problem presented by MyMathLab© for homework, View an Example was the feature they chose.

One participant stated, "I definitely used View an Example more often because it helped me solve. I didn't want help with *that* problem. I just wanted to see how it was done so I could work the other problem myself. I definitely used the, not the Help Me Solve This, the View an Example more." Another participant described why View an Example was the first choice feature saying, "I already had worked this one problem out so many times. I was like, 'I'm not getting a new one. I am not getting a new one.'" Participants wanted to complete as few problems as possible for homework. When MyMathLab© would present a new problem after using a feature, this meant that students would have to complete one more version of the problem for credit on the assignment. Another participant agreed, “I like it when they give you the same basic problem, but just with different numbers instead. That was tremendously helpful for me.” Interviewees preferred not to complete multiple versions of homework problems if at all possible. View an Example was a feature that allowed this option.

One of the disadvantages of using this feature, mentioned by one student interviewed, was that the guidance from MyMathLab© did not always appear to align with the method for solving that was taught in class. Though the method was the same, the wording or visual representation of the sample problem was unrecognizable to the participant. The student portrayed this difficulty when comparing the assistance provided by the feature with the steps that had been taught by the researcher stating:

> It was actually different than what you would kind of say in class. It wasn't matching up with the notes. It was making it a little bit harder than what you said but more in depth, I guess. It would give you extra steps to do it, and I'm like, "Why don't I just stick to what she's saying," because for a whole three-hour class, I don't want to reprogram my brain to learn another way. I think that's why I really stuck with your notes.

Participants used View an Example when they did not want to complete a new problem and the guidance unambiguously supplemented their understanding of the material presented in class.

Help Me Solve This. As mentioned earlier regarding View an Example, interviewees were less likely to use Help Me Solve This because they did not want to solve two similar problems to earn credit for only one problem on the homework assignment. Participants used Help Me Solve This when they were not sure how to approach a problem or after they had incorrectly attempted the problem on their own. One participant felt that entering the answers after each step was cumbersome but beneficial. This feature was popular but was not used by all students interviewed for this study.

Interviewees used the resources in MyMathLab© when they needed assistance while completing homework. Help Me Solve This created more work for students as one participant described, “When I tried to do it through Help Me Solve This, I didn't really want it just to help me solve it, because it actually took away the problem, because it gave you the answer, so I would try the other one that was maybe a similar problem.” This student preferred using View an Example hoping to only complete the original homework problem. Another participant chose not to use Help Me Solve This declaring, “I didn’t use it because I guess I felt independent. I wanted to do it myself.” Help Me Solve This was not every participant’s first choice feature for assistance because it created a new homework problem.

Other interviewees found the Help Me Solve This feature a great way to check their comprehension or to get started on a problem. When a participant was asked whether they used Help Me Solve This before trying a problem or after, the participant responded, “A lot of the times I would just look at the problem and not know right off the bat how to go about solving it, so I would have them help me. Sometimes if I felt like I had the idea, but I got it wrong, then I’d have them help me. It’s pretty even.” Another participant concurred that Help Me Solve This was a helpful feature when one or more incorrect answers had already been entered saying, “If I do it again myself and I still don't get the right answer then I do the Help Me Solve This problem thing. You click on that and then it walks you through step-by-step their way and shows you how to do it and then usually by then I can get it right.” As one participant said, “You go through, they make you do each step one by one by one and it was frustrating, but ultimately helpful." Help Me Solve This created more work for students but those interviewed that used it found the assistance advantageous at times.

Video. According to the interviews, most students did not try the video feature. Two participants tried the video feature. One did not like that the lessons did not discernibly align with the material taught by the researcher. Though the method was the same as the one used in class, the participant had difficulty making the relation. The other found the videos to be very helpful and used it often. Video feature use was not prevalent during this study.

Regarding the Video feature, one participant stated, "I never used the one where I would watch the video. That confused me more because it was not the same style as what you taught us. If I didn't get one style I certainly wouldn't get a mix of two, so I tried to avoid that." This confusion was a common theme throughout this student's interview mentioned earlier when speaking regarding the View an Example feature. Using notes from the course was this student's preference while working on homework. Supplementing the notes with additional information was challenging for this participant. On the contrary, another interviewee did find the video aided with completing homework saying:

> Towards the end, I loved the video, because I remember I had texted you about ... It was like a multiplication. You said, "The zero." For some reason, I wasn't understanding. I'm like, "What is zero?", and I looked at the multiplication. I think it was during the multiplication, and I looked at the video, and she wrote it out. I saw, and I went, "Oh, okay. I understand now. I get what she's saying." I was going more with the video. I liked that a lot.

The Video feature was not available on all problems and was only preferred by one student interviewed for this study.

Text. Most of the students interviewed for this study did not use the Text option. One participant mentioned looking at the feature to check it out but did not return to the feature as a regular resource. Another participant used the Text feature in the same manner as a textbook. This student referenced sample problems for guidance while completing the homework. The Text feature was not used very often by the students interviewed for this study.

The Text option allowed interviewees to view the textbook without having to look up the appropriate section for each problem. A participant explained this feature saying, "I did use the option where I would go back into the textbook and it would even pull up the pages and show you exactly where it was, so I did use that because it also had examples there." Nonetheless, most interivewees did not use this feature. Some of the participants may have explored the feature as a resource when becoming acclimated to MyMathLab© but chose not to use it afterward. One interviewee stated, "I didn't really use it often but I did want to see how it looked like in our book so I could get an understanding of what it would look like outside of MyMathLab© and they looked similar but I just didn't use it very often." The Text feature was not widely used during this study.

Animation. Interviewees did not use the Animation feature during this study. When asked about the feature, the researcher was met with statements, such as "I never clicked on the Animation because I don't remember that." The Animation feature was not available on all problems assigned throughout the course and was never viewed by students.

Not all of the resources featured in MyMathLab© were valued by students in this study. When asked about the Video, Text and Animation features, one participant responded, “I've not seen any of those.” Though the Text feature was available on every problem, it did not appeal to most participants. View an Example and Help Me Solve This were the most often discussed features amongst the interviews. Interviewees did rely heavily on the resources within MyMathLab©; each student used them in the manner that best suited their comprehension. Participants hinted that MyMathLab© gave them a sense of empowerment over their math comprehension. Rather than relying on teachers as they had in the past, interviewees were able to access immediate assistance when they needed it.

According to the interviewees, MyMathLab© was not without fault. Some participants found it challenging to work through a sample problem for assistance only to find that they had to complete a new homework problem for credit. One participant felt that the assistance offered within MyMathLab© differed from the lessons taught in class, even though that was not the case. MyMathLab© helped participants be self-reliant, though it took some practice for them to determine which resources worked best for their comprehension.

When asked whether they liked homework in MyMathLab©, one participant said, “It's easy, it helps me walk through a problem without having to bother the family or ... Certainly, it’s easier. I really love it.” MyMathLab© provided interviewees with resources that helped them successfully complete their homework assignments throughout this study.

RQ#3: What specifiable impact does MyMathLab© have on the math anxiety, self-efficacy and performance of developmental math students?

The purpose of the quantitative aspect of this study was to compare the math anxiety, self-efficacy and performance of developmental math students in two similar learning environments to determine whether MyMathLab© made any impact. Specifically, the study investigated whether there was a significant difference in:

- mathematics anxiety as measured by pre and post Abbreviated Math Anxiety Scales (AMAS),
- mathematics self-efficacy as measured by pre and post Math Self-Efficacy Surveys (MSES), and
- mathematics performance as measured by pre and post-performance tests

for students enrolled in two separate course sections of Introductory Algebra. The control group completed homework from the textbook while the treatment group completed homework using MyMathLab©. Limited statistical analysis was performed due to the small sample size of this study.

Statistical Analysis

The quasi-experimental quantitative component of this study used the non-randomized control group pretest-posttest design since students were not randomly assigned to the groups and enrolled themselves in the courses. Only ten students participated in all aspects of this study limiting the researcher from conducting any meaningful inferential statistical analysis. Though inferential statistics would have provided meaningful analysis with regards to the possible relationships between math anxiety, self-efficacy, and performance within the treatment and control groups, this type of analysis was not used due to the small sample size. Descriptive statistics were used to evaluate the data collected from this study in lieu of inferential statistics. These descriptive statistics and analysis for mathematics anxiety, self-efficacy, and performance are presented below.

Math Anxiety. Nine participants completed the pre and post Abbreviate Math Anxiety Scale during this study. The data for math anxiety were analyzed for mean and standard deviation. Table 4-1 shows the descriptive statistics for math anxiety by method: control and treatment. Math anxiety did not change for the control group from pre-scale to post-scale, which were reported at 3.04. The treatment group's pre-scale mean reported at 2.85 with a decreased post-scale mean of 2.65. Math anxiety only decreased in the treatment group during the study.

