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A STUDY OF MATH ANXIETY IN DEVELOPMENTAL COURSES IN A TEXAS COMMUNITY COLLEGE

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A Study of Math Anxiety in Developmental Courses in a Texas Community College

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DEDICATION

This dissertation is dedicated to my wonderful husband, Travis, who loved me enough to let me go pursue this dream of attaining a doctorate at The University of Texas at Austin. I would also like to dedicate this dissertation to my supportive family. Their never-ending support and faith in me has been crucial to my success. Thank you for always having high expectations and plentiful resources of love, strength, and courage.

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A Study of Math Anxiety in Developmental Courses in a Texas Community College

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Abstract: The purpose of this study was three fold 1) to investigate the effects of math anxiety with respect to its impact on developmental students in a community college, 2) to determine if math anxiety could significantly reduced in one semester and 3) to determine if addressing anxiety issues and pedagogical practices would result in students having a more positive attitudinal perspective towards math. The final purpose was to determine if math anxiety was a significant variable contributing to math deficiencies among developmental students. A mixed methods design was most effective to quantitatively capture the results of a comparative experimental design and qualitatively capture the experience of the student. In the quantitative section of this study, a pre-test/post-test design was utilized to measure and compare math anxiety reduction (dependent variable). The study consisted of a pre-test measuring math anxiety levels and attitudes towards math at the beginning of the semester. A parallel form was given at the end of the semester. There was a comparison (control) group and a treatment (experimental) group for the purposes of comparing data. The researcher delivered an intervention in the form of a presentation to address math anxiety issues. In this presentation she provided cognitive-behavioral techniques aimed at reducing math anxiety. Post-test scores were then compared to pre-test scores to determine if there were any significant changes in the math anxiety variable. The overall findings of the study revealed the treatment group did not have a significant reduction in anxiety scores. However, the researcher found math anxiety scores to be higher among college algebra students. Thus, the overall effect of the intervention served as an inhibitor to math anxiety when scores were compared between the treatment and control groups.

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CHAPTER ONE

INTRODUCTION

Math anxiety is a problem for many college students - not only those in developmental math courses. This anxiety is so acute for some that it is dysfunctional and causes problems in cognitive processes needed for math skill mastery. Anxiety added to difficult circumstances compounds the effects in students' educational lives. However, if a technique were found that facilitates the alleviation of math anxiety for students through improved pedagogies, information, and resources, professors could remedy students' math anxiety while helping them acquire the necessary math skills required for degree completion.

Math anxiety is a deterrent to a holistic education. U.S. Americans are vigilant about protecting equality and equity regarding education. A civil rights activist claimed, "Mathematics education is a civil rights issue; and children who are not quantitatively literate may be doomed to a second-class economic status in our increasingly technological society" (Schoenfield, 2002, p. 13). It is important that mathematical literacy be of highest quality and accessibility for all students. Mathematics has been recognized as the "critical filter" that separates students with math skills to educational tracks that put them on their way to high paying technological jobs. Those without these skills will be left behind (Schoenfield, 2002, p. 13).

The term math anxiety itself emerged in the early 1970's. The origin of the term is unknown, but one of the first researchers to investigate this dynamic was Shelia Tobias. The story that sparked Tobias' attention, a researcher/activist, was an informal survey conducted by Lucy Sells at the University of California at Berkeley in 1972. Sells, a sociologist, surveyed incoming freshman concerning their mathematics backgrounds. She found that 57 percent of incoming males had completed four years of math before enrolling in college; however, only 8 percent of the females had the same experience. Tobias concluded:

> Without four years of high school math, students at Berkeley were ineligible for the calculus sequence, unlikely to attempt chemistry or physics, and inadequately prepared for intermediate statistics and economics. Since they could not take the entry-level courses in these fields, 92 percent of the females were excluded from ten out of twelve colleges at Berkeley and twenty-two out of forty-four majors (Tobias, 1978, p. 13).

This informal study became the impetus for researchers to begin looking at the cultural and social implications of math achievement in society.

It seems that math aversion is a socially and culturally accepted practice in the United States. (By contrast, studies confirm that in Asian countries such as Japan, Taiwan, and Thailand, math anxiety exists at a much smaller scale than in the United States.) Studies have been done where students were asked to speculate why some people were better at math than others. Asian students consistently attributed the skills to hard work, while American students cited innate ability (Tobias, 1993, p. 52; Engelhard Jr., 1990). For some American students it seems easier to accept the title of "I'm not a math person," rather than invest the hours of hard work that some math mastery demands. This might explain why students who opt for more math courses in high school do better overall in college related to persistence.

The United States is unique in its emphasis on universal education. In the quest to make education fun and open to each person the value of basic hard-work, organization, and computational skills may have been compromised. With technological assistance such as calculators and computers, U.S. Americans can find the answers to math questions. However, once these tools are removed, many are left paralyzed with anxiety due to the unfamiliar mechanics of arithmetic and algebra.

Finally, the phenomenon of math anxiety is more common than many people realize. Betz (1978) reported that 68 percent college students at a large Midwestern university had significant levels of math anxiety. Based upon her research, she concluded that math anxiety had an inverse relationship with performance measures in many forms, including achievement test scores, self-esteem, and career choices (Betz, 1978, p. 441).

Statement of the Problem

Developmental education has a long history in higher education. Remediation began its tradition in higher education in the 17th century at Harvard College, and it has been a core function of the community college since its inception (Waycaster, 2001, P. 404). A significant part of our nation's future could depend on the community college's ability to effectively remediate students who need to gain these skills to be competitive in a fast paced technology-driven economy. Enrollment trends in higher education project continued future growth. Community colleges will have to meet the challenge of increasing numbers of students with basic skills needs.

Waycaster (2001) reported, "for students who completed college preparatory courses in high school and immediately attended community college, 40 percent needed math remediation (p. 404). This is a large part of the college population if one considers, "during any given academic year, about 3,000,000 students are in developmental education programs" (Moore, 2002, p.56).

Definitions

Developmental Education: "Developmental education is a field of practice and research within higher education with a theoretical foundation in developmental psychology and learning theory. It promotes the cognitive and affective growth of all postsecondary learners, at all levels of the learning continuum. Developmental education is sensitive and responsive to the individual differences and special needs among learners" (National Association for Developmental Education, 2001, para. 1).

Math Anxiety: Math anxiety was defined by Freedman (2001) as, "an emotional reaction to mathematics based on past unpleasant experience which harms future learning." According to Richardson and Suinn (1972), math anxiety is characterized by "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Alexander & Martray, 1989, p. 143).

Significance of the Study

This study is important due to the prevalence of the math anxiety phenomenon at all levels of education. The purpose of this study is to address math anxiety issues and provide anxiety reduction strategies for community college students. According to developmental studies literature, math remediation classes are among the largest and most needed courses. Therefore, educational leaders should be concerned with factors that inhibit student success in math courses. Community college math faculty can use the findings of this study to gain a new understanding of a recurring and entrenched phenomenon, and further acquire suggestions to alleviate or reduce anxiety in their classrooms over the course of a single semester.

Purpose of the Research Study

The purpose of this study is threefold: 1) to investigate the effects of math anxiety with respect to its impact on developmental students in a community college, 2) to determine if math anxiety can be significantly reduced in one semester, and 3) to determine if addressing anxiety issues relative to pedagogical practices will result in students having a more positive attitudinal perspective towards math. In order to facilitate this study, the following questions were posed.

Research Questions

This research focused on the following two main research questions:

1) Is math anxiety high among developmental math students?

2) Can math anxiety be significantly lowered over a semester?

Research Hypotheses

There were two hypotheses for the research questions:

1) Math anxiety will be high among developmental students.

2) Math anxiety can be significantly lowered over a single semester.

CHAPTER TWO

REVIEW OF THE LITERATURE

Arguments Related to the Need for a Math-Competent Citizenry

Roueche & Roueche (1999) reported:

> Today 25% of the U.S. workforce is functionally illiterate. This number must be reduced if the United States wants to remain competitive in a global market economy. There are few unskilled jobs left, and the majority of new jobs require a high school diploma and some post secondary education. In a survey of manufacturing firms – 96% said they provide training for their hourly employees (2/3 indicated they provided remedial- reading, writing, and math) (p.2).

"Peter Drucker noted in a recent issue of *The Harvard Business Review* that 'America's sole advantage in the global economy is our supply of knowledge workers.…This supply seems to be in serious jeopardy'" (Chell, 2001, p.76). National trends indicate the United States has a strategic economic position that could become vulnerable in the future. Moreover,"60% of the new jobs in the early 21st century will require skills possessed today by only 20% of the present workers'"(Chell, 2001, p. 77).

Workforce training and basic education are inherent in the fabric of a democratic society. The issue of people with marketable skills quickly translates into an economic equation of supply and demand. "The Economic Development

Review predicts that by 2010, as many as 300,000 jobs will be taken abroad due to lack of skilled workers and worker availability in this country" (Chell, 2001, 77). The education of our workforce or "lack thereof" will have uncalculated reverberations if these issues are not addressed. "The skills of U.S. workers will decide the future of individuals, businesses, communities, and the nation" (Chell, 2001, p.78). "Sustaining America's future will depend on innovations in the knowledge industries and on developing a more productive workforce. Brainpower and technology can multiply individual productivity to compensate for our higher wages and help America retain economic leadership" (McCabe, 2001).

Dr. Robert McCabe, former president of Miami-Dade Community College in Florida, has written extensively on developmental education. He champions the idea that what makes America a great nation is the belief that everyone deserves a chance and access to an education:

> Few educational programs are more misunderstood and less appreciated than community college developmental education. Both legislatures and colleges afford it a low priority, yet it is essential to our nation's well being. Developmental education can be cost effective and productive, and it is easily one of the most important services provided by community colleges (McCabe, 2001, para. 1).

McCabe agreed with the sentiments President Bush expressed in his 2001 inaugural address when, addressing education said, “that everyone belongs, that everyone deserves a chance, that no insignificant person was ever born” (McCabe, 2001, para. 5).

Today, it appears more people have accepted the idea that postsecondary education can have a significant impact on one’s future. “Frances Rosamond of National University, among others, estimates that starting salaries go up $2,000 per year for every mathematics course taken after ninth grade” (Tobias, 1993, p. 34). Enrollment trends predict increasing participation in higher education. "Enrollment in degree granting institutions hit a record level of 14.8 million in the fall of 1999, and another record of 15.3 million is expected in the fall of 2001. Enrollment is expected to increase by an additional 16 percent between 2001 and 2011" (Snyder & Hoffman, 2002, p.11). The numbers of developmental and first-generation college students will increase proportionally with these projections. Studies report 50 percent and higher of all first-time and non-traditional students test into one of three developmental courses: reading, writing, and/or math. “Even with aggressive school reforms in place in many states, every year over one million academically underprepared students enter higher education and are in need of developmental, or remedial, education services”(McCabe, 2000). These students are not all recent high school graduates – first time and non-traditional students are from all walks of life (Roueche & Roueche, 1999).

McCabe (2000), in his "Report to Public Decision-Makers and Community College Leaders," stated "sixty-two percent of remedial education students are deficient in mathematics, compared with 37.7 percent in reading and 44.6 percent in writing"(p. 41). These statistics illustrate the greater need for effective developmental math programs. MCabe (2000) offered:

> In most community colleges, remedial education is not given the priority or support commensurate with its importance to the United States. Helping under-prepared students maybe the most important service that community colleges can render to our country. Effective remedial education is an essential bridge in this effort. Yet, remedial programs are not recognized for their importance and are systematically under supported (p. 44).

The American Mathematical Association of Two-Year Colleges (AMATYC) clearly delineated the current situation:

> Higher education is situated at the intersection of two major crossroads: A growing societal need exists for a well-educated citizenry and for a workforce adequately prepared in the areas of mathematics, science, engineering, and technology while, at the same time, increasing numbers of academically under prepared students are seeking entrance to postsecondary education (AMATYC, 1995, p.3, as cited in Zopp, 1999, p.19).

This is an issue of economics and it is important due to the computerized advancements ahead in society.

Completion of Math Courses Can Predict College Enrollment

Student's completion of math courses in high school can predict college enrollment and persistence. Sells (1978) introduced the concept that mathematics has served as a "critical filter." In educational literature, "mathematics has traditionally been a gateway to technological literacy and to higher education" (Schoenfeld, 2002, p. 13).