Table 4-1. Descriptive Statistics for Math Anxiety by Method

		Pretest		Posttest	
	N	Mean	SD	Mean	SD
Control	3	3.04	0.29	3.04	0.64
Treatment	6	2.85	1.24	2.65	0.76
Total	9				

Math Self-Efficacy. Nine participants also completed the pre and post Math Self-Efficacy Survey during this study. The data for math self-efficacy were analyzed for mean and standard deviation. Table 4-2 shows the descriptive statistics for math self-efficacy by method: control and treatment. The mean reported for math self-efficacy in the control group increased from 3.95 to 4.79. The treatment group's pre-survey mean reported at 4.86 with an increased post-scale mean of 5.30. Math self-efficacy increased for both groups during the study.

Table 4-2. Descriptive Statistics for Math Self-Efficacy by Method

		Pretest		Posttest	
	N	Mean	SD	Mean	SD
Control	3	3.95	0.83	4.79	1.32
Treatment	6	4.86	2.15	5.30	1.03
Total	9				

Math Performance. Twelve participants completed the pre and post-performance test during this study. The data for math performance were analyzed for mean and standard deviation. Table 4-3 shows the descriptive statistics for math performance by method: control and treatment. The mean reported for math performance in the control group increased from 3 to 3.6. The treatment group's pre-performance mean reported at 2 with an increased post-scale mean of 3.29. Math performance increased for both groups during the study.

Table 4-3. Descriptive Statistics for Math Performance by Method

		Pretest		Posttest	
	N	Mean	SD	Mean	SD
Control	5	3	0.71	3.6	2.19
Treatment	7	2	1.53	3.29	2.29
Total	12				

One purpose of this study was to identify any specifiable impact of MyMathLab© on student's math anxiety, self-efficacy, and performance. Unfortunately, one of the limitations of practical research is the inability to control sample size. Due to the small sample size of this study, no significant differences could be identified. For the control group, math anxiety did not change and both math self-efficacy and performance increased during the study. For the treatment group, math anxiety decreased and both math self-efficacy and performance increased during the study.

Summary

The objective for this chapter was to describe the qualitative and quantitative findings for the study. Each of the following research questions was analyzed using the appropriate data collected:

1. What factors do students attribute their successes and challenges to in math?
2. What factors do students attribute their successes and challenges to with MyMathLab©?

3. What specifiable impact does MyMathLab© have on math anxiety, self-efficacy, and performance of developmental math students?

This chapter included discussion on the themes that emerged from the qualitative data followed by the descriptive statistics for the quantitative data. With regard to the first two research questions, the qualitative data pointed to three similar themes from students' experience historically in math and with MyMathLab©: feedback, organization, and resources. With regard to the last research question, the quantitative data could not be evaluated for inferential statistics due to the small sample size.

Interviewees from the study placed emphasis on feedback from teachers and from MyMathLab©. Both forms of feedback helped participants determine their level of comprehension. Some participants indicated that asking questions of the teacher was necessary to gain a deeper understanding. A few participants noted that asking questions could be challenging when teachers were negative or unhelpful in their responses. All of the interviewees indicated that the feedback from MyMathLab© was a positive feature, which allowed students to instantly gauge their understanding and to avoid creating bad mathematical habits while completing their homework. During the interviews, there were no challenges reported with the feedback from MyMathLab©.

Organization with regard to taking notes and turning in homework was another theme that emerged during the interviews. Several participants noted the importance of taking step-by-step notes and keeping them organized in a notebook for future reference when working math problems alone at home. Some of the challenges mentioned in the interviews were not knowing which notes were important to copy during class and not having access to step-by-step instructions. According to the interviewees, MyMathLab© offered a user-friendly, organized structure allowing them to submit homework upon completion. Some interviewees noted that submitting homework online helped them avoid missing the assignment when it was given out in class and forgetting their homework when it was due. Overall, interviewees felt that organization was a factor for success in mathematics, whether taking notes or working on homework in MyMathLab©.

The final theme that materialized during the interviews was the importance of resources. Two interviewees expressed the difficulty caused by lacking resources by discussing their challenges with inexperienced parents and unaffordable tutors. Before MyMathLab© was introduced in the interview, all interviewees placed a major emphasis on the role of the teacher as a resource. Upon mentioning MyMathLab©, interviewees illustrated in detail all of the features within and whether they found those features to be helpful or not. All of the interviewees liked the View an Example feature. Other features were favored by different interviewees; however, View an Example was the only feature all participants agreed was beneficial to their comprehension.

An overarching theme throughout the interviews materialized when discussing the themes above. Interviewees placed blame on their teachers for their current and past math challenges. From not providing step-by-step notes to lack of enthusiasm when assisting students, participants felt that the teacher had a substantial impact on their successes and challenges with math. The students interviewed for this study depicted a newfound empowerment when describing MyMathLab© in detail. Each interviewee indicated a sense of accomplishment and confidence when using MyMathLab© while completing homework assignments alone.

CHAPTER 5
DISCUSSION AND IMPLICATIONS

The purpose of this study was to explore developmental students' perspectives on their unique math history and interactions with MyMathLab©. A secondary goal of this study was to identify any specifiable impact MyMathLab© had on math anxiety, self-efficacy, and performance in developmental mathematics students. Using a mixed methods approach, this study was performed to explore the 'what' and the 'why' that students associate with their successes and challenges in math (Johnson & Onwuegbuzie, 2004; Johnstone, 2007). Greater emphasis was placed on the qualitative data collected from interviews following treatment using a partially mixed sequential dominant status design (Leech & Onwuegbuzie, 2009). Semi-structured qualitative interviews were conducted to investigate the math history and MyMathLab© experiences of five participants. A quasi-experimental non-randomized control group pretest-posttest design was employed to identify any effects of MyMathLab© on math anxiety, self-efficacy, and performance (Gribbons & Herman, 1997). This chapter provides a synopsis of the study and an overview of the themes that emerged from the data presented in Chapter 4. This chapter also presents additional limitations to the study, implications from the findings and recommendations for further research.

Discussion of the Findings

Within the five qualitative interviews conducted for this study, there was no mention or speculation regarding the origin of each student's unique math anxiety. Participants spoke about their positive and negative experiences throughout their math careers. While no empirical evaluations on the causes of math anxiety exist (Ashcraft, 2002), the themes identified throughout this study align with previous studies that attempt to uncover the origin of this debilitating phobia. By discussing math successes, participants in the interviews for this study suggested tools they use to alleviate their own math anxiety. The challenges in math noted throughout the interviews allude to possible causes of math anxiety for each participant. The themes of feedback, organization and access to resources that emerged during qualitative analysis hint at specific areas where students place responsibility for their successes and challenges in math. By addressing the three themes that were identified during the qualitative aspect of this study, this section will describe in detail how the findings of this study support or contrast previous literature regarding math anxiety.

Feedback

All of the interviewees from this study mentioned their first negative math experience occurring between third and sixth grade. When recalling these early experiences and later negative math experiences, participants placed all of the blame for their miscomprehension on the teacher. Each participant went into great detail about the tools teachers used or did not use and how the teacher's behavior affected their success in math. Outside of the quick mention of sloppy handwriting and forgotten homework when discussing benefits of MyMathLab©, interviewees did not indicate any introspection when discussing math challenges. Every negative experience was associated with a teacher's poor feedback or disorganization. Participants placed blame on past teachers for every challenge in math. Interviewees felt unsupported or ill-equipped due to the teacher's behavior.

Throughout the interviews, the theme of feedback emerged in regard to math history and MyMathLab©. Every interviewee felt supportive feedback was significant for math success. Feedback allowed students to reevaluate their methodology and understanding while working on math problems. When recounting math experiences, participants discussed the positive and negative aspects of asking questions in math class. Participants also spoke about receiving feedback through grading as a way of gauging their comprehension. Overall, students that were interviewed for this study stressed the importance of getting assistance and measuring their mastery through feedback.

All participants placed emphasis on feedback through teacher responses when asking questions during class. Two participants felt that asking questions was important to round out their comprehension on specific math topics and expressed a willingness to ask questions regardless of the outcome. Every participant in the interview portion of the study valued getting adequate assistance when asking questions. When interviewees had positive responses from teachers, they were able to internalize the feedback and reorganize their comprehension if necessary. This form of feedback allows students to affirm, replace, augment or reform their existing knowledge (Butler & Winne, 1995). Interviewees emphasized the importance of quality responses to their questions. They felt that comprehensive answers made them more effective math learners. According to several studies, students are more successful when they utilize externally provided feedback to refocus their understanding (Bangert-Drowns et al., 1991; Kulhavy & Stock, 1989; Meyer, 1986). Corno and Snow (1986) suggest the following ways for teachers to be more effective by using feedback: to reinforce correct answers, explain incorrect answers, and to encourage students to try again. All participants valued receiving helpful feedback.