In recent years, researchers have attempted to locate a critical point in students' mathematics education so that schools can be proactive in alleviating this epidemic. Horn and Nunez (2000) noted, "given the strong link between mathematics curricula and college enrollment (Riley, 1997), the analysis of first generation students' academics preparation focuses on mathematics course taking, beginning in the eighth grade" (p.81). Horn and Nunez also reported that students who completed course work beyond algebra 2 in high school had a significantly better chance of enrolling and persisting in college. Horn and Nunez clearly demonstrated the impact that parental influence has in the students' choice of classes. (As a result of course selection in the eighth grade it could have exponential consequences.) It seems that counselors, peers, and teachers most often influenced course selection if the parents were not involved in the students' academic choices for their class schedule.

What is Anxiety?

Anxiety is a phenomenon that has been acknowledged for centuries. "The word anxiety comes from the Latin word anxius, meaning a condition of agitation and distress. The term has been in use since the 1500s" (Bourne, 1995, p. 2). Bourne (1995) distinguishes anxiety from fear, in that anxiety has a more holistic affect on one's being; while fear seems to be a more acute response focused on concrete or external situations (p.2).

Over 19 million Americans suffer from some kind of anxiety problem (Repich, 2002, para. 1). There are many types and degrees of anxiety problems that can translate themselves into extremely debilitating situations. Anxiety can range from being relatively harmless, as in becoming nervous, to the escalation of extreme behavioral responses such as like shortness of breath, heart palpitations, sweating, nausea, and other physical reactions that restrict normal functioning. The extreme anxiety responses are considered phobias.

According to anxiety statistics, "women suffer from anxiety and stress almost twice as much as men. Also, anxiety disorders are the most common mental illness in America, surpassing even depression. Americans spend $46.6 billion annually on these issues" (Repich, 2002, para. 2).

Since anxiety seems to be such a pronounced problem in society, it makes sense that educators should explore the implications of anxiety on learning.

High Math Anxiety Yields Low-Achievement Scores

Hembree (1990), who investigated the relationship between math anxiety and achievement scores, reported:

> Correlations between mathematics anxiety and aptitude/achievement measures were inverse across grade levels, so higher mathematics anxiety consistently related to lower mathematics performance. Positive attitudes toward mathematics consistently related to lower mathematics anxiety, with strong inverse relations observed for an enjoyment of mathematics and self-confidence in the subject. High-anxious students took fewer high school mathematics courses and showed less intention in high school and college to take more mathematics" (38).

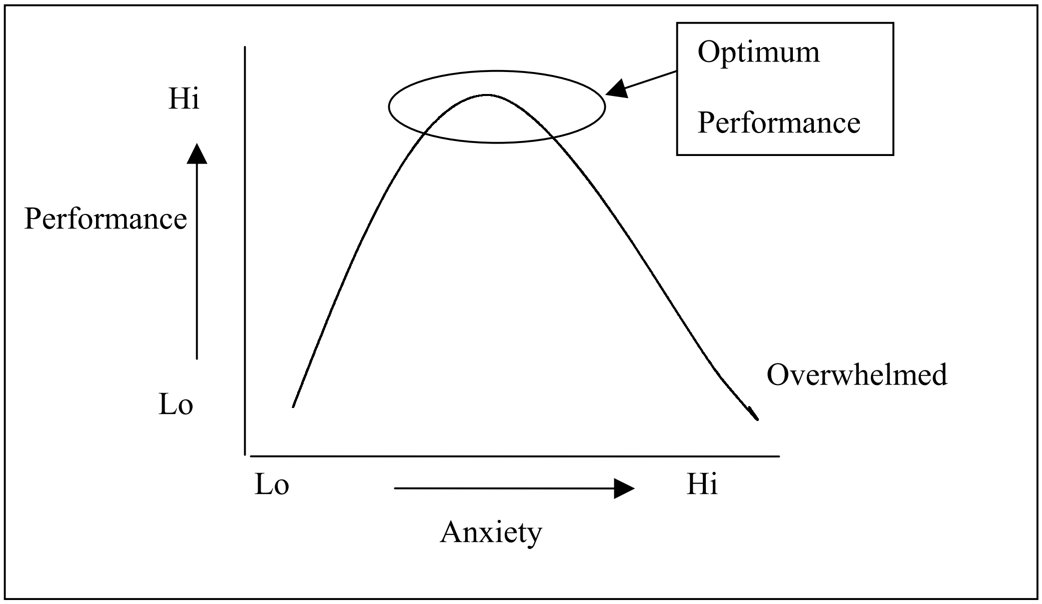
This data supports the first hypothesis offered that math anxiety will be high among developmental math students.

Research has shown that it is difficult for students with math anxiety to concentrate; therefore performance measures reflect inaccurate learning. “Eysenck argued that high anxiety subjects engage in significantly more task irrelevant processing (worry) than their low anxiety counterparts (e.g., Ganzer, 1968; Morris & Liebert, 1970; Paulman & Kennelly, 1984). The highly anxious subject thus has effectively smaller working memory capacity to devote to task resolution" (Darke, 1988, p. 488).

The Performance Curve - Yerkes-Dodson Law

The performance curve is a concept in psychology that illustrates the relationship between arousal (anxiety) and performance. This relationship was first observed in 1908 by Robert M. Yerkes and John D. Dodson. The basic notion of this relationship was that performance increased as anxiety increased to a certain point. This manageable level of anxiety or arousal served as a motivator for performance. The important thing the Yerkes-Dodson law illustrated was when people's arousal or anxiety increased beyond a manageable level their performance began to decline. Therefore, it is critical for optimum level performance for people to be able to manage their anxieties or arousal levels (Clark, 2000). This model was presented in the anxiety reduction intervention described in the following chapter (see Figure 1).

Figure 1: Yerkes-Dodson Law - Arousal



Rational Emotive Behavior Therapy (REBT)

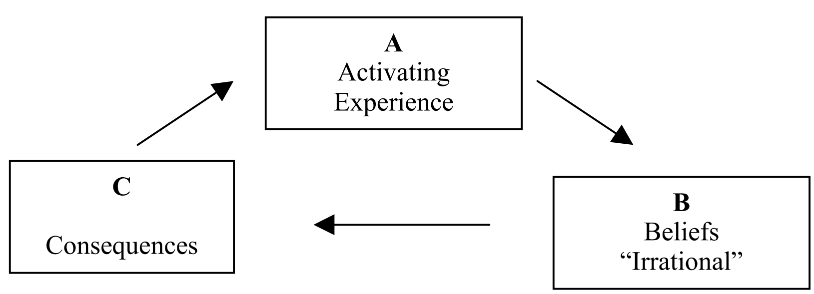
Rational Emotive Behavior Therapy was established by Dr. Albert Ellis in 1955. Ellis is famous for his solution focused approach aimed at changing negative or unproductive cognitive and behavioral habits with more positive thoughts and behaviors.

> Dr. Albert Ellis developed REBT which is an action-oriented therapeutic approach that stimulates emotional growth by teaching people to replace their self-defeating thoughts, feelings and actions with new and more effective ones. REBT teaches individuals to be responsible for their own emotions and gives them the power to change and overcome their

unhealthy behaviors that interfere with their ability to function and enjoy life (Albert Ellis Institute, 2003, para. 1).

The theoretical premise from which REBT works is a three step process. The theory is easy to remember because it begins with ABC. A is for activating experiences, such as unsuccessful efforts in math and traumatic experiences that trigger beliefs. "B stands for beliefs, especially the irrational, self-defeating beliefs that are the actual sources of our unhappiness. And C is for consequences, the neurotic symptoms and negative emotions such as depression, panic, and rage that come from our beliefs" (Boeree, 2000, p. 2). This ABC model, see in Figure 2, is a cycle that reinforces itself if left unattended to. The goal of REBT is to confront irrational beliefs and change the unhealthy cycle to a more positive and productive cycle.

Figure 2: ABC Model of Rational Emotive Behavior Therapy



The strength of this theoretical perspective depends on one's ability to identify these components and demonstrate the beliefs the individual arrives at are irrational. If the therapist or counselor can refute the irrational beliefs and encourage the client to change their thinking, the impact results in a more successful cycle of thinking, feeling, and behaving (Boeree, 2000, p. 2).

Math Anxiety and Learned Helplessness

This study is concerned with the experience of students placed in developmental classes due to math deficiencies. Math anxiety can impact a students' learning and attitudes in ways that have serious consequences. Hembree (1990) integrated 151 studies by meta-analysis to analyze the construct of mathematics anxiety. "Mathematics anxiety is related to poor performance on mathematics achievement tests. It relates inversely to positive attitudes toward mathematics and is bound directly to avoidance of the subject" (p.33). Hembree's work reinforces the notion that students avoid math classes and have poor performance scores due to math anxiety.

A developmental students' psyche is very important to his or her attitude and success in developmental studies. "Many nontraditional students who enter the community college's open door bring with them a history of failing to control the outcomes of their lives, both in and out of the classroom" (Roueche and Mink, 1982, p. 2). Many developmental students believe they don't have much control in their lives. They believe they are impacted by other's choices. As a result, they view control of what happens in their own lives as merely a reaction to others.

Over time, students adopt an attitude of, *Why try?* or *What's the point?* These feelings of helplessness are detrimental to the students' success academically and, if not addressed, students ultimately exhibit a victim mentality. If educators want to assist developmental students in successfully overcoming this feeling of helplessness, they must first understand the phenomenon of learned helplessness and learn to deal with the components that can help students empower themselves and overcome anxieties that have impeded their progress (Roueche & Mink, 1982).

Mikulincer and Nizan (1988) reported learned helplessness is a result of global and specific attributions as well as cognitive interference. The implications of this study are that students who believe there are forces beyond their personal control could exhibit decreased motivation and reduced task performance (Mikulincer & Nizan, 1988, p. 470).

Studies consistently report the importance of empowering students to overcome beliefs that impede their growth and academic skills acquisition. Math anxiety must be addressed to help students gain control in their lives and so they can increase their math literacy. This cognitive reprogramming is challenging, given the many hurdles students must already overcome.

The Cultural Component of Math Deficiencies

The implicit messages embedded in society are that, if one is not good at math it is not ones fault, it's okay, and common. It seems somewhat socially acceptable to "not" be a good at math. This troublesome norm has found its way into the mainstream of education.

Smith (2002) reported, "the fact is that mathematics has a tarnished reputation in our society. It is commonly accepted that math is difficult, obscure, and of interest only to 'certain people' i.e. nerds and geeks" (para. 8). In other cultures, mathematics is a foundational literacy that is understood to be of great importance. "It comes as a surprise to many people to learn that this attitude is not shared by other societies. In Russian or German cultures, for example, mathematics is viewed as an essential part of literacy, and an educated person would be chagrined to confess ignorance of basic mathematics" (Smith, B. S., 2002, para. 9).

These attitudes of math illiteracy are deep-seeded in our society; therefore, math instructors must be vigilant in the changing and shaping of perspectives and attitudes towards the discipline. Jackson and Leffingwell (1999) conducted a study investigating the instructor's role in creating math anxiety for students. They reported, "only 7 percent had positive experiences with mathematics from kindergarten through college, 16 percent had bad experiences in grades three and four, 26 percent had bad experiences in high school level, especially 9-11, and 27 percent had bad experiences in college level math courses" (p. 583). According to this data, only 7 percent of our students are having positive experiences in mathematics education. In light of this the teaching of math should be reevaluated.

Math Anxiety and Working Memory

Studies have shown there is a relationship between math anxiety and working memory. "Math anxiety exerts this effect by making it difficult to hold new information in mind while simultaneously manipulating it, the researchers hold. Psychologists regard this capacity, known as working memory, as crucial for dealing with numbers" (Bower, 2001, p.405).

The first study to address math anxiety and "the underlying cognitive processes involved in doing math" was conducted by Ashcraft and Kirk and published in 2001. A number of studies established the relationship between anxiety and physical responses, such as increased heart rate and respiration. Bower (2001) cited Ashcraft and Kirk's study as the, "first solid evidence that math-anxious people have working-memory problems" (p. 405). One of the theories used to support this study was the Eyesenck and Calvo's processing efficiency theory. According to Ashcraft and Kirk, the theory predicted "that performance deficits due to generalized anxiety will be prominent in exactly those tasks that tap the limited capacity of working memory"(p. 405). According to this theory, anxiety and worry interfere with the thinking process and compete for the fixed resources of working memory. This interference of efficient thinking directly results in decreased performance related to speed and accuracy. Overall, the most important finding of Ashcraft & Kirk's study was, "working memory is negatively correlated with math anxiety" (Ashcraft & Kirk, 2001, 225). Therefore, as anxiety increases, working memory decreases. This leaves students with bad experiences of math and test scores that reflect an inaccurate assessment of the students' knowledge.

Covington and Omelich (1987) conducted a study investigating anxiety and the variables that contribute to ineffective classroom test performance. The hypothesis is related to the concept that anxiety impedes efficient recall in memory. Therefore, students that tend to have high anxiety will perform at much lower levels than students that have low anxiety. "The assumption underlying the blockage hypothesis is that anxiety inhibits not original learning, but performance" (Covington & Omelich, 1987, p. 393). One of the outcomes of the study illustrated what happens to students that study and prepare completely, but perform poorly on exams. This finding indicated that highly anxious students need information and recommendations related to reducing anxiety to be more successful in academia. Another finding related to test preparation indicated the best way to increase performance is to prepare efficiently (Covington & Omelich, 1987, p. 396).

Attribution Theory

Attribution theory permeates the literature as researchers have investigated the variables associated with math anxiety. Scholars have attempted to explain this phenomenon with gender studies, cultural studies, educational experiences and attainment histories, looking for explanations that students could use to understand and reduce their math anxiety (Tobias, 1993, p. 80).

One of the reoccurring issues discussed in the literature regarding math ability is the question: Is math ability innate or the result of hard work? On the international front, it has been reported that U.S. students tend to attribute their math proficiency to ability, implying a genetic predisposition, versus Asian students that attribute their math performance to hard work and many hours of study (Tobias, 1993, p. 52; Engelhard Jr., G., 1990).

The literature regarding gender variables of U.S. students related to their math skills revealed inverse relationships in attribution styles. Tobias (1993) reported that males and females explain their success in math in very different ways. According to the data, when students explained their successful math experiences, males attributed it to ability, while females attributed their success to effort. The converse of this was true when the students were asked to describe experiences of failure related to math. The male students reported lack of effort, while females described lack of ability (Tobias, 1993, p. 81).

Gender Bias According to Studies

Gender has been a topic of discussion and research related to math anxiety for many years. A number of studies have found gender to be both a significant and insignificant variable to consider.

The most generally accepted belief is that gender is a predictor of math anxiety (Reily, 1992, p. 1). Some researchers believe that these differences in levels of math anxiety between genders may actually be due to cultural expectations rather than any real differences in ability (Ernest, 1976, 1980, 1981, 1993). Fennema and Sherman (1977) stated, "many females have as much mathematical potential as do many males. The generalized belief that females cannot do well in mathematics is not supported" (p. 69). Society has discouraged females from excelling in mathematics (Ernest, 1976; Fox, 1976; Rogers & Kaiser, 1995; Sells, 1978; Tobias, 1976; Zaslavsky, 1994, as cited in Cook, 1997, p.16).

Gender dynamics are prevalent at different intensities in the maturation process. "Similar to Tocci and Engelhard's (1990) results Hyde et al. (1990) revealed that males stereotyped math as masculine more than females did and that the peak in this gender difference occurred in high school years" (Abramovich, 1997, p. 6).

Benbow and Stanley's well-known studies in the early 1980s concerned gender issues and achievement. The Study of Mathematically Precocious Youth identified students at age thirteen that were distinguished in their mathematical abilities. The data on 40,000 students confirmed the hypothesis that gender was a significant variable related to mathematical reasoning and ability (Benbow, et al., 2000, p. 474).

Math Anxiety and Teaching

Research indicates that teachers have a significant impact on students' learning. Teachers' attributes may also have an effect on students' anxiety levels (Kovark, 1999, p. 18). Hamacheck (1972) warns:

> Somehow in our frantic quest for better teaching methods, more efficient instructional strategies, specifically defined behavioral objectives, and more effective methods of inquiry, we have all but forgotten that the success of those 'better' things depends very much on the 'style' of the teacher who uses them(p. 313), (as cited in Kovarik, 1999. p.18).

Many issues in the classroom surrounding teaching can affect students' learning. The teacher's style is important for the classroom environment to be conducive to learning. Ward and Jungbluth (1980) discovered in their research that girls are more responsive to positive feedback than boys. They speculated that the students' responses were based on their socialization process – where girls were more sensitive than boys (p. 255).

CHAPTER THREE

METHODOLOGY

The purpose of this chapter is to explain the methodology to be used in this comparative experimental study and to provide a rationale for research design. This study is a mixed methods approach that utilized both quantitative and qualitative measures. The post-positivist paradigm served to quantitatively test this experimental design. "This paradigm holds that objectivity is the standard to strive for in research; thus, the researcher should remain neutral to prevent values or biases from influencing the work by following prescribed procedures rigorously" (Mertens, 1998, p. 10). The quantitative component of the methodology yielded inferential statistics. “Inferential statistics are used to determine whether sample scores differ significantly from each other or from population values. Inferential statistics are used to compare differences between groups” (Mertens, 1998, p. 333). More specifically, the design required the data to be examined with an analysis of covariance (ANOVA) due to the multiple groups compared. The ANOVA allowed the researcher to test for main effects and interactions between groups.

Over the last ten years scientific inquiry has been debated, and as a result methodologies have improved. Denzin & Lincoln (2002) noted:

> The issues that scholars are proposing today make it clear that new paradigm inquiry is not, and never will be, second rate conventional

> scientific inquiry. It is scientific inquiry that embraces a set of three new commitments: first, to new and emergent relations with respondents; second, to a set of stances – professional, personal, and political – toward the uses of inquiry and toward its ability to foster action; and finally, to a vision of research that enables and promotes social justice, community, diversity, civic discourse, and caring (p. 330).

Traditionally, scholars have debated the concept of rigor and the qualitative and quantitative perspectives from which they come. Northcutt (2001) addressed the topic of rigor by comparing it to Lincoln and Guba's definition of the truth-value of research. Northcutt and McCoy (2001) noted:

> Naturalistic Inquiry suggested the 'traditional' properties of rigor – objectivity, internal, and external validity, and reliability – ought to be reconceptualized in the light of postmodern thinking and the (in 1985) concomitant rise in popularity of qualitative research. Lincoln and Guba proposed approximately parallel set of desirable properties of rigor which they call confirmability, credibility, transferability, and dependability.

Credibility in this study will be addressed two ways due to the mixed methods design. Mertens (1998) noted:

> Guba and Lincoln (1989) identified credibility as the criterion in qualitative research that parallels internal validity in postpositivist

research. Internal validity means the attribution within the experimental situation that the independent variable caused the observed change in the dependent variable. In qualitative research, the credibility test asks if there is a correspondence between the way the respondents actually perceive social constructs and the way the researcher portrays their viewpoints (p. 180 – 181).

Credibility is important in general due to the nature of a comparative study. Quantitatively, internal validity is very important so the researcher can make recommendations based on the findings.

Transferability as articulated in Guba and Lincoln's qualitative perspective correlates to external validity in postpositivist research. "External validity means the degree to which you can generalize the results to other situations. In qualitative research, the burden of transferability is on the reader to determine the degree of similarity between the study site and the receiving context" (Mertens, 1998, 183).

Dependability has been paralleled with the quantitative concept of reliability. "Reliability means stability over time in the postpositivist paradigm" (Mertens, 1998, p.184). Reliability issues were be addressed with appropriate instrumentations and a uniform protocol.

Confirmability in qualitative research has been linked to objectivity in the quantitative world. "Objectivity means that the influence of the researcher's judgment is minimized"(Mertens, 1998,p.184). Guba and Lincoln address this with respect to Yin's concept of a "chain of evidence." The most important criteria here was that the data could be traced back to the original source (Mertens, 1998,p.184).

Porter (1997, p. 523) wrote, "of all empirical work, comparative experiments provide the strongest evidence about the effects of education interventions. Unlike other empirical methods, these comparative experiments can supply answers to questions." Typically, limitations and criticisms of this kind of study consist of the lack of contextual information; however this mixed methods approach addressed those issues with a qualitative component to explain the quantitative findings.

Research Questions / Hypotheses

The research study explored the following two research questions:

1) Is math anxiety high among developmental math students?

2) Can math anxiety be significantly lowered over a semester?

There are currently two main research hypotheses offered:

1) Math anxiety will be high among developmental students.

2) Math anxiety can be significantly lowered over a single semester.

Research Design

Mixed Methodology

A mixed methods design was most effective to quantitatively capture the results of a comparative experimental design and qualitatively capture the experience of the student. In the quantitative section of the methodology the researcher was a pre-test/post-test design to measure and compare math anxiety reduction (DV) with an instructional intervention. The study was consisted of a pre-test measuring math anxiety levels and attitudes towards math. There was a comparison (control) group and a treatment (experimental) group for the purposes of comparing data. The intervention (IV) took the form of a presentation given by the researcher that addressed math anxiety and realistic self-image issues. Post-test scores were be compared to pre-test scores to determine if there were any significant changes in the math anxiety variable. "This pre-test/post-test design controls for the effects of history, maturation, testing, instrumentation, and experimental mortality by the use of control groups and for differential selection by the use of random assignment to conditions" (Mertens, 1998, p. 72).

Using a mixed methods approach was an attempt to increase the strength of the study and additionally provide comprehensive multiple data forms to support the findings. Patton (1990), a well-known research scholar stated:

> The advantage of quantitative approach is that it's possible to measure the reactions of a great many people to a limited set of questions, thus facilitating comparison and statistical aggregation of the data. This gives broad, generalizable set of findings presented succinctly and parsimoniously. By contrast, qualitative methods produce a wealth of detailed information about a much smaller number of people and cases. This increases understanding of the cases and situations studied but reduces generalizability (Patton, 1990, p.14).

Many studies have utilized the mixed methods approach to paint a more complete picture of the phenomenon the researcher is studying. As Mertens (1998) noted:

> Reinharz (1992) suggests that the conflict between adherence to strict scientific (post positivist) procedures and a desire to work within an emancipatory framework can be resolved by using what she calls a 'dual vision' (p.93). She describes the dual vision as a way of embracing contradictions that synthesizes the political and scientific. The concept is described in Reinharz's citation of Roberta Spalter-Roth and Heidi Hartmann's (1989) work. They design their work so that it meets the standards of the mainstream social science community of validity, reliability, objectivity, and replicability (p. 110).

The authors of *User-Friendly Guide to Mixed Methods Evaluations* (2002) wrote, ”experienced evaluators have found that most often the best results are achieved through the use of mixed method evaluations, which combine quantitative and qualitative techniques.” Mixed methods approaches can use the statistics generated to determine relationships, and the qualitative components can explain the findings through narratives. “Quantitative and qualitative techniques provide a tradeoff between breadth and depth and between generalizability and targeting to specific (sometimes very limited) populations. The issues of techniques, results, and generalizability are related to the perception of the value of data” (http:// ehr.nsf.gov/HER/REC/pubs/NSF97-153/CHAP_1.html , 2002).

Intervention

The intervention introduced to the treatment group was a presentation on math anxiety. The presentation incorporated aspects of cognitive, behavioral, cognitive-behavioral, and rational-emotive therapy techniques designed to reduce math anxiety tendencies. Rational-emotive therapy, which is similar to cognitive-behavioral therapy, is defined as, “ the identification of automatic thoughts and imagery and of maladaptive behavior…The process may open up new challenges to the participant’s thinking” (Beck, Emery, and Greenberg, 1985, p. 312). The presentation helped students become aware of the math anxiety phenomenon, define it for themselves, and provided suggestions to help students control their anxieties for better math performance. The presentation lasted one hour. The researcher conducted the presentation for each of the treatment groups using the same presentation format in order to control for the treatment as uniformly as possible. Intervention techniques included suggestions for relaxation, cognitive restructuring, and systemic desensitization. The intervention also explored definitions of basic terms that were used for discussion purposes. Topics of motivation and self-perception were also are incorporated. The presentation made students aware of the cycles of behaviors they had previously engaged in that maintained negative emotions.