Several of the participants had been conditioned by the negative responses they received from teachers in the past. They either stopped asking questions or were more hesitant for fear of public ridicule. These participants had asked questions that were met with avoidance, annoyance and lack of care in the past. A few teachers mentioned in the interviews either did not help or seemed too “burned out” to put forth the effort. The possibility of public humiliation and interaction with unsupportive teachers has been shown to create or increase math anxiety in the past (Ashcraft, Krause, & Hopko, 2007; Jackson & Leffingwell, 1999). In fact, some of those negative memories have lasted beyond twenty years (Jackson & Leffingwell, 1999). Though all the participants valued the knowledge that could be constructed by asking questions, not all participants were willing to take the risk of requesting help when they needed it.

Though asking questions was not an option for some interviewees, all participants desired graded feedback. High grades represented mastery to the interviewees. These students liked knowing how they were doing so they could determine their level of understanding. Every participant appreciated the immediate feedback within MyMathLab© because they did not have to wait for the teacher to grade their responses. MyMathLab© immediately responded, letting students know whether their answers were correct or incorrect. While there is some dispute on whether delayed or immediate feedback is most effective, all studies regarding feedback have shown an increase in retention and performance (Cole & Todd, 2003). Feedback is a tool that helps students identify their mistakes and make corrections in their understanding (Kulhavy & Stock, 1989). One interviewee stressed the importance of immediate feedback to avoid developing bad habits while completing math assignments alone. According to Cardelle-Elawar (1992), students with lower mathematic abilities need assistance in determining whether their responses are incorrect and will continue to make similar mistakes without that feedback. Graded feedback allows students to measure their level of understanding and make corrections to their knowledge as needed.

Overall, interviewees from this study desired feedback on their efforts. Prior literature suggests that appropriate and timely feedback can lead to student success and increased performance. On the contrary, negative feedback can cause or increase math anxiety. According to the interviewees from this study, poor or no feedback leads to challenges for math students. Immediate feedback from computer-assisted instruction (CAI) may lessen the opportunity for these negative interactions with teachers.

Organization

Organization was another theme that emerged during the interview process. Participants preferred a structured learning environment with step-by-step procedures for completing math assignments. They believed that a disorganized teacher or poorly presented material could lead to math challenges. When discussing past challenges, participants repeatedly brought up the benefits of organized instruction and notes. Participants placed blame on past teachers for their math challenges when material was not presented in a step-by-step process with details that they could understand. Several interviewees stated that, historically, step-by-step notes provided in the classroom assisted in their successes in math. The step-by-step resource features that were available within MyMathLab© were positively mentioned by all interviewees as well. Participants were more inclined to use the Help Me Solve This, View an Example and Video features which provided this step-by-step procedural instruction. Participants also referenced the convenience and organization associated with online homework within the interviews. When using MyMathLab©, interviewees were pleased to avoid submitting work with illegible handwriting or forgetting to submit their homework altogether. Organization was viewed as a key to success in mathematics by all interviewees.

When discussing mathematical procedures for solving problems, interviewees repeatedly mentioned using a step-by-step process. Participants preferred notes that were provided in an organized manner during class with clear instructions on how to work out each type of problem. They wanted teachers to write down the steps along with solving the problem so that they would have them for reference in the future. While one participant mentioned learning the Cornell Method for taking notes, all the other participants implied that the teacher was responsible for an organized presentation of the material covered in class. Across multiple studies, researchers found that students felt that instructors have a responsibility to provide clear notes (Anthony, 2010; Kiewra, 1985; McAndrew, 1983; Readence, Bean, & Baldwin, 1989). Interviewees preferred structured notes that they could use as a reference when completing math assignments on their own. According to Anthony (2010), successful students stressed the importance of clearly presented lectures with many worked examples. Notes that are created as external storage for reference prior to an examination tend to be the most helpful (Anthony, 2010; Hartley & Davies, 1978; Henk & Stahl, 1985). Participants showed appreciation throughout the interviews for the availability of a clearly written reference when studying and working problems, whether from notes or resources within MyMathLab©.

Participants shared the negative aspects related to being unorganized throughout their math history. Illegible handwriting and homework left on a table at home had hurt participants' chances for success in the past. As noted in Chapter Two, developmental math students have been shown to thrive in highly structured environments (Norwood, 1994). MyMathLab© was applauded by all interviewees for its structure, making the homework submission process easier and without fault. Participants were able to submit their typed answers online from home with no opportunity for illegible answers or forgotten homework. Due dates and assignments were clearly organized and visible upon entering MyMathLab©. Interviewees felt that MyMathLab© aided their success by increasing their organization.

On the whole, the students interviewed for this study desired a structured and organized environment. It appears that they preferred and benefited from clearly presented material. Prior literature suggests that thorough notes are beneficial to students and that students entrust teachers with part of the responsibility to provide notes that they can use as a future resource. When material was not presented in an orderly manner, interviewees placed blame on the teacher for their challenges when solving math problems on their own. Step-by-step instructions became a valuable resource for participants when practicing math away from the classroom.

Resources

Many types of resources were mentioned throughout the interview process. For instance, participants spoke of teachers when asking questions and notes when working problems alone. They also spoke about the negative aspects of unreliable family members and unaffordable tutors. MyMathLab©'s features were described in detail by all the interviewees. Participants preferred resources that were step-by-step in nature and required the least amount of problem solving. The following features offering step-by-step instructions were preferred by the interviewees from this study: View an Example, Help Me Solve This and Video. Ultimately, MyMathLab© was viewed as a beneficial resource by all interviewees.

As mentioned earlier, some participants had negative past experiences interacting with teachers. After asking questions that were unsatisfactorily answered, interviewees would turn elsewhere for support. No participants mentioned peer tutoring and only one participant mentioned tutoring with a family member. For this participant, tutoring was a negative experience because the family member was unable to break down the concepts to the level needed for further comprehension. Another participant mentioned not being able to afford a tutor, though a tutor may have proven helpful. When interviewing first year mathematics students, Anthony (2010) found that successful students understand the importance of support that is of high quality and available. Interviewees in this study also appreciated the assistance that quality and available support could afford them.

Within MyMathLab©, interviewees favored features that provided step-by-step instruction such as the View an Example, Help Me Solve This and Video options. Most participants indicated a preference for features that showed similar problems with clear instructions that allowed the student to complete the original homework problem. A few interviewees noted their frustration when using the Help Me Solve This feature due to the new problem created after using the feature. One participant had difficulty making the connections between the steps within MyMathLab© and the steps provided through notes during the lecture, not recognizing the similarity between the two. The Text and Animation features were rarely used as resources. After working with MyMathLab© throughout the study, interviewees found resources within MyMathLab© that they returned to on a regular basis.

Interviewees desired access to helpful resources, whether those resources were people or text. For this study, MyMathLab© served as a reasonable substitute for tutoring. After detailing challenges in math with blame placed on past teachers, interviewees indicated a sense of empowerment when using MyMathLab©. The teacher was no longer the main source of support and feedback. Prior literature suggests that successful students recognize the importance of quality resources. No participants indicated the use of assistance from outside sources during this course. Participants relied on the notes provided by the teacher and the resources within MyMathLab©.

Implications

The interviewees in this sample were developmental mathematics students at a small college in Florida with varying math histories that presented with some level of math anxiety. They all had a desire to be successful in mathematics and had made observations from past experiences to determine which factors were most likely to lead to their future success. These participants had tried asking questions of their teachers, reading the textbook, taking notes, seeking familial help and exploring MyMathLab©. Looking at how developmental math students assess factors in their success with math could reinforce positive interactions and support from instructors, including appropriate feedback and structured lessons. The positive feedback from developmental students regarding MyMathLab© may enhance its use in developmental classrooms by considering best practices going forward. Though these findings are not generalizable to a larger population, there are possible implications that can be taken away from this study and further explored. This section details those implications.

Teacher Interactions

One of many factors that may lead to the development of math anxiety is negative interactions with instructors (Ashcraft et al., 2007). These negative interactions may include avoidance, public embarrassment, and inconsideration. Many of these interactions have already taken place before the student has even entered middle school (Jackson & Leffingwell, 1999; Swetman, 1994; Tankersley, 1993). Elementary school teachers may be to blame for some students' onset of math anxiety.

In the past, college students planning to teach elementary school have exhibited the highest levels of math anxiety (Hembree, 1990). For most elementary school teacher degree programs, college students are required to take very few math classes (Ma, 1999). This degree choice could result from the college student's own math anxiety and decision to avoid careers which require more math courses in college. Math avoidance is a common behavior for students with math anxiety (Ma, 1999). The prevalence of math anxiety in elementary school teachers has led to multiple studies related to this ongoing issue (Beilock et al., 2010; Gunderson, et al., 2013; Harper & Daane, 1998; Kelly & Tomhave, 1985; Wilson, 2013). Due to their own math anxiety, elementary school teachers may be ill-equipped to handle challenging math teaching moments in the classroom. Teachers may be unsupportive and defensive due to their own math anxiety (Ashcraft et al., 2007). Elementary school students may be at a disadvantage when placed in a classroom with a teacher that is uncomfortable giving instructive explanations for every math topic.

Teachers of all levels should be made aware of the negative effects of math anxiety and the significant role they can play in causing or increasing math anxiety through their actions. Their interest and enthusiasm for mathematics makes an impact on students (Jackson & Leffingwell, 1999). Teachers should be made aware of the symptoms of math anxiety such as the inability to answer when called upon unexpectedly in class or to participate effectively in group activities. They should be educated on how to identify math anxiety so they can provide the right tools to help empower students to alleviate math anxiety. Professional development for math instructors should include components regarding math anxiety and the detrimental effects it can have on a student's math career. Teachers should be educated on how to provide answers to students when they do not immediately know the answer themselves. Elementary school teachers with anxiety should be identified and given instruction on how to support students in their classes that are weak in math. Math teachers should have a distinct awareness and an understanding of math anxiety, including tools to help themselves and students when needed.

Teacher Support

As indicated earlier, students prefer feedback and organization. Teachers can provide support for students by providing timely and supportive feedback. They can also help instruct students on organizational behaviors that lead to success. Giving students tools for success puts the responsibility for success in the hands of the learner.

Feedback allows learners to reinforce skills when they are correct and to reorganize their knowledge when they are incorrect. Teachers can provide this feedback in multiple ways. Feedback can be immediate or delayed. It can be written, verbal or visual. Regardless of the manner in which feedback is presented, many studies have shown that feedback increases student performance (Cole & Todd, 2003). The findings from this study suggest that students like feedback on how they are doing. It allows them to identify errors and make corrections in their understanding (Kulhavy & Stock, 1989). This feedback can be provided directly by the teacher or through the use of CAI. Participants from this study were pleased with the feedback presented within MyMathLab© and felt it enforced good habits while helping them determine their level of mastery. Feedback should be an integral part of every math classroom.

Participants in this study also indicated a preference for an organized learning environment. Teachers can help students be successful by creating a structured classroom and prompting students to organize instructional materials by themselves (Corno & Snow, 1986). Whether presenting notes in a step-by-step manner or providing students the time to create those steps themselves, teachers can help students organize their notes and their knowledge with instruction specific to organization. Notes were very important to students in this study and previous studies (Anthony, 2010; Kiewra, 1985; McAndrew, 1983; Readence, Bean, & Baldwin, 1989). Students were more concerned with receiving a clear presentation of the information provided in class than with a specific note-taking mechanism (Anthony, 2010). These notes become valuable resources when studying for an exam or working out a problem alone.

MyMathLab©

While there is no replacement for human interaction, computer software can often take on human tasks such as providing feedback and organization. There is limited, scholarly literature on the effects of MyMathLab© on math anxiety, self-efficacy and performance. Interviewees from this study indicated a preference for online homework through MyMathLab© with the availability of the resource features MyMathLab© provides. They indicated a sense of empowerment when using MyMathLab© on their own. Participants could complete entire assignments without any additional assistance from family, teachers or text. Several suggestions should be noted following the interviews from this study for students and instructors.

Students should be introduced to all of the features made available within MyMathLab© by the instructor. There are many features which can be turned on or off by the instructor that will change the student experience within the program. Some instructors only allow students one attempt at each homework problem, others offer a small, limited number, while others offer unlimited attempts. For this study, students were given two attempts to complete each problem. Some might argue that offering unlimited attempts opens the opportunity for the student to manipulate the technology to the point of happening upon the right answer. However, the emphasis that participants placed on the feedback within MyMathLab© indicated an understanding that homework completion aided in their comprehension. Participants implied that they were aiming for mastery, not just completion of an assignment. Students should also be introduced to the advantages and disadvantages with each type of resource within MyMathLab©. The participants from this study indicated a penchant for the following features: View an Example and Help Me Solve This. Participants leaned toward these features due to the step-by-step nature of the assistance. Students should have the opportunity to learn how to use MyMathLab© before their first assignment.

When programming MyMathLab©, instructors should consider their goals for the software. As mentioned above, instructors have control over the number of attempts for each homework problem. MyMathLab© has other features such as online quizzes/tests, study problems and Ask an Instructor. For purposes of this study, these features were not included to ensure a similar learning environment for both the treatment and control groups. Instructors should consider the benefits of each feature before employing them within MyMathLab©. They should also familiarize themselves with the techniques and methods offered as resources throughout the program to align their instruction for easy recognition by students. MyMathLab© does grade the assignments automatically for instructors and the time saved should be considered as well. Instructors should weigh the benefits of each feature before including it.

MyMathLab© served as a substitute for textbook homework in this study. All interviewees indicated satisfaction with MyMathLab© and a preference for online homework in future courses. This software could be advantageous for both student and instructor.

Additional Limitations

Several additional limitations were discovered during this study. Each student's math history was unique and varied; however, the generalizability of this study to all developmental math courses is limited. This study represents the findings from this small sample and may not apply to all settings. Next, the qualitative data collected during this study was subject to recall bias. Participants were asked to speak about their earliest math experiences through to their most current math course with the researcher. It was assumed that all participants gave truthful recollections to the best of their ability. Finally, this study focused solely on the student perspective. It would be prudent to address the instructor perspective as well.

Recommendations for Further Research

Many questions still remain regarding math anxiety. This study only captured the views of five developmental students at a community college. Math anxiety is a unique and often crippling phobia that varies from person to person. As such, continued study should be focused in the following areas:

- Origins of math anxiety,
- Methods for math anxiety alleviation, and
- Effects of CAI on math anxiety, self-efficacy, and performance.

The origins of math anxiety are worthy of continued research. If math anxiety can be traced back to its source, researchers and practitioners can work together to stop or lessen math anxiety before it spirals out of control affecting both math self-efficacy and performance. Further qualitative interviews with students and teachers regarding their own math experiences will help pinpoint the roots of math anxiety. Knowing the causes of math anxiety can better inform the methods used to treat or avoid math anxiety altogether.

Various methods for lessening math anxiety have been mentioned throughout this study from systematic desensitization to highly structured learning environments. With the prevalence of math anxiety from third grade through college, it would be prudent to continuously research and improve upon methods for alleviating math anxiety. As new teaching methods and technologies emerge, they should all be weighed in benefitting math students that suffer from math anxiety.

With limited empirical data on the effects of CAI on math anxiety, self-efficacy, and performance, further research seems timely with constant advances in CAI software and an ever-growing population of students suffering from the negative effects of math anxiety. As long as varied CAI are being used as teaching tools for math, they should constantly be measured and reviewed for effectiveness in improving learning. In an effort to increase the generalizability of this study, more research is needed to substantiate the findings.

APPENDIX A
UF IRB APPROVAL

UF | **Institutional Review Board**
UNIVERSITY *of* FLORIDA

PO Box 112250
Gainesville, FL 32611-2250
352-392-0433 (Phone)
352-392-9234 (Fax)
irb2@ufl.edu

DATE: April 23, 2013

TO: Tasha Wells
[redacted]

FROM: Ira S. Fischler, PhD; Chair
University of Florida
Institutional Review Board 02

SUBJECT: Approval of Protocol #2013-U-0518
The Effect of MyMathLab on Math Anxiety, Self-Efficacy, and Performance in Developmental Mathematics Students

SPONSOR: None

I am pleased to advise you that the University of Florida Institutional Review Board has recommended approval of this protocol. Based on its review, the UFIRB determined that this research presents no more than minimal risk to participants. Your protocol was approved as an expedited study under category 7: *Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.*

Given this status, it is essential that you obtain signed documentation of informed consent from each participant. Enclosed is the dated, IRB-approved informed consent to be used when recruiting participants for the research. If you wish to make any changes to this protocol, *including the need to increase the number of participants authorized*, you must disclose your plans before you implement them so that the Board can assess their impact on your protocol. In addition, you must report to the Board any unexpected complications that affect your participants.