Description of Sample for the Quantitative Statistics

Participants for the treatment and control groups

The population sample was comprised of students enrolled in the second level of the developmental math sequence and students enrolled in college algebra at a community college. The quantitative pre-test survey was distributed to all targeted developmental and college algebra classes participating in the study. The purpose was to determine a baseline math anxiety score to ultimately compare to the post-test. The post-test was distributed to the same classes of developmental math and college algebra at the end of the semester. The group receiving the post-test was comprised of treatment (experimental) classes that received the intervention and comparison (control) classes that did not receive the intervention. Focus groups were conducted with participants from three areas. The first focus group was open to all students at the college. Signs were posted and flyers were distributed inviting all students to participate in a math anxiety focus group. The second focus group was comprised of students from the treatment (experimental) classes. The third focus group consisted of participants from the comparison (control) classes.

Contents of the Math Anxiety Reduction Intervention

Brief Math Anxiety Survey

The beginning of the presentation was a brief survey that determined students' math anxiety. The survey was composed of seven statements which students were asked to rate with a Likert Scale of 1 – 5 ((1) = Disagree, (5)= Agree). These statements were extracted from a ten-statement anxiety survey used by Ellen Freedman at http://www.mathpower.com/anxtest.htm. After the students responded to the seven statements, they were asked to tally their score to see where they were on the math anxiety continuum. The survey used in this study follows (see Table 1).

Table 1: Brief Math Anxiety Survey Presented in the Intervention

I hate math class.	1	2	3	4	5
This class isn't tough now but it is going to get tough soon.	1	2	3	4	5
I tune out in class. I don't mean to do it…it just happens.	1	2	3	4	5
I don't really like asking my teachers questions.	1	2	3	4	5
I panic when called on in class.	1	2	3	4	5
I worry about these tests more than any other kind.	1	2	3	4	5
I can't wait until I get out of these classes.	1	2	3	4	5

Table 2: Brief Math Anxiety Survey Results

28 to 35	Yep! You've got it.
21 to 27	Not exactly comfortable with this subject.
14 to 20	Hanging Loose
7 to 13	Whew! Cool as a cucumber.

Once students' anxiety levels were determined, the next step in the intervention was to define terms and explain to students the definition of the term math anxiety. The first definitions presented were students' thoughts on math anxiety. Some of the examples students provided were:

- Stress you feel when you think about math or have to go to math class.
- Scared of math.
- Insecurity of not knowing the material, lack of confidence, and second guessing my answer.

Afterwards, formal definitions of anxiety and math anxiety were presented. For the purposes of the presentation, math anxiety was defined as, "an emotional reaction to mathematics based on past unpleasant experience which harms future learning" (Freedman, 2003).

Once the students discovered where they were on the anxiety scale and terms were clarified the researcher then described the physiological and mental symptoms that high levels of anxiety could elicit. These symptoms are described in the following table.

Table 3: Mental and Physical Symptoms of High Math Anxiety

Mental Block	Mental Distraction	Physical Symptoms
1. Freeze Up	1. Procrastination – You have waited until the last minute.	1. Fidgeting
2. Knowing the material but you draw a blank.	2.You cannot concentrate.	2. Butterflies
3. Bad timing on test – take your time.	3. Sensitive to noise.	3. Rapid heart rate
	4. Room Temperature	4. Difficulty Breathing
	5. Lighting	5. Nausea
		6. Headache
		7. Muscular Tension

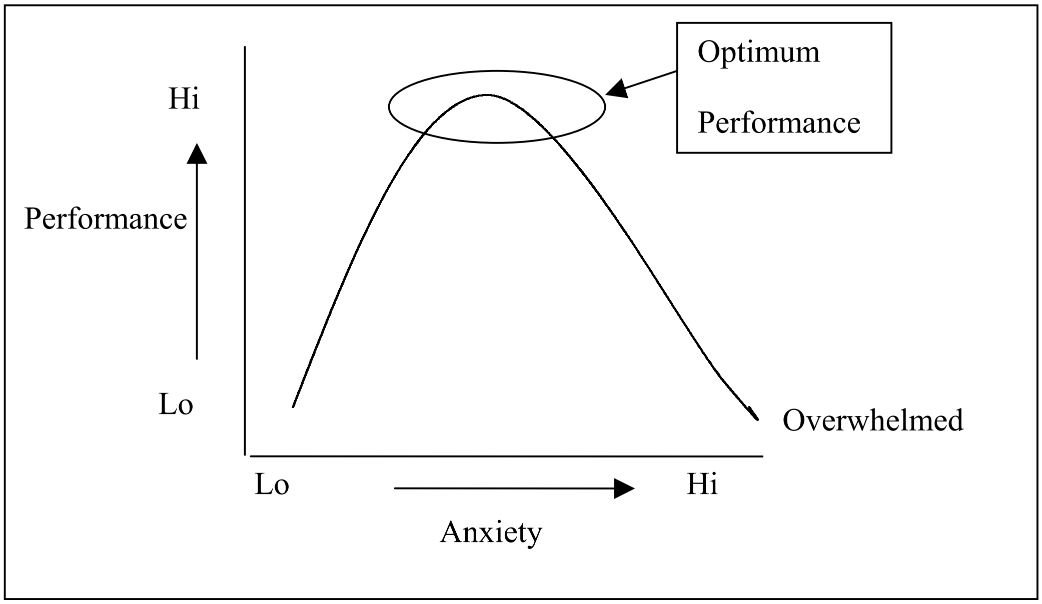
Table 3 describes many of the physical and mental manifestations of anxiety that allowed students to identify their own symptoms. The intent of this information was to allow students to be able to identify anxious characteristics correctly and be aware of the effects anxiety can have on an individual. The ultimate goal was to reduce these effects of anxiety for students in the future.

The first part of the presentation was dedicated to helping students understand the condition of math anxiety, while the second phase of the presentation was dedicated to illustrating how anxiety inhibits a students' performance.

The Performance Curve

This model was critical for students to understand due to the ramifications of the optimum performance zone. The researcher presented multiple applications of this performance curve so students could see the empirical utility of the concept. The Yerkes-Dodson law gave further validation to the literature that reported with higher levels of stress or anxiety, subjects had reduced resources for working memory, and therefore performance suffered (Bower, 2001).

Figure 1: Yerkes-Dodson law - Arousal



After the relationship between anxiety and performance was presented, the next area that was addressed involved correcting students' irrational thoughts about wrong math answers.

Irrational Thoughts

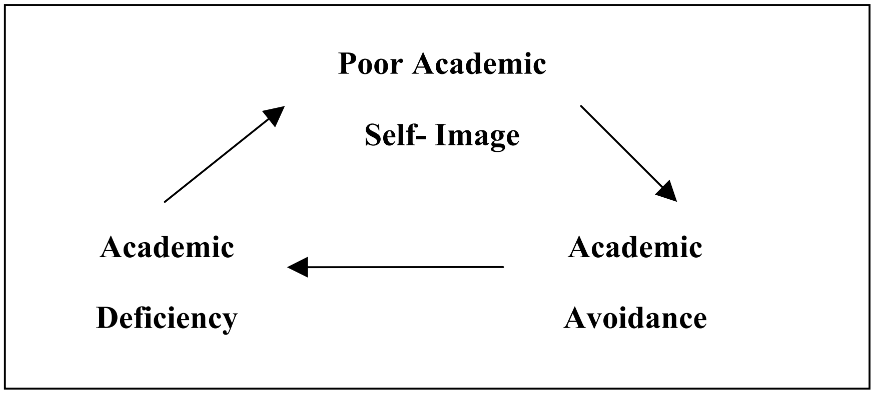
The correction of irrational thoughts was a central them Rational Emotive Therapy. This therapeutic concept was imperative to help students with the cognitions associated with "wrong answers" in math. Over the last several years the researcher had casually asked the question of developmental math students, "What is a wrong answer?" And students had replied with, "It means you are stupid. It means you don't know what you are doing. It means you can't do math." It was these responses that made the researcher aware of the importance of this misconception, and elevated the need for the irrational thoughts to be addressed. The researcher presented material to convince the students that wrong answers were important for discovery and nothing more than information. The intent was to redirect some of the students' negative thoughts they had originally associated with wrong answers to more productive kinds of messages. This was based on changing the students' conception of wrong answers.

The salient component in this section was alleviating some of the negative messages associated with wrong answers. As noted earlier, negative influences lead to a vicious cycles that perpetuate negative thinking. However, before one can change the vicious cycle, one must understand it.

The Vicious Cycle

The vicious cycle was presented as the state people experience when they feel badly about themselves in a particular area. This cycle was based on a poor academic self-image and demonstrated the feedback loop students could get caught in. Figure 3 details this cycle.

Figure 3: The Vicious Cycle



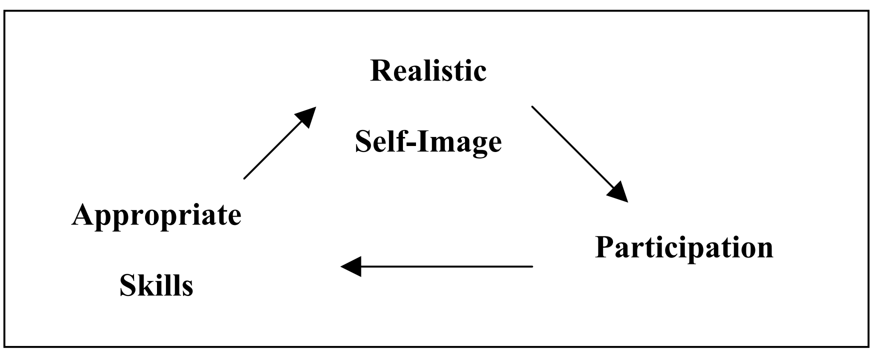
The vicious cycle began with the poor academic self-image. At this stage, students expressed ideas such as, "I'm not a math person and I've never been good in math, etc." From the poor academic self-image students tended to make bad choices that involved avoiding the kinds of behaviors that could remedy those feelings. The behaviors students avoided were asking questions, detailed note-taking, doing homework, and working extra problems. The natural consequences of these choices were academic deficiencies. And, logically, these deficiencies validated all the original thoughts related to the students' poor academic self-esteem.

It was imperative for the students to understand the vicious cycle and see how the choices they were making fueled it. However, with a few changes in the students' behaviors, they could turn the downward spiral into a successful process.

The Success Cycle

They key to the successful cycle was to get the students to start off in a different place. Students needed to evaluate their negative self-talk they had engaged in and stop self-criticisms. Students needed to change the, "I'm not a math person" to something such as, "Math is not my forte, but I can get it if I try hard enough." This was an example of shifting the negative self-talk to a more realistic self-image. Students were asked to make this kind of cognitive shift so they could adopt a more realistic self-image. The Success Cycle is shown in Figure 4.

Figure 4: The Success Cycle



The key to the success cycle working was selling the students on making the adjustments to their self-image. The researcher presented the cycles back-to-back so students could recognize the differences between the cycles. Once the students realized there were clear choices to make and behaviors to change, the process would seem more manageable. In the presentation, the researcher suggested different ways to engage students in higher levels of class participation. Among the suggestions were asking questions, moving to the front of the room during class, doing all assigned homework, and seeking out a tutor. According to the success cycle, once the student engaged in the learning process through higher levels of participation, the results of those actions was the gaining of appropriate skills. After the vicious and success cycles were presented, the researcher presented the concept of motivation.

Motivation

The next topic the researcher covered in the presentation was motivation and its three components. The researcher briefly introduced motivation, and asked students the reasons they were attending college. The three components of motivation addressed by the researcher were 1) attitudes, 2) goals, and 3) learning styles. As the researcher explained each of these topics, students were asked to be reflective of their individual situation. Afterwards, the researcher provided some additional solution-focused suggestions to help students manage their math anxieties.

Anxiety Management Exercises

The final portion of the intervention was anxiety management and reduction techniques. These recommendations ranged from very simple to involved and time consuming. Relaxation techniques of deep breathing and visualization were first suggested by the researcher. Another recommendation was becoming aware of overreactions, so students would be more aware of their responses and monitor their positive and negative self-talk. The final suggestion was systematic desensitization. Systematic desensitization is a cognitive technique that requires the student to build a list of ten things that elicits their math anxiety and to list the items in rank order from least anxiety producing to most. The student was then asked to spend time thinking and visualizing themselves successfully negotiating each item on the list with great success and little, if any, anxiety.

At the conclusion of the intervention, students had an opportunity to ask questions about anything they did not understand. This intervention and the surveys composed the quantitative portion of this study.

The student self-report experience of math anxiety was captured through four focus groups using the Interactive Qualitative Analysis (IQA). The qualitative data contributed valuable insight to the dimensions of math anxiety and provided the researcher with an additional means to understand the students' self-reported experience of math anxiety.

Interactive Qualitative Analysis (IQA)

The qualitative component of this research was acquired through Interactive Qualitative Analysis Method. This Method gave contextual explanation to the findings. The researcher used an abbreviated Interactive Qualitative Analysis (IQA) Method to generate themes (affinities) of the developmental students' experiences to account for changes in math anxiety. The abbreviated form of IQA was chosen based on the efficient use of focus groups.

The philosophy grounding IQA is, "a way of thinking about a process of gathering and analyzing data which depends heavily on group processes, interviews, and observation to understand and explain naturally occurring phenomena in a naturally occurring state" (Northcutt & McCoy, 2001, p. 2). "IQA is described as an innovative research method that blends traditional approaches to data analysis. It is a system driven process that essentially brings theory to people. IQA identifies elements and their relationships and places them in a visual context." (Northcutt & McCoy, 2001, p 3).

IQA was inspired by grounded theory. "Grounded theory was developed by Glaser and Strauss and can be described as 'a general methodology for developing theory that is grounded in data systematically gathered and analyzed' (Strauss & Corbin, 1994, p. 273). The defining characteristic of grounded theory is that the theoretical propositions are not stated at the outset of the study" (Mertens, 1998, p. 170). This theoretical orientation allowed the researcher greater latitude to explore themes or significant events that emerged throughout the process of the study.

IQA was chosen as a research methodology because it utilized focus groups in a manner that generated large amounts of data in a short amount of time. In the qualitative part of the methodology, the researcher used focus groups to gather data that facilitated further understanding of the quantitative findings.

IQA Protocol

The researcher conducted a total of four focus group sessions. The first two groups were open to all students on the community college campus where the research was conducted. The third group was comprised of the treatment or experimental population, while the fourth group came from the control group population. The researcher first explained the purpose of the study to each focus group. After the participants understood the task, the researcher asked the group to silently focus on the statement: ***What has been your experience with math anxiety?*** The researcher then directed the participants to write their thoughts on index cards while remaining silent. This is called a silent nominal process. The purpose of the silence was for all group members to participate and minimize feelings of alienation or intimidation from other group members. Once the group participants felt they captured their thoughts on the index cards, then all cards were taped on a wall so everyone in the group could see them. At that time, the researcher read each card aloud, making sure everyone in the group was aware of and understood all the information generated. After this clarification process, the participants were asked to cluster the cards into similar themes, which were called affinities. Once the group generated the information, clarified the responses, and clustered the data into affinities, the group was asked to determine relationships between the affinities that were created with the clustering process. This determining of relationships between the affinities was a theoretical coding process that revealed to the researcher how the participants viewed the relationships among the affinities generated. Then the researcher led the group through all possible combinations of affinities. Once the relationships were determined, the researcher took a vote from the group on all combinations. This voting process was important for the construction of the visual representation. The relationships of the affinities were then placed in an interrelationship diagram where the researcher, via a few computations, was able to determine if the affinity was primarily a cause (driver), or more of an effect (outcome) in the phenomenon being explored. This process was designed to yield a diagram that told a story of that focus group's experience.

Between five and nine affinities relating to student math anxiety were produced in the four focus groups. The affinities generated by each focus group were aggregated, and eleven common affinities emerged. These affinities are shown in Table 4.

Table 4: List of Eleven Aggregated Focus Group Affinities

1.	Teaching Style (Professionalism)
2.	Background
3.	Personal Issues
4.	Classroom Environment
5.	Fear and Frustration
6.	Memorization
7.	Time (Sense of Urgency Student and Teacher)
8.	Utility & Purpose of the Math
9.	Performance / Tests
10.	Technology / Calculators
11.	Emotional Responses and Reactions

The researcher then determined the relationship between each of the eleven affinities, keeping in mind the input recorded by the four focus groups. These relationships are shown in Table 5.

Table 5: Aggregated Affinity Relationship Table

Affinity Relationship Table											
1	<>	2	2	→	11	5	→	6	8	<>	10
1	→	3				5	←	7	8	→	11
1	→	4	3	→	4	5	←	8			
1	→	5	3	→	5	5	→	9	9	<>	10
1	<>	6	3	→	6	5	→	10	9	→	11
1	→	7	3	<>	7	5	→	11			
1	→	8	3	→	8				10	→	11
1	→	9	3	→	9	6	←	7			
1	<>	10	3	<>	10	6	←	8			
1	→	11	3	→	11	6	→	9			
						6	<>	10			
2	→	3	4	→	5	6	<>	11			
2	→	4	4	<>	6						
2	→	5	4	←	7	7	<>	8			
2	→	6	4	<>	8	7	→	9			
2	<>	7	4	→	9	7	<>	10			
2	→	8	4	<>	10	7	→	11			
2	→	9	4	→	11						
2	→	10				8	→	9			

Once these relationships were determined, the researcher rank ordered the affinities in an effort to reveal drivers and outcomes. In IQA methodology, these relationships are transferred into the Tabular Interrelationship Diagram (IRD), an organized matrix representing all of the relationships that were determined in the Affinity Relationship Table (ART). This Interrelationship Diagram allowed the researcher to efficiently organize the affinities and ultimately determine their status as either drivers or outcomes for the final Mind Map (see Table 6).

Table 6: Aggregated Mind Map Tabular Interrelationship Diagram

Aggregated Mind Map Tabular IRD														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	***Out***	***In***	**Δ**
1		<>	↑	↑	↑	<>	↑	↑	↑	<>	↑	7	0	7
2	<>		↑	↑	↑	↑	<>	↑	↑	↑	↑	8	0	8
3	←	←		↑	↑	↑	<>	↑	↑	<>	↑	6	2	4
4	←	←	←		↑	<>	←	<>	↑	<>	↑	3	4	-1
5	←	←	←	←		↑	←	←	↑	↑	↑	3	6	-3
6	<>	←	←	<>	←		←	←	↑	<>	<>	1	5	-4
7	←	<>	<>		↑	↑		<>	↑	<>	↑	4	1	3
8	←	←	←	<>	↑	↑	<>		↑	<>	↑	4	3	1
9	←	←	←	←	←	←	←	←		<>	↑	1	8	-7
10	←	←	<>	<>	←	<>	<>	<>	<>		↑	1	3	-2
11	←	←	←	←	←	<>	←	←	←	←		0	9	-9

$$\Delta = \textit{Out} - \textit{In}$$

$$\Delta = (\uparrow)\ \textit{up}\ - (\leftarrow)\ \textit{left}$$

Once the relationships were entered into the diagram, the researcher rank ordered the data as either drivers or outcomes. The drivers were more fundamental elements that produced an impact on the affinities that followed. The outcomes were those affinities affected, or receiving influence, by the drivers.

The up arrows represent the row driving the column, and the left arrows represent the column driving the row. If this is done correctly, the shaded diagonal on the IRD could be thought of as a reflection axis where each half confirms the other.

The researcher determined which of the affinities were drivers and outcomes. The arrows on the IRD gave the researcher the data needed for this process. The up arrows represented the “outs” and the left arrows represented the “ins.” The researcher found the difference in the relationships of *Outs* and *Ins* to rank order the data. The greater the value of the difference determines the ranking of *Drivers* to *Outcomes.* This difference is called delta (Δ). The formula used to determine delta was…

$$\Delta = \text{Out} - \text{In}$$

Once that calculation was done in each row, the researcher sorted the table in descending order by the delta value. This organized the affinities in order from drivers to outcomes (see Table 7).

Table 7: Sorted Aggregated Mind Map Tabular IRD

Aggregated Mind Map Tabular IRD														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	***Out***	***In***	**Δ**
2	<>		↑	↑	↑	↑	<>	↑	↑	↑	↑	8	0	8
1		<>	↑	↑	↑	<>	↑	↑	↑	<>	↑	7	0	7
3	←	←		↑	↑	↑	<>	↑	↑	<>	↑	6	2	4
7	←	<>	<>		↑	↑		<>	↑	<>	↑	4	1	3
8	←	←	←	<>	↑	↑	<>		↑	<>	↑	4	3	1
4	←	←	←		↑	<>	←	<>	↑	<>	↑	3	4	-1
10	←	←	<>	<>	←	<>	<>	<>	<>		↑	1	3	-2
5	←	←	←	←		↑	←	←	↑	↑	↑	3	6	-3
6	<>	←	←	<>	←		←	←	↑	<>	<>	1	5	-4
9	←	←	←	←	←	←	←	←		<>	↑	1	8	-7
11	←	←	←	←	←	<>	←	←	←	←		0	9	-9

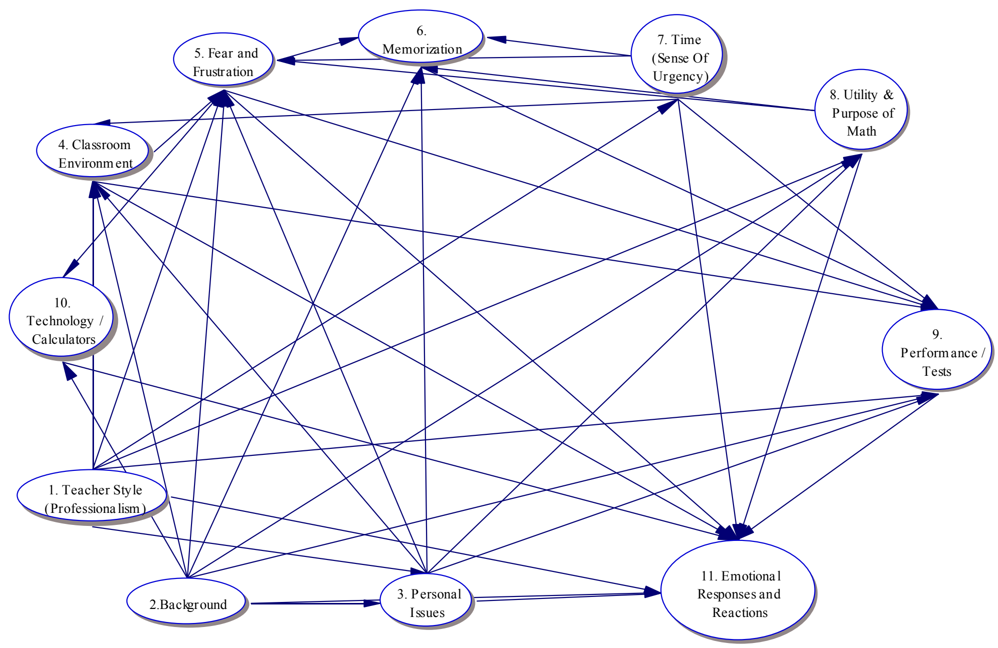
Once the researcher calculated the delta value, the affinities were identified and listed in the following Tentative Systems Influence Diagram (SID) Assignment chart. The table revealed that the primary driver for this study was *Teaching Style (Professionalism)*, while the primary outcome was *Emotional Responses & Reactions* (see Table 8).