It is essential that each of your participants sign a copy of your approved informed consent that bears the IRB approval stamp and expiration date.

This approval is valid through **April 15, 2014**. If you have not completed the study prior to this date, please telephone our office (392-0433) and we will discuss the renewal process with you. **Additionally, should you complete the study on or before the expiration date, please submit the study closure report to our office. The form can be located at http://ib.ufl.edu/irb02/Continuing_Review.html.** It is important that you keep your Department Chair informed about the status of this research protocol.

ISF:dl

An Equal Opportunity Institution

APPENDIX B
SJR STATE IRB APPROVAL

ST. JOHNS RIVER
STATE COLLEGE

Memorandum

To: Tasha Wells – Principal Investigator
From: Rosalind Humerick, Ph.D., Chair of the Institutional Review Board
Date: 4/5/2013
Re: Institutional Review Board Application

I have reviewed your application requesting approval for the research project entitled, "The Effects of MyMathLab on Math Anxiety, Self-Efficacy, and Performance in Developmental Students." The Institutional Review Board (IRB) of St. Johns River State College has **approved your research** as exempt under the following category of exemption:

> Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; **and** (b) any disclosure of the human subjects' responses outside the research reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

As exempted research, it requires no further review. If any changes need to be made during the implementation of this research, the PI is responsible for submitting such changes to the IRB for its review. Also, if any incidents occur during the course of research, please notify the IRB as soon as possible.

We wish you success with your research project.

Sincerely,

Rosalind Humerick

Rosalind Humerick, Ph.D.
Institutional Review Board Chair

APPENDIX C
INFORMED CONSENT

INFORMED CONSENT

Dear Student:

We are conducting a study to determine the effects of MyMathLab© on math anxiety, self-efficacy and performance in developmental mathematics students. In this study, you will be asked to complete a combined math anxiety and self-efficacy survey before the course begins and a combined math anxiety and self-efficacy survey and final exam upon completion of the course. You will be asked to answer a brief questionnaire about your math history prior to the course. Your participation should take about 45 minutes before the course and 45 minutes after the course. You may be asked to participate in a voluntary structured interview upon completion of the course regarding your experience with MyMathLab©. Your participation in this voluntary interview should take about 30 minutes.

There are no risks to you.

There are no direct benefits to you for participating in the study. The benefits of your participation include helping instructors and administrators determine the best instructional methods to meet the math needs of students. Students may experience a decrease in math anxiety, increase in math self-efficacy and an increase in mathematics performances due to the built-in supports within MyMathLab© and the immediate feedback regarding their answer responses. There is no compensation to you for participating in the study.

All information will be handled in a strictly confidential manner, so that no one will be able to identify you when the results are recorded/reported. Your identity will be kept confidential to the extent provided by law. The instructor will not have access to any results until after grades have been submitted for this course. All results will be maintained by Mark Wilson, SJR State Math Department.

Your participation in this study is totally voluntary and you may withdraw at any time without negative consequences. If you wish to withdraw at any time during the study, simply email aritzhaupt@coe.ufl.edu noting your desire to be removed.

Please feel free to contact Tasha Wells, Adjunct Instructor, at [redacted] or Albert Ritzhaupt, Assistant Professor, at [redacted] if you have any questions about the study. Or, for other questions, contact St. Johns River State College Institutional Review Board Chairperson at [redacted]. For questions about your rights as a research participant contact the Institutional Review Board at the University of Florida at 352-392-0433.

I understand the study described above and have been given a copy of the description as outlined above. I am 18 years of age or older and I agree to participate.

Signature of Participant Date

Approved by
University of Florida
Institutional Review Board 02
Protocol # 2013-U-0518
For Use Through 04/15/2014

APPENDIX D
COURSE SYLLABUS FOR TREATMENT GROUP

Logistics:	3 College Preparatory Credits, Days M W, Time 9:45 am – 12:55 pm, Room H0218, Section 30449
Instructor:	Tasha Wells, Office Hours: By Appointment
Course Description and Student Learning Outcomes:	This is a first course in algebra. Topics include linear equations, linear inequalities, exponents, polynomials, factoring, rational expressions, graphing linear equations and square roots. After completing this course, the learner will be able to: 1. Solve a linear equation. 2. Simplify an expression using properties of exponents. 3. Calculate the product of two binomials. 4. Solve a quadratic equation by factoring. 5. Identify the graph of a linear equation in two variables.
Prerequisite:	MAT0018 Pre-Algebra with a grade of C or higher or a satisfactory score on a placement test.
Textbook and Resources:	Prealgebra & Introductory Algebra, 3rd edition, by Martin-Gay, Student Solutions Manual, Math Tutor Center, MyMathLab Course Compass ID: **XXXXXX** Calculators will not be allowed during class or testing. Check SJRState student email regularly.
Assessment:	Cumulative final exam 30% Homework 30% Quizzes (in class) 30% Classwork/Participation 10% *Participation-reasons for not receiving full credit include, but are not limited to: missing class, arriving late, leaving early, sleeping during class, not taking notes, talking during class, texting, cell phone use*
Grading Scale:	90-100% A, 80-89% B, 70-79% C, 60-69% D, 0-59% F
Make-Ups:	A student who wants a make-up ***must*** provide proof of a legitimate reason for missing the test. Make-ups must be scheduled with the instructor in advance via email or telephone. There will be no make-up quizzes.
Attendance:	A student may receive a warning when the equivalent of three 50-minute class periods have been missed and may be withdrawn from the course after the fourth 50-minute absence during the withdrawal period. The last day to withdraw is Monday, June 10, 2013. Plan to arrive on time and stay for the entire class period. Arriving late or leaving early is a distraction to others. It is inappropriate to use cell phones or other electronic devices during class.
Academic Integrity:	Students in this class must know, observe, and not compromise the principles of academic integrity. It is not permissible to cheat, to fabricate or falsify information, to submit the same academic work in more than one course without prior permission, to plagiarize, to receive unfair advantage, or to otherwise abuse accepted practices for handling and documenting information. The grade for this course includes the judgment that the student's work is free from academic dishonesty of any type. Violations or infractions will be reported to the Vice President for Student Affairs and may lead to failure of the course and other sanctions imposed by the College.
Disability Services:	Accommodations are available for students with disabilities; please visit the Counseling Center. If you have the accommodation of having a notetaker, you must tell me if you would like to have one for this class by the end of the second week.

Date	**<u>Tentative Schedule of Topics to be Covered</u>**
Wed, 5/8	4.6 Complex Fractions and Review of Order of Operations 6.1 Ratio and Proportion 6.6 Percent: Sales Tax, Commissions, and Discount 6.7 Percent: Interest 8.7 Temperature & Conversions Between US and Metric
Mon, 5/13	9.1 Symbols and Sets of Numbers 9.2 Properties of Real Numbers 9.3 Further Solving Linear Equations 9.4 Further Problem Solving
Wed, 5/15	**4.6 – 9.4 Quiz** 9.5 Formulas and Problem Solving 9.6 Linear Inequalities and Problem Solving 10.1 Exponents 10.2 Negative Exponents
Mon, 5/20	10.3 Introduction to Polynomials 10.4 Adding and Subtracting Polynomials 10.5 Multiplying Polynomials
Wed, 5/22	**9.5 – 10.5 Quiz** 10.6 Special Products 10.7 Dividing Polynomials by a Monomial 11.1 The Greatest Common Factor
Mon, 5/27	***Memorial Day Holiday (No School)***
Wed, 5/29	11.2 Factoring Trinomials of the Form $x^2 + bx + c$ 11.3 Factoring Trinomials of the Form $ax^2 + bx + c$ 11.4 Factoring Trinomials of the Form $ax^2 + bx + c$ by Grouping 11.5 Factoring Perfect Square Trinomials and the Difference of Two Squares
Mon, 6/3	**10.6 – 11.5 Quiz** 11.6 Solving Quadratic Equations by Factoring 11.7 Quadratic Equations and Problem Solving 12.1 Simplifying Rational Expressions
Wed, 6/5	12.2 Multiplying and Dividing Rational Expressions 12.3 Adding and Subtracting Rational Expressions – Same Denominator 12.4 Adding and Subtracting Rational Expressions – Different Denominators
Mon, 6/10	**11.6 – 12.4 Quiz** 13.1 The Rectangular Coordinate System 13.2 Graphing Linear Equations 13.3 Intercepts ***(Last day for withdrawal with a grade of W)***
Wed, 6/12	13.4 Slope and Rate of Change 15.1 Introduction to Square Roots 15.2 Simplifying Square Roots
Mon, 6/17	**13. 1 – 15.2 Quiz** 15.3 Adding and Subtracting Square Roots 15.4 Multiplying and Dividing Square Roots 15.6 Radical Equations and Problem Solving
Wed, 6/19	**Final Exam**

All homework assignments will be completed through MyMathLab. Homework assignments are due by 9:45 am the day of class.