Table 8: Tentative SID Assignments

Tentative SID Assignments		
2	***Background***	***Primary Driver***
1	Teaching Style (Professionalism)	Secondary Driver
3	Personal Issues	Secondary Driver
7	Time (Sense of Urgency)	Secondary Driver
8	Utility & Purpose of Math	Secondary Driver
4	***Classroom Environment***	***Pivot***
10	Technology / Calculators	Secondary Outcome
5	Fear and Frustration	Secondary Outcome
6	Memorization	Secondary Outcome
9	Performance / Tests	Secondary Outcome
11	***Emotional Responses & Reactions***	***Primary Outcome***

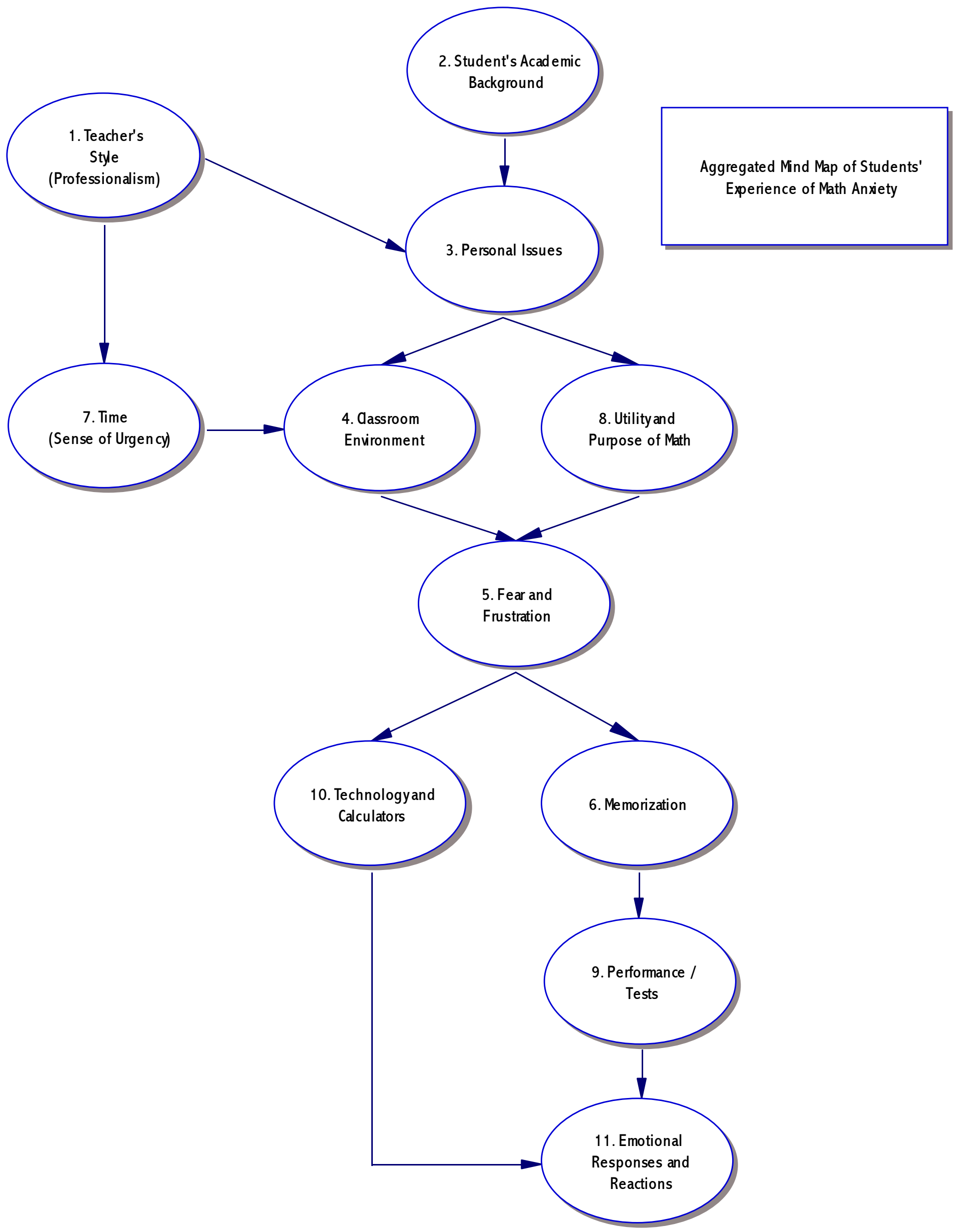
At this point, the researcher assembled the Saturated Mind Map from the aggregated focus group data (see Table 9).

Table 9: Saturated Aggregated Mind Map



Once the relationships were examined, the researcher removed redundant links to simplify the diagram (Mind Map). The unsaturated diagram became the Mind Map used to draw the conclusions presented in Chapters Four and Five of this study (see Table 10).

Table 10: Unsaturated Mind Map



Procedures for Data Collection

Administration of Pre-test / Post-test Questionnaires

The researcher attended classes to administer the pre-test and post-test questionnaires. The data collection for the qualitative component of this study consisted of focus group's themes as feedback so the researcher could attribute significant effects correctly. These focus groups were conducted by the researcher to facilitate the IQA process.

Survey Instrument: Alexander & Martray's Abbreviated Version of MARS

The quantitative component of the research was a survey with some preliminary demographic data followed with a math anxiety questionnaire. The instrument that was used to assess math anxiety in this study was an abbreviated version of The Mathematics Anxiety Rating Scale constructed by Alexander & Martray (1989). Alexander & Martray chose the 98-item Math Anxiety Rating Scale (MARS) due to its "sound psychometric attributes and because of extensive data on the reliability and validity of the scale" (Alexander & Martray, 1989, p.143). The 25-item abbreviated version focused on three factors that were most salient when a factor analysis was conducted on the long version of the MARS. "The eigenvalues for the first five factors were 24.4, 3.94, 3.08, 2.46, and 1.87. The number of factors to be rotated was initially estimated as three, based both on

Cattell's (1966) 'scree' test and on factor interpretability. The three unrotated factors accounted for approximately 24%, 4%, and 3% of the variance of the MARS scores. The factors were rotated to the varimax criterion" (Alexander & Martray, 1989, p.146). The first factor that was defined with 15 items on the abbreviated form was labeled Math Test Anxiety.

Alexander & Martray (1989) noted:

> The pattern coefficients on the first factor ranged from .71 to .78 with a mean coefficient of .74. Factor I was, therefore, labeled Math Test Anxiety….The second factor the coefficients ranged from .40 to .54 with a mean pattern coefficient of .50. Factor II was labeled Numerical Task Anxiety because the items compromising the factor reflected anxiety about executing numerical operations….The pattern coefficients on the third factor ranged from .42 to .49 with a mean coefficient of .46. Items comprising Factor III was Math Course Anxiety (p.146).

The internal consistency of the scale scores using the 25 salient items…was examined by calculating coefficient alpha. Coefficient alpha was .96 for the 15 items associated with Factor I (Math Test Anxiety), .86 for the five Factor II (Numerical Task Anxiety) items, and .84 for the five Factor III (Math Course Anxiety items. These coefficients compare favorably with the .97 coefficient alpha reported by Richardson and Suinn (1972) for the full scale 98 item MARS" (Alexander & Martray, 1989, p. 147).

The abbreviated version of the Mathematics Anxiety Rating Scale was a good test for this study's purposes. However, a parallel form was needed for the post-test condition. Therefore, the researcher created a parallel form of the abbreviated version of the MARS.

Parallel Form Pilot Test Results

The researcher needed to create a parallel form of the abbreviated version of the MARS. The form also had to be tested to in order to preserve the integrity of the study. The parallel form was piloted at the same community college in which the study was conducted. Forty subjects participated in the pilot that yielded strong results of the successful creation of this parallel form.

The paired t-test reported that the forms were highly correlated, with averages that were not statistically different, and, therefore, very reliable. The positive correlation was .954, indicating the forms were essentially equivalent. When the average of the two forms were compared, the paired t-test determined there was no significant difference between the forms. The reported difference was .425, but this was not enough to be considered significant. The reliability of each form was very good. Form A (Alexander & Martray's form) had an alpha level of .9143, with only 1 item in the analysis that had a questionable correlation. Form B (parallel form created by the researcher) had an alpha level of .9190, with the same item as form A reporting questionable correlation. Upon review of the problematic item (item # 16), the researcher decided to eliminate it from the final version when the surveys were given.

Summary of Chapter Three

The researcher used data analysis techniques that compared and contrasted math anxiety levels with students' attitudes towards math. A repeated measure ANOVA was used to test the overall significance of the main effects and interactions. The qualitative data was condensed into an aggregated mind map and portrayed in a diagram in an effort to enrich the quantitative statistics. The results allowed the researcher to determine if developmental math students' math anxiety was significantly different from that of college algebra students. The pre-test / post-test component allowed the researcher to determine if there was a significant reduction in math anxiety over the course of a single semester. Once this data was compiled, the researcher assessed the findings with a qualitative component adapted from IQA.

CHAPTER FOUR

FINDINGS

Overview

The data collected for this study were in the form of math anxiety scores and focus groups. The focus groups provided valuable insight for the researcher to understand the experience and stories behind the quantitative scores. The qualitative portion of the study was composed of themes that emerged through focus groups. These themes and the relationships between them resulted in the construction of mind maps. The maps allowed the researcher to gain insight into the students' experience of math anxiety. The quantitative data collected were pre-test and post-test anxiety scores. These scores elicited a picture of migration in the treatment group that reflected students' scores moved towards the reduction of math anxiety.

To explain the phenomenon of math anxiety thoroughly, the researcher asked students about their personal math learning experiences.

Qualitative Research

The researcher conducted four focus groups in order to put a human face on math anxiety. The focus groups provided feedback that helped the researcher conceptualize the students' experience of math anxiety. Each focus group produced a number of themes or affinities that were significant for each group. The researcher aggregated the data and produced the following eleven affinities (see Table 4).

Table 4: List of Eleven Aggregated Focus Group Affinities

1. *Teacher Style*
2. *Students' Academic Background*
3. *Personal Issues (Self-Esteem)*
4. *Classroom Environment*
   (Physically Comfortable / Emotionally Safe)
5. *Fear and Frustration*
6. *Memorization*
7. *Time (Sense of Urgency)*
8. *Utility / Purpose of Math*
9. *Performance / Tests*
10. *Technology / Calculators*
11. *Emotional Responses & Reactions*

Focus Group Affinities

1. Teacher Style (Professionalism)

Teacher related feedback was prevalent in the students' responses. Students attributed much influence and power to their math teachers. There were three sub-dynamics in this affinity. The first dynamic reflected was the teacher – student interaction. This was illustrated with examples of commentary that teachers had directed at students, both positive and negative. Some examples of negative comments made by teachers were, "You should know this already," or, "You should have learned this in high school," and, "It's in the book - look it up." Other comments included the use of sarcasm that ultimately belittled and embarrassed students. These kinds of comments obviously shut down the students' willingness to engage the teacher and explore the topic any further whether they had questions or not. On the other hand, a positive example that students offered was when the teacher checked to ensure students were understanding a math problem worked on the board with a comment such as, "Are you getting this?" This was of course much more inviting to students and exhibited a willingness on the teacher's part to engage in further explanation.

The second sub-dynamic in this affinity was the student to teacher interaction. Students expressed feelings of frustration with the vocabulary of mathematics. Several said, "I know what I want to ask, I just don't know how to ask it." Another reoccurring frustration that contributed to anxiety resulted was when teachers skipped steps in problems. When students didn't always follow along, they subsequently did not realize computations had been completed. Therefore, they sometimes missed vital steps due to lack of communication with the teacher.

The final dynamic associated with the teacher's style was characterized as professionalism. Students offered lots of feedback that surrounded communication issues. These issues included difficulty in understanding professors for whom English was not their first language, as well as speed of delivery. Students across all four focus groups reported issues of speed in their classes. One reported problem of speed arose when teachers did not manage their curriculum, spending extended time in some sections, and then speeding through unfinished chapters at the end of the semester to complete the course material. The lack of even a pace produced lots of anxiety for students. Another component to professionalism was the teacher's ability to convey ideas and concepts clearly. One student reported, "It's one thing for teachers to be able to 'do' the math…It is another for them to be able to 'teach' it or communicate it effectively.

The following data were generated by focus groups and were compiled into the affinity entitled Teacher Style (Professionalism).

Teacher Style (Professionalism)

Teacher to Student

-Teacher says, "You should know this!"
-Very helpful when teacher checks with students…"Are you getting this?"
-Too many tests not enough reviewing
-Communication issue (The teacher can be a genius, but that doesn't mean they can communicate it where students can learn it.)
-"They make you feel dumb when you don't get it."
-Teaching style (open to questions)
-Do not exhibit confidence in their ability as a teacher
-Homework (how much they assign)
-Afraid to ask teacher questions (safety issue)
-Teachers that are flexible and accept different ways of working the problem. (If I learned to do things a different way.)

-Teacher / Student relationship? I don't understand what you mean by this.
-Teacher's ability to explain the problems well. (Communicate effectively)
-"Too fast"
-If the teacher has an accent it is hard enough to understand the math much less work through the accent.
-Teacher's don't break down steps
-Boring Teacher
-Teacher using sarcasm when you mess up
-No stable teacher, substitutes, feeling abandoned
-Bad teachers (impatient)
-Poor Instructors (act as if they don't care, sarcasm)
-Go too fast in class
-Doesn't show all of the steps
-Poor communication skills

Student to Teacher

-Fast Paced (?)
-I need direct answers…get to the point
-so many ways of working one problem
-takes long steps (long process)
-Too much work just to get one small answer
-too much work for a simple answer
-steps left out, teacher skips steps (should this be in the first subgrouping?)
-not willing to ask more questions
-not knowing what to ask to get the right question or answer
-don't understand some of the math words…vocabulary
-too many formulas

Professionalism (Pace)

-Missed Out, Missed something (this relates to the second subgrouping, I think)
-Bad teacher (explaining, patience, speaking [hard to understand], Not good answers)
-Learning Style
-Teacher Style
-Put on the spot

-Math has changed, teaching it differently (returning student)
-Bad teachers for fundamentals…poor background
-Clear steps needed (recipe book)
-Reteach, again and again
-Belittled
-Missed a fundamental step (absent, illness)
-Communication skills
-Don't know what to ask-Teacher is too far advanced, wants students to skip steps when the student still needs them (Does this relate to the first or second subgrouping?)

2. Students' Academic Background

This affinity generated very interesting discussion. Students reported their foundational experiences were responsible for their current math performance abilities. Students shared their experiences of learning enough to "get by," stealing the instructor's manual to get answers, and traumatic past experiences that continue to influence current math perceptions. Many students shared stories of liking math early in their academic careers. However, this positive attitude dissipated as a result of being absent for a long period of time due to illness, a move to another school, or teacher turnover during a fundamental year of learning. These disruptions in the establishment of foundational concepts left conceptual gaps which students didn't realize until years later.

Surprising Story

A surprising story offered by a middle-aged African-American female student surrounded her fifth grade experience of math. She was eleven years old at the time of the integration of the Dallas, Texas K-12 school system where she was a student. She reported that this transition was more than just moving to a new school during a critical year in her learning - it was an experience that literally changed her life. The emotional miles traveled seconded the physical miles that were added to her commute to and from a different school…a "white" school.

She recounted her experience of the "new" textbooks. The books at the integrated school were described as totally different, newer with more advanced concepts. As an adult looking back on her experience she knew there would have been a difference in what concepts students were learning and she needed help to make the transition successfully. However, she didn't receive the required assistance during the transition. As a result, she experienced a gap in her math fundamentals, which resulted in deficiencies. She subsequently developed a negative attitude towards math because she didn't understand what was going on in the classroom.

Students' Academic Background

-Bused to "white" school in 5th grade (bussing) (11-12 yrs old)
-Gap in learning…missed fundamentals
-New school curriculum was far advanced – huge learning curve
-Culture Shock
-Emotional transition
-Routine Change
-Different Teachers
-Outdated and substandard text books

-Loved math before moved to new place…new school, different teacher, bad experience
-Learned enough to get by
-Our surroundings
-Classroom settings
-Visual aides, stimulating environment
-The school we went to (poor)
-High School Prep was too easy

3. Personal Issues (Self-Esteem)

Confidence and self-esteem represented a central theme reported by a majority of students. The belief in self influenced participation rates in terms of a willingness to take a risk and ask questions in class. Students spoke at length about wrong answers and how their level of understanding or lack of understanding could be illustrated with that one wrong answer. Students reported they did not want to spend extra time working on a subject that was either right or wrong when most of the time their responses were wrong. These wrong answers were powerful deterrents to math success. Over time, the wrong answers chipped away at students' confidence and initiative when they worked on math.

Other topics of discussion that surrounded self-esteem included cultural issues. Students reported that it was "okay" to not be good in math, that in some circles it was socially acceptable to claim, "I've never been good in math," or "I'm just not a math person." A related self-esteem issue was perfectionism. Some students held such high expectations for themselves when they got wrong answers in the learning process they jumped to extreme conclusions such as, “I’m stupid,” or “I’m just not a logical thinker.”

These personal issues carried considerable weight in the student math experience. Students grouped the following feedback items under the personal issues/self-esteem affinity.

Personal Issues (Self-Esteem)

-Pressure to do well (from self)
-Don’t want to be left behind
-I second guess myself
-Fear of being slow, left behind
-Fighting the need to be perfect
-Perfectionist
-Scared of going to the board…people are looking at you
-Lack of confidence
-Belittle self during study sessions
-Fear of being laughed at
-General fear of math
-Fear of not knowing
-Feel like a baby when making excuses for failure
-Uncontrollable nervousness
-Fear of slowing class down by asking “stupid” questions
-Scared to ask questions
-Taking math too serious
-Feel like all eyes are on me during tests.
-Fear of dragging other people behind
-Fear of being wrong
-Making a bad grade
-I don’t like when I get the problem wrong
-Fear of failing
-Need help
-Lack of study
-Need Tutor
-Cheated in high school…caused gap in learning
-Too much to remember; I forget and can’t keep it straight

-Loss of concentration
-Time limit on test…have to rush
-Missed too many days to get caught up…left behind
-Very challenging
-I'm not a logical thinker
-Not retaining parts of the equation
-Excuses for not participating
-High school gave us more practice
-Always trying to find the easy way out
-Bad experiences
-Ultimate fear…death
-Teacher / Student personality conflict
-Society's Perceptions…"Never been good at math" – Acceptable
-Bad attitudes in class – disrespect (of teacher, by teacher?)
-Personal lives

4. Classroom Environment (Physically Comfortable / Emotionally Safe)

Another important dimension of math anxiety surrounded environmental concerns. Physically students reported that if the temperature of the classroom was to hot, cold, or stuffy, it affected their ability to pay attention. Another physical dimension was students' ability to read the chalkboard. Students complained about excessive chalk dust clouding their view. Also, students pointed out sometimes light colored markers didn't show up very well on the white boards and they were not able to see as a result.

As regards the emotional component to the classroom, students offered feedback about how they felt participating in class. Students addressed this topic by telling each other stories about how in some classes they were encouraged to help each other, while in others they were encouraged to "do their own work." It was very important for students to feel emotionally safe in the learning environment. Students reported participating more when they felt safe by asking questions, volunteering answers, and taking risks by volunteering to go to the board to work a problem. The feedback generated in the focus groups for this affinity were:

Classroom Environment (Physically Comfortable / Emotionally Safe)

-Compatible cliques in the classroom
-Stuffy
-Can't read the chalkboard
-Teaching environment
-Desks are too small for book and paper to take notes.
-Emotional Safety – don't feel safe enough to take risks
-Comfortable
-Cold
-Boys and Girls split
-Emotional safety issues (students have to feel safe and comfortable to take chances on being right or wrong)

5. Fear and Frustration

Fear and frustration were very real and frequent emotions that students struggled with throughout their math experience. A couple of the groups discussed frustration with trying to take notes, understand the new concept, and synthesize the material quickly enough to be able to ask the questions necessary to complete that evening's homework. Students reported that once they had the sense of being lost and confusion had set in, it was hard to regain focus and generate the necessary momentum to get back on track. Another source of student frustration was a sense that, in the words of one student, "The teacher doesn't understand what it is like to struggle with math because he/she never has."

When the student separated him or herself from the teacher, it created a deeper sense of marginalization and exacerbated the negative emotion. Some of the older students talked of the frustrations associated with different methods of teaching. These students reported that when they had gone to school years earlier, the teachers taught math differently, and as a result, it felt like they sometimes had to totally relearn how to do some things.

Fear and Frustration

Things you are afraid of.

-Math itself
-Very hard
-Showing I'm a dummy
-Being very confused…(who, where, what, when)
-Fear (test, not getting it, bad grade)
-Confusing Questions
-Age difference (They know things I don't [other students]).
-Lost
-Frustrated
-Fear of low test grade
-Fear of the Teacher
-Rhetorical Question…Why? What's the purpose? Real Life?
-Stressful studying for math
-Crying
-Lost in lecture and tests
-Teacher doesn't understand what it is like to understand what it is like to struggle with math because he/she never has
-Problems, books, teachers, and presentations are hard to follow

6. Memorization

Students offered lots of feedback surrounding memorization issues. Many times students described their experience of being overwhelmed in memorizing too many formulas. Students also described difficulty in memorizing steps to algebra concepts and having trouble getting them committed to memory. The most salient comment that surrounded memorization was, "At test time, I go BLANK!"

Memorization

-Have to memorize too many formulas
-I found myself wanting to be ahead of others in the classroom (positive motivation for memorization.)
-Fractions
-Formulas get mixed up
-Tests make me freeze up
-I get it in lecture but on the test I freeze up. (In class I am okay, outside of class—No way)
-Mental Block
-Too many formulas to remember
-Trouble with memorization
-Forget the formula
-Trouble recalling Algebra formulas from long time ago (returning student)
-I ask myself why I can't remember? (and blame myself)
-Too many formulas
-I go BLANK
-Blank at test time.
- I forget everything
-Forgetfulness
-Not knowing the formulas

7. Time (Sense of Time Urgency)

The theme relating to time was comprised of three dimensions. When older students spoke of time with a sense of urgency, they specifically referred to the fact they did not want to spend two or three years doing remedial or developmental coursework. Older students reported they needed to get on with courses that were going to count. Other students discussed the many responsibilities they had with work and family which resulted in the sense of being pressured for time. Time to study for extended periods was also reportedly hard to come by. The third sub-theme of time related to instructor pace. Students talked about instructor concerns for covering the curriculum in the semester. It seemed there was a sense of urgency from both the instructor's perspective as well as the students'.

Time (Sense of Time Urgency)

-Time pressure
-I feel like I take too long to work the problems.
-I think about how much time I have left.
-Not having enough time to finish math exams.
-I stay on one thing too long. (I don't know how to pace myself.)
-Not enough time in class to cover topics.
-Don't have enough time to prepare for class or tests.
-Fear of not having enough time for tests
-Time Pressure
-Time Crunch

8. Utility / Purpose of Math

The next affinity described as math utility or purpose received attention due to students' desire for meaning in their courses. The question that reoccurred was, "When am I going to use this?" Students struggled with the purpose of algebra beyond their degree plan. Basically, students accepted the fact that math was a requirement for their degree but could not see its benefit in “real life.”

Utility / Purpose of Math

-Background preparation (middle school and high school prep classes)
-You either got it or you didn’t.
-Need it for future application, must understand
-You don’t use this stuff, only in class!
-Never think about math unless in math class
-Couldn’t focus in class
-Easy to focus when you know what you are doing
-Never used
-No application to real life
-Not understanding when you are done
-What is the problem asking for?
-Long problems…too many steps
-Scared of word problems…How they word them/what are they asking for?
-Math rules, when do they apply?
-Lack of concentration during tests
-Lack of understanding homework when reviewing for tests
-Word problems
-At what point will this stuff make sense or mean anything for real?
-Right/wrong (this stuff is so concrete…you are one or the other)
-Not knowing the answer…or what you are looking for
-Need to be in a study group that you feel comfortable to ask questions.

9. Performance / Tests

Students described performance as an affinity related to math anxiety. The majority of the discussions focused on tests and quizzes. However, some students considered classroom performance as part of this dynamic. Students talked about how they felt when teachers called on them in class; some felt put on the spot, whereas others felt picked on. One brave student was courageous and confessed to years of cheating due to performance pressures from her parents.

Performance / Tests

-I study before class and do well, during class in the test I go “BLANK.”
-I study at home and do well. (I do well at home because no pressure).
-I need to talk it out or write it out…testing format is hard for me.
-Tests
-Quizzes
-Pop Quizzes
-Disliked being called on, felt picked on
-Scared of the chalk board (don’t want to mess up in front of people)
-Different ways to do a problem
-On the test the problem is changed or looks different
-Cheat…don’t want to do poorly so just cheat

10. Technology/ Calculators

The technology affinity came out of the random selection group. Students in this group who were enrolled in college algebra reported an extreme amount of anxiety related to using the required graphing calculator. Students reported spending significant amounts of time “just learning how to use the calculator, then I have to figure out what’s going on with the math!”