All chapter assignments are made available the day of the previous chapter's test. i.e. Chapter 2 assignments will be made available the day you take the Chapter 1 Test.

******No late homework will be accepted for any reason.******

APPENDIX E
COURSE SYLLABUS FOR CONTROL GROUP

Logistics:	3 College Preparatory Credits, Days T Th, Time 6:00 pm – 9:10 pm, Room H0218, Section 30450
Instructor:	Tasha Wells, Office Hours: By Appointment
Course Description and Student Learning Outcomes:	This is a first course in algebra. Topics include linear equations, linear inequalities, exponents, polynomials, factoring, rational expressions, graphing linear equations and square roots. After completing this course, the learner will be able to: 6. Solve a linear equation. 7. Simplify an expression using properties of exponents. 8. Calculate the product of two binomials. 9. Solve a quadratic equation by factoring. 10. Identify the graph of a linear equation in two variables.
Prerequisite:	MAT0018 Pre-Algebra with a grade of C or higher or a satisfactory score on a placement test.
Textbook and Resources:	Prealgebra & Introductory Algebra, 3rd edition, by Martin-Gay, Student Solutions Manual, Math Tutor Center, MyMathLab Course Compass ID: **XXXXXX** Calculators will <u>not</u> be allowed during class or testing. Check SJRState student email regularly.
Assessment:	Cumulative final exam 30% Homework 30% Quizzes (in class) 30% Classwork/Participation 10% *Participation-reasons for not receiving full credit include, but are not limited to: missing class, arriving late, leaving early, sleeping during class, not taking notes, talking during class, texting, cell phone use*
Grading Scale:	90-100% A, 80-89% B, 70-79% C, 60-69% D, 0-59% F
Make-Ups:	A student who wants a make-up ***must*** provide proof of a legitimate reason for missing the test. Make-ups must be scheduled with the instructor in advance via email or telephone. There will be no make-up quizzes.
Attendance:	A student may receive a warning when the equivalent of three 50-minute class periods have been missed and may be withdrawn from the course after the fourth 50-minute absence during the withdrawal period. The last day to withdraw is Monday, June 10, 2013. Plan to arrive on time and stay for the entire class period. Arriving late or leaving early is a distraction to others. It is inappropriate to use cell phones or other electronic devices during class.
Academic Integrity:	Students in this class must know, observe, and not compromise the principles of academic integrity. It is not permissible to cheat, to fabricate or falsify information, to submit the same academic work in more than one course without prior permission, to plagiarize, to receive unfair advantage, or to otherwise abuse accepted practices for handling and documenting information. The grade for this course includes the judgment that the student's work is free from academic dishonesty of any type. Violations or infractions will be reported to the Vice President for Student Affairs and may lead to failure of the course and other sanctions imposed by the College.
Disability Services:	Accommodations are available for students with disabilities; please visit the Counseling Center. If you have the accommodation of having a notetaker, you must tell me if you would like to have one for this class by the end of the second week.

Date	Tentative Schedule of Topics to be Covered
Thurs, 5/9	4.6 Complex Fractions and Review of Order of Operations 6.1 Ratio and Proportion 6.6 Percent: Sales Tax, Commissions, and Discount 6.7 Percent: Interest 8.7 Temperature & Conversions Between US and Metric
Tues, 5/14	9.1 Symbols and Sets of Numbers 9.2 Properties of Real Numbers 9.3 Further Solving Linear Equations 9.4 Further Problem Solving
Thurs, 5/16	**4.6 – 9.4 Quiz** 9.5 Formulas and Problem Solving 9.6 Linear Inequalities and Problem Solving 10.1 Exponents 10.2 Negative Exponents
Tues, 5/21	10.3 Introduction to Polynomials 10.4 Adding and Subtracting Polynomials 10.5 Multiplying Polynomials
Thurs, 5/23	**9.5 – 10.5 Quiz** 10.6 Special Products 10.7 Dividing Polynomials by a Monomial 11.1 The Greatest Common Factor
Mon, 5/27	***Memorial Day Holiday (No School)***
Tues, 5/28	11.2 Factoring Trinomials of the Form $x^2 + bx + c$ 11.3 Factoring Trinomials of the Form $ax^2 + bx + c$ 11.4 Factoring Trinomials of the Form $ax^2 + bx + c$ by Grouping 11.5 Factoring Perfect Square Trinomials and the Difference of Two Squares
Thurs, 5/30	**10.6 – 11.5 Quiz** 11.6 Solving Quadratic Equations by Factoring 11.7 Quadratic Equations and Problem Solving 12.1 Simplifying Rational Expressions
Tues, 6/4	12.2 Multiplying and Dividing Rational Expressions 12.3 Adding and Subtracting Rational Expressions – Same Denominator 12.4 Adding and Subtracting Rational Expressions – Different Denominators
Thurs, 6/6	**11.6 – 12.4 Quiz** 13.1 The Rectangular Coordinate System 13.2 Graphing Linear Equations 13.3 Intercepts
Mon, 6/10	***(Last day for withdrawal with a grade of W)***
Tues, 6/11	13.4 Slope and Rate of Change 15.1 Introduction to Square Roots 15.2 Simplifying Square Roots
Thurs, 6/13	**13. 1 – 15.2 Quiz** 15.3 Adding and Subtracting Square Roots 15.4 Multiplying and Dividing Square Roots 15.6 Radical Equations and Problem Solving
Tues, 6/18	**No Class**
Thurs, 6/20	**Final Exam**

All homework assignments will be completed using the textbook. Homework assignments are due at 6:00 pm the day of class.

All chapter assignments are made available the day of the previous chapter's test. i.e. Chapter 2 assignments will be made available the day you take the Chapter 1 Test.

******No late homework will be accepted for any reason.******

APPENDIX F
SAMPLE PAGE FROM MATH PERFORMANCE PRETEST

MAT1033
Pre-Assessment Test

1. Simplify:

$$8 - 4 \div 2 - 10 \div 2$$

A. -4

B. 1

C. -3

D. 4

2. Simplify:

$$12 - (-3)^2 \div (7 - 4)$$

A. 1

B. 7

C. 9

D. 15

3. Simplify:

$$|-8| - |-5|$$

A. -13

B. -3

C. 3

D. 13

APPENDIX G
SAMPLE PAGE FROM MATH PERFORMANCE POSTTEST

MAT 1033
Post-Assessment Test

1. Simplify: $18+3\times 2\div 6$

   A. 19
   B. 18
   C. 7
   D. 4

2. Simplify: $(6-2)^2\div 4$

   A. 8
   B. 4
   C. 2
   D. 1

3. Simplify: $|15|+|-3|-|17|$

   A. -5
   B. 1
   C. 29
   D. 35

LIST OF REFERENCES

Alexander, L., & Cobb, R. (1984). *Identification of the dimensions and predictors of math anxiety among college students.* Paper presented at the Annual Meeting of the Mid-South Educational Research Association (New Orleans, LA, November 16, 1984). ERIC, ED 251320.

American Association of Community and Junior Colleges. (1989). Policy statements of the American Association of Community and Junior Colleges. In American Association of Community and Junior Colleges Membership Directory. Washington, D.C.: Author.

Anthony, G. (2000). Factors influencing first year students' success in mathematics. *International Journal of Mathematical Education in Science and Technology, 31*(1), 3-14.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 2*(5), 181-185.

Ashcraft, M. H., & Faust, M. W. (1994). Mathematics anxiety and mental arithmetic performance: An exploratory investigation. *Cognition & Emotion, 8*(2), 97-125.

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General, 130*, 224-237.

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review, 14*(2), 243-248.

Ashcraft, M. H., Krause, J. A., & Hopko, D. R. (2007). Is math anxiety a mathematical learning disability? *Why is math so hard for some children,* 329-348.

Ashcraft, M. H., & Ridley, K. S. (2005). Math anxiety and its cognitive consequences: A tutorial review. In J. I. D. Campbell (Ed.), *Handbook of Mathematical Cognition* (pp. 315-327). New York, NY: Psychology Press.

Atkinson, R. (2003). *An experimental evaluation of tutorials in problem solving (TiPS): A remedial mathematics tutor.* Office of Naval Research ONR N00014-02-1-0191.

Bailey, T., Jeong, D.W., & Cho, S.-W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education, 29*(2), 255-270.

Bandura, A. (1969). *Principles of behavior modification.* New York, NY: Holt, Rinehart & Winston.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes, 50*, 248-287.