Technology / Calculators

-Calculator – too advanced technology

11. Emotional Responses & Reactions

The final theme or affinity of emotional responses and reactions was the most popular category of discussion. Students wanted to talk about how math affected them and how it made them feel. Some reactions were mild, as in feeling sad and confused, while other reactions were more intense. The more intense emotions reported by students were hate, ignorance, overwhelmed, anger at self, nausea, and humiliation. These negative emotions represent the manifestation of the students' anxious state when confronted with mathematics.

Emotional Responses & Reactions

-Shaking
-Overwhelmed
-Cry after tests
-Nausea
-"You should already know that!"
-Frustration
-Humiliation
-Emotions Hurt
-Personal hurt
-Feel like giving up
-Feeling stupid
-Nervous
-Scared
-Embarrassed
-Overwhelmed
-Dislike
-Hate
-Just what to do
-Overwhelmed
-Fear not being able to grasp it
-Fear
-Forgetful on the test
-Memory Lapses
-Fear keeping things straight
-Overwhelming…so many numbers
-Crash and burn
-Fear of the Teacher (used to love it / now I don't)

-Ignorance
-Clueless
-Sadness
-Anger at self
-Overwhelmed
-Confused
-Unclear…all mixed together

In conclusion, these eleven affinities were produced in four different focus groups during the semester in an effort to better understand developmental math students' perspective of math anxiety. These affinities gave voice to the complex nature of math anxiety as each highlighted a different dimension comprising students' experiences.

Quantitative Data

The quantitative data generated from the survey pre-test and post-test administrations yielded thought provoking results. This information has given the researcher ample data to address the research questions that initiated this study.

Research Questions

This research focused on the following two main research questions:

1) Is math anxiety high among developmental math students?

2) Can math anxiety be significantly lowered over a semester?

Research Hypotheses

There were two hypotheses for the research questions:

2) Math anxiety will be high among developmental students.

2) Math anxiety can be significantly lowered over a single semester.

Demographics of Sample

The sample was described based on the participant's age, gender, and race categories. In the age category, the majority of student participants were in the 18-25 range. The gender classification showed that more women than men took the surveys. The racial descriptors revealed that the majority of the participants were White, Hispanic, and then African American (see Table 11).

Table 11: Demographics of the Sample Population

	Age					Gender	
	18 - 25	26 - 35	36 -49	50 - 60	61+	Female	Male
Total	105	23	21	2	0	94	57
%	69.54%	15.23%	13.91%	1.32%	0%	62.25%	37.75%

Race					
African American	Asian	Hispanic	Native American	White	Other
29	4	39	2	72	4
19.21%	2.65%	25.83%	1.32%	47.68%	2.65%

In addition to the basic demographic data, students were asked three brief questions (See Table 12).

Table 12: Questions Regarding Students' Affection for Math

Do you like math?		Do you like fractions?		Do you think math is useful?	
Yes	No	Yes	No	Yes	No
67	84	26	125	141	10
44.37%	55.63%	17.22%	82.78%	93.38%	6.62%

The majority of these students did not enjoy math. A total of 55.63% reported not liking math, as compared to 44.37% reporting a liking for the subject. When students were asked about fractions, the disapproval rating increased dramatically, jumping to 82.78% disapproval, while 17.22% expressed a positive attitude towards fractions. The final question related to the usefulness of math. The overwhelming majority 93.38% agreed that math is useful. These three questions illustrated that while students did not particularly enjoy math in general, nor fractions in particular, they did agree that math was useful.

Research Question #1

This first question was a comparison of the level of anxiety between developmental and college algebra students. The intent of this question was to determine if developmental students suffered from higher levels of math anxiety to explain some of the students' need for remediation. Table 13 compared the pre-test anxiety levels of developmental students to that of college algebra students.

Table 13: ANOVA Analysis of College Algebra Compared to Developmental Students (Pre-test)

ANOVA Analysis of College Algebra Compared to Developmental Students (Pre-test)					
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	**179.5837**	**1**	**179.58368**	**0.455027**	**0.501039**
Within Groups	**56831.9**	**144**	**394.66599**		
Total	**57011.49**	**145**			

Group Summary			
Group	*Count*	*Average*	*Std Dev*
Col. Alg. Pre-test	**57**	**62.333333**	**20.3385044**
Dev. Pre-test	**89**	**64.606742**	**19.5597093**

According to the p-value, there is no significant difference in college algebra students compared to developmental students at the time of the pre-test. The researcher accepted the null hypothesis that indicated there was no significant difference in the groups pre-test scores.

The groups were compared again at the time of the post-test to see if there was a significant difference at the end of the semester (see Table 14).

Table 14: ANOVA Analysis of College Algebra Compared to Developmental Students (Post-test)

ANOVA Analysis of College Algebra Compared to Developmental Students (Post-test)					
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	177.782	1	177.781952	0.60115	0.439411
Within Groups	42586.03	144	295.736341		
Total	42763.82	145			

Group Summary			
Group	*Count*	*Average*	*Std Dev*
Col. Alg. Post-test	57	62.052632	16.9583745
Dev. Post-test	89	64.314607	17.3471215

The data reflected the same kinds of results for the post-test. According to the p-value, there was not a significant difference in either the college algebra or developmental students' anxiety levels. Therefore, all students, both those in developmental and in college algebra classes, would benefit equally from math anxiety information since the groups were not significantly different in the pre-test or post-test assessment. The implications for these findings are that math students are similar in their anxiety levels in developmental and college algebra courses.

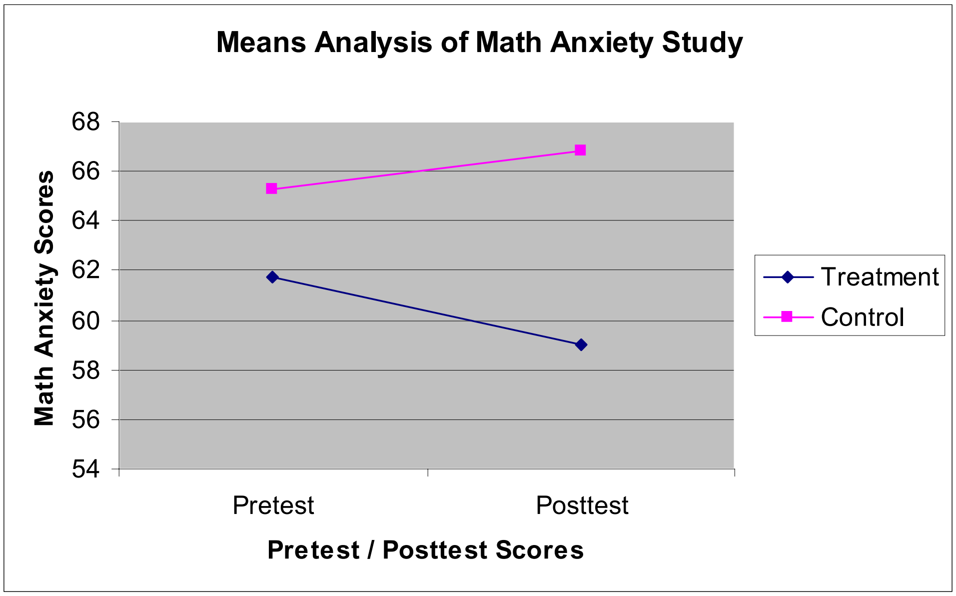
Research Question #2

The quantitative data revealed that anxiety scores between the two groups were significantly different in the post-test. This data answered the second question of this study, Can math anxiety be significantly lowered over a semester?

Means Analysis of Treatment and Control Groups

The data produced in this study was most cogently represented in Figure 5 (see following page). The line graph demonstrates the divergence in the anxiety scores when the treatment group pre-test / post-test means were compared to the control group pre-test / post-test means.

Figure 5: Means Analysis of Math Anxiety Study



	Pre-test Means	Post-test Means
Treatment	61.70313	59.04688
Control	65.29268	66.85366

Figure 5, in the view of the researcher, was the best synthesis of the data. The graph revealed the direction of the anxiety in the groups and reported the four pre-test and post-test means of the treatment and control groups. The treatment group's pre-test mean reported at 61.70 with a decreased post-test score of 59.05.

The control group's trend was in the opposite direction. This group's pre-test mean was 65.29 with an increased post-test score of 66.85.

Validating the Population Sample

The pre-test means were compared to determine if the two groups began the study at approximately the same anxiety levels. According to the one-way ANOVA in table 15, the group pre-test means were not statistically different.

Table 15: ANOVA Analysis of Pre-test Scores for Treatment and Control Groups

ANOVA Analysis of Pre-test Scores for Treatment and Control Groups					
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	463.1513	1	463.151317	1.179412	0.27929
Within Groups	56548.33	144	392.696771		
Total	57011.49	145			

Group Summary			
Group	*Count*	*Average*	*Std Dev*
Pre-test (Exp.)	64	61.703125	19.617517
Pre-test (Cntrl)	82	65.292683	19.9700317

Table 15 evaluated a comparison between the treatment and control Pre-test scores. The researcher accepted the null hypothesis because the p-value was greater than .05. Therefore, no interaction or significant difference was detected at the time of the re-test. This data ultimately validated that the two groups were not statistically different in the beginning and that the population sample was good.

The next logical comparison to evaluate was the means of the post-tests between the treatment and control groups. Table 16 (see following table) provided the one-way ANOVA statistics demonstrating a significant change in the groups.

Table 16: ANOVA Analysis of Post-test scores for Treatment and Control Groups

ANOVA Analysis of Post-test Scores for Treatment and Control Groups					
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	2190.712	1	2190.71179	7.775163	0.006013
Within Groups	40573.1	144	281.757662		
Total	42763.82	145			

Group Summary			
Group	*Count*	*Average*	*Std Dev*
Post-test (Exp.)	64	59.046875	17.5159154
Post-test (Cntrl)	82	66.853659	16.1948948

In Table 16, the treatment and control group post-test scores were compared. The null hypothesis that stated the two group means were equal was rejected at the .006 level, indicating there was a significant difference between the treatment and the control group scores at the time of the post-test. The treatment group's post-test scores were 59.047, while the control group scores were significantly higher at 66.85.

Migration Patterns within the Groups

The researcher further examined the anxiety scores of the treatment and control groups and found there were migration patterns within the groups. The researcher classified anxiety scores in three categories: Low, with scores of 0-49; Moderate, with scores of 50-69; and High, with scores of 70 – 125. These categories allowed the researcher to track the movement of subjects from pre-test to post-test conditions. Differences were found between the groups. Trends in the treatment group showed that students were reducing anxiety, while in the control group, students were increasing anxiety. These migration patterns further validated the analysis of means in Table 17.

Table 17: Migration Patterns Within the Treatment Group.

	Post-Lo	Post-Mod	Post-Hi	Total	Percentage
Pre-low	16	0	0	16	25%
Pre-Mod	7	19	0	26	41%
Pre-Hi	0	5	17	22	34%
Total	23	24	17	64	100%
Percentage	36%	38%	27%	100%	

This cross tabs table showed the specific numbers of students in each category at pre-test and post-test times of measurement. The treatment group's migration moved towards lower levels of anxiety. The first change worth noting was the increase in the low anxiety category. In the pre-test condition, 25% of participants fit into this category. There was an 11% increase in students who reported low anxiety at the end of the semester. A total of 36% reported low anxiety in the post-test condition. The moderate and high anxiety conditions also reported favorable migration patterns. Forty-one percent of students were categorized with moderate levels of anxiety in the pre-test condition, while the post-test revealed only 38% of students still reported moderate levels of anxiety. Finally, in the high anxiety category, the pre-test yielded 34% of students. However, when the post-test statistics were tallied, only 27% of those people still claimed high math anxiety. These decreased anxiety levels further demonstrated the benefit to students.

Migration Patterns in the Control Group

The migration patterns within the control group also yielded valuable insight, allowing the researcher to comprehensively track the subjects (see Table l8).

Table 18: Migration Patterns Within the Control Group