Bandura, A., Blanchard, E. B. & Ritter, B. (1969). Relative efficacy of desensitization and modeling approaches for inducing behavioral, affective, and attitudinal changes. *Journal of Personality and Social Psychology, 13*(3), 173-199.

Bangert-Drowns, R. L., Kulik, C. L. C., Kulik, J. A., & Morgan, M. (1991). The instructional effect of feedback in test-like events. *Review of Educational Research, 61*(2), 213-238.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences, 107*(5), 1860-1863.

Bessant, K. C. (1995). Factors associated with types of mathematics anxiety in college students. *Journal for Research in Mathematics Education, 26*, 327-345.

Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counseling Psychology, 25*, 441-448.

Betz, N. E. & Hackett, G. (1983).The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior, 23*, 329-345.

Boeije, H. (2002). A purposeful approach to the constant comparative method in the analysis of qualitative interviews. *Quality and Quantity, 36*(4), 391-409.

Boylan, H. R. (2011). Improving success in developmental mathematics: An interview with Paul Nolting. *Journal of Developmental Education, 34*(3), 20-27.

Brush, L. R. (1978). A validation study of the Mathematics Anxiety Rating Scale (MARS). *Educational and Psychological Measurement, 38*, 485-490.

Bryman, A. (2006). Integrating quantitative and qualitative research: how is it done? *Qualitative Research, 6*(1), 97-113.

Burch, K. J. & Kuo, Y. -J. (2010). Traditional vs. online homework in college algebra. *Mathematics and Computer Education, 44*(1), 53-63.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*(3), 245-281.

Buzzetto-More, N. & Ukoha, O. (2009). The efficacy of a web-based instruction and remediation program on student learning. *Issues in Informing Science and Information Technology, 6*, 285-298.

Capraro, M. M., Capraro, R. M., & Henson, R. K. (2001). Measurement error of scores on the Mathematics Anxiety Rating Scale across studies. *Educational and Psychological Measurement, 61*, 373-386.

Cardelle-Elawar, M. (1992). Effects of teaching metacognitive skills to students with low mathematics ability. *Teaching and Teacher Education, 8*(2), 109-121.

Cartnal, R. (1999). *Preliminary success and retention rates in selected math courses. Cuesta College Matriculation and Research Service.* San Louis Obispo, CA. ERIC, ED 442480.

Clark, R.E. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53*(4), 445-459.

Clark, R.E. (1985). Evidence for confounding in computer-based instruction studies: Analyzing the meta-analyses. *Educational Communication and Technology Journal, 33*(4), 249-262.

Clark, R.E. (1994). Media will never influence learning. *Educational Technology Research and Development, 42*(2), 21-29.

Chiu, L. H., & Henry, L. L. (1990). Development and validation of the Mathematics Anxiety Scale for Children. *Measurement and Evaluation in Counseling and Development, 23*, 121-127.

Christmann, E. & Badgett, J. L. (1999). A comparative analysis of the effects of computer-assisted instruction on student achievement in differing science and demographical areas. *Journal of Computers in Mathematics and Science Teaching, 18*, 135-143.

Cohen, P. A., & Dacanay, L. S. (1992). Computer-based instruction and health professions education: A meta-analysis of outcomes. *Evaluation & the Health Professions, 15*, 259-281.

Cole, R. S., & Todd, J. B. (2003). Effects of web-based multimedia homework with immediate rich feedback on student learning in general chemistry. *Journal of Chemical Education, 80*(11), 1338-1343.

Corno, L., & Snow, R. E. (1986). Adapting teaching to individual difference among learners. *Handbook of Research on Teaching, 3*, 605-629.

Cotton, K. (1991). *Computer-assisted instruction.* Portland, OR: Northwest Regional Educational Laboratory.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches.* (3rd ed.). Los Angeles, CA: Sage.

Crumb, G. H., & Monroe, E. E. (1988). *CAI use by developmental studies students.* ERIC, ED 301410.

Davison, G.C. (1968). Systematic desensitization as a counter-conditioning process. *Journal of Abnormal Psychology, 73*(2), 91-99.

De Bronac-Meade, L. M., & Brown, R. (1982). *Reduction of mathematics anxiety: A cognitive behavior modification approach.* Paper presented at the annual meeting of the American Education Research Association, New York, NY.

Developmental Education Initiative: What We Do. Retrieved on January 1, 2012 at http://www.deionline.org/about/

Dew, K. M., Galassi, J. P. & Galassi, M. D. (1984). Math anxiety: Relation with situational test anxiety, performance, physiological arousal, and math avoidance behavior. *Journal of Counseling Psychology, 31*(4), 580-583.

Fennema, E. & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitudes Scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education, 7*(5), 324-326.

Fletcher-Flinn, & Gravatt, B. (1995). The efficacy of computer assisted instruction (CAI): A meta-analysis. *Journal of Educational Computing Research, 12*, 219-242.

Glass, G. V. (1976). Primary, secondary, and meta-analysis of research. *The Educational Researcher, 10*, 3-8.

Glass, G. V. (1977). Integrating findings: The meta-analysis of research. In L. S. Shulman (Ed.), *Review of Research in Education (Vol. 5)* (pp. 351-379). Itasca, IL: Peacock.

Greenwood, J. (1984). My anxieties about math anxiety. *Mathematics Teacher, 77*, 662-663.

Gribbons, B. & Herman, J. (1997). True and quasi-experimental designs. *Practical Assessment, Research & Evaluation, 5*(14).

Gunderson, E. A., Ramirez, G., Beilock, S. L., & Levine, S. C. (2013). Teachers' spatial anxiety relates to 1st and 2nd graders' spatial learning. *Mind, Brain, and Education, 7*(3), 196-199.

Guthrie, E. R. (1952). *The psychology of learning.* New York: Harper.

Hackett, G. & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education, 20*(3), 261-273.

Hall, J. M., & Ponton, M. K. (2005). Mathematics self-efficacy of college freshmen. *Journal of Developmental Education, 28*(3), 26-30.

Harper, N. W., & Daane, C. J. (1998). Causes and reduction of math anxiety in preservice elementary teachers. *Action in Teacher Education, 19*(4), 29-38.

Hartley, J., & Davies, I. K. (1978). Note-taking: A critical review. *Programmed Learning and Educational Technology, 15*(3), 207-224.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*, 33-46.

Henk, W. A., & Stahl, N. A. (1985). *A meta-analysis of the effect of notetaking on learning from lecture.* In 34th Annual Meeting of the National Reading Conference. (ED 258 533).

Ho, H-Z., Senturk, D., Lam, A. G., Zimmer, J. M., Hong, S. & Okamoto, Y. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in Mathematics Education, 31*(3), 362-379.

Hopko, D. R., Mahadevan, R., Bare, R. L. & Hunt, M. K. (2003). The abbreviated math anxiety scale (AMAS): Construction, validity and reliability. *Assessment, 10*(2), 178-182.

Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *The Mathematics Teacher, 92*(7), 583-586.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26.

Johnstone, P. L. (2007). Weighing up triangulating and contradictory evidence in mixed methods organizational research. *International Journal of Multiple Research Approaches, 1*(1), 27-38.

Kazdin, A. E. & Wilcoxon, L. A. (1976). Systematic desensitization and nonspecific treatment effects: A methodological evaluation. *Psychological Bulletin, 83*(5), 729-731.

Kelly, W. P., & Tomhave, W. K. (1985). A study of math anxiety/math avoidance in preservice elementary teachers. *The Arithmetic Teacher, 32*(5), 51-53.

Kiewra, K. A. (1985). Students' note-taking behaviors and the efficacy of providing the instructor's notes for review. *Contemporary Educational Psychology, 10*(4), 378-386.

Kinney, P. (2001). *Implementation models for interactive multimedia software in developmental mathematics.* National Association for Developmental Education (NADE) Selected Conference Papers, 7.

Koç, M. (2005). Implications of learning theories for effective technology integration and pre-service teacher training: A critical literature review. *Journal of Turkish Science Education, 2*(1), 6-18.

Kodippili, A. & Senaratne, D. (2008). Is computer-generated interactive mathematics homework more effective than traditional instructor-graded homework? *British Journal of Educational Technology, 39*(5), 928-932.

Kulhavy, R. W., & Stock, W. A. (1989). Feedback in written instruction: The place of response certitude. *Educational Psychology Review, 1*(4), 279-308.

Kulik, C-L. & Kulik, J. A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior, 7*, 75-94.

Kulik, C., Kulik, J., & Bangert-Drowns, R. (1984). *Effects of computer based education on secondary school pupils*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Kulik, J., Bangert, R., & Williams, G. (1983).Effects of computer-based teaching on secondary school students. *Journal of Educational Psychology, 75*(1), 19-26.

Kulik, J. A. & Kulik, C-L. (1988). Timing of feedback and verbal learning. *Review of Educational Research, 58*(1), 79-97.

Kulik, J., Kulik, C., & Cohen, P. (1980). Effectiveness of computer-based college teaching: A meta-analysis of findings. *Review of Educational Research, 50*, 525-544.

Lancaster, M. (2001). *Jefferson Davis Community College and developmental education: A partnership for student success.* ERIC, ED 454892.

Leder, G. & Grootenboer, P. (2005). Editorial. *MERJ Special Edition on Affect and Mathematics Education, 17*(2), 1-8.

Leech, N. L., & Onwuegbuzie, A. J. (2009). A typology of mixed methods research designs. *Quality & Quantity, 43*(2), 265-275.

Liao, Y. -K. C. (2007). The effects of computer-assisted instruction on students' achievement in Taiwan: A meta-analysis. *Computers and Education, 48*(2), 216-233.

Livingston, T. (2001). *The cognitive impact of a computer algebra system on intermediate algebra students at the community college level.* Orange Coast College. ERIC, ED 458901.

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education, 30*(5), 520-540.

Mahmud, R., Ismail, M. A. H., & Kiaw, L. A. (2009). Development and evaluation of a CAI courseware 'G-Reflect' on students' achievement and motivation in learning mathematics. *European Journal of Social Sciences, 8*(4), 557-568.

Martin-Gay, K. E. (2010). *Prealgebra & introductory algebra.* (3rd ed.). New York, NY: Prentice Hall Higher Education Group.

Mathison, S. (1988). Why triangulate? *Educational Researcher, 17*(2), 13-17.

McAndrew, D. A. (1983). Underlining and notetaking: Some suggestions from research. *Journal of Reading, 27*(2), 103-108.

McLeod, D. B. (1994). Research on Affect and Mathematics Learning in the JRME: 1970 to Present. *Journal for Research in Mathematics Education, 25*(6), 637-647.

Meece, J. L. (1981). *Individual differences in the affective reactions of middle and high school students to mathematics: A social cognitive perspective.* Unpublished doctoral dissertation. University of Michigan.

Meece, J. L., Wigfield, A. & Eccles J. S. (1990).Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82*(1), 60-70.

Mesa, V., Sitomer, A., Ström, A., & Yannota, M. (2012). Research Commentary: Moving from anecdote to evidence: The need for a research agenda in community college mathematics education.

Mevarech, Z. R. & Ben-Artzi, S. (1987). Effects of CAI with fixed and adaptive feedback on children's mathematics anxiety and achievement, *Journal of Experimental Education, 56*(1), 42-46.

Meyer, L. A. (1986). Strategies for correcting students' wrong responses. *The Elementary School Journal,* 227-241.

MyMathLab© Product Info. Retrieved on June 20, 2011 at http://www.mymathlab.com/product-info

National Center for Education Statistics. (2003). *The condition of education 2003*. Washington, DC: U.S. Department of Education.

National Center for Education Statistics. (2011). *The condition of education 2011*. Washington, DC: U.S. Department of Education.

Norwood, K. S. (1994). The effect of instructional approach on mathematics anxiety and achievement. *School Science & Mathematics, 94*(5), 248-255.

Pasick, R. J., Burke, N. J., Barker, J. C., Galen, J., J. A., Otero-Sabogal, R., … & Guerra, C. (2009). Behavioral theory in a diverse society: Like a compass on Mars. *Health Education Behavior, 36*(5), 11S-35S.

Quinn, D. (2003). *Report on the PLATO adult learning technologies implemented for developmental education at Miami-Dade Community College, Miami, Florida.* PLATO Learning, Inc.

Readence, J. E., Bean, T. W., & Baldwin, R. S. (1989). *Content area reading: An integrated approach.* Dubuque, IA: Kendall.

Richardson, F. C. & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551-554.

Richardson, F. C. & Suinn, R. M. (1973). A comparison of traditional systematic desensitization, accelerated massed desensitization, and anxiety management training in the treatment of mathematics anxiety. *Behavior Therapy, 4*(2), 212-218.

Rogers, T. F. (1976). Interviews by telephone and in person: Quality of responses and field performance. *The Public Opinion Quarterly, 40*(1), pp. 51-65.

Rosenthal, R. (2002). Covert communication in classrooms, clinics, courtrooms and cubicles. *American Psychologist, 57*(11), 839-849.

Rounds, J. B. & Hendel, D. D. (1980).Measurement and dimensionality of mathematics anxiety. *Journal of Counseling Psychology, 2*(7), 138-149.

Saldana, J. (2009). *The coding manual for qualitative researchers*. (2nd ed.). Los Angeles, CA: Sage Publications.

Sandman, R. S. (1979). Factors related to mathematics in the secondary school. Paper presented at the annual meeting of the American Education Research Association, San Francisco, CA.

Schneider, W. J. & Nevid, J. S. (1993). Overcoming math anxiety: A comparison of stress inoculation training & systematic desensitization. *Journal of College Student's Development, 34*, 283-288.

Shuy, R. W. (2003). In-person versus telephone interviewing. In J. A. Holstein & J. F. Gubrium (Eds.), *Inside interviewing: New lenses, new concerns* (pp. 175-193). Thousand Oaks, CA: Sage.

Skinner, B. F. (1968). *The technology of teaching*. New York, NY: Appleton-Century-Crofts.

Speckler, M. D. (2009). Make the grade, V.3, A compendium of data-driven case studies on the effectiveness of MyMathLab© and MathXL. Retrieved on June 27, 2011 at http://www.mymathlab.com/makingthegrade_v3.pdf

Spradlin, K. & Ackerman, B. (2010).The effectiveness of computer-assisted instruction in developmental mathematics. *Journal of Developmental Education, 30*(2). 12-14,16,18,42.

Stern, M., Beck, J., & Woolf, B. P. (1996). Adaptation of problem presentation and feedback in an intelligent mathematics tutor. In C. Frasson, G. Gauthier and A. Lesgold (Eds.), *Intelligent tutoring systems* (pp. 603-613). New York, NY: Springer-Verlag.

Swetman, D. L. (1994). Fourth grade math: The beginning of the end? *Reading Improvement, 31*(3), 173-76.

Tankersley, K. (1993). Teaching math their way. *Educational Leadership,50*(8), 12-13.

Testone, S. (2005). Using publisher resources to assist developmental mathematics students. *Research and Teaching in Developmental Education, 21*(2), 81-84.

Timmerman, C. E. & Kruepke, K. A. (2006). Computer-assisted instruction, media richness, and college student performance. *Communication Education, 55*(1), 73-104.

Tobias, S. (1978). *Overcoming math anxiety*. New York, NY: W.W. Norton & Company, Inc.

Traynor, P. L. (2003). Effects of computer-assisted instruction on different learners. *Journal of Instructional Psychology, 30*(2), 137-143.

Turner, J. C., Midgley, C., Meyer, D. K., Gheen, M., Anderman, E. M., Kang, Y. and Patrick, H. (2002). The classroom environment and students' reports of avoidance strategies in mathematics: A multimethod study. *Journal of Educational Psychology, 94*(1), 88-106.

Wenglinsky, H. (1998). *Does it compute? The relationship between educational technology and student achievement in mathematics.* Princeton, NJ: Educational Testing Service.

Wigfield, A., & Meece, J. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology, 80*, 210-216.

Wilson, S. (2013). Mature age pre-service teachers' mathematics anxiety and factors impacting on university retention.

Wolpe, J. (1958). *Psychotherapy by reciprocal inhibition.* Stanford, CA: Stanford University Press.

Wright, D. E., & Miller, L. D. (1981). Math anxiety: A research report.

Wright, J. H. & Wright, A. S. (1997). Computer-assisted psychotherapy. *Journal of Psychotherapy Practice and Research, 6*(4), 315-329.

BIOGRAPHICAL SKETCH

Tasha Wells graduated from the University of North Florida with a Bachelor of Science degree in computer science. Upon graduation, she began teaching mathematics to middle school students in Jacksonville, Florida where she found her life's passion – to educate. Tasha returned to school as an online student to earn her Master of Science degree in mathematics education at Florida State University. Following this degree, she transitioned to teaching developmental math both on campus and online.

After playing the roles of both online educator and student, Tasha decided to pursue her lifelong dream of attaining a doctoral degree. While attempting to merge her computer background and mathematics experience, she discovered the educational technology program at the University of Florida. Tasha's passion for reaching every math student and helping them rise to their full potential has driven her research on math anxiety and the use of computer-assisted instruction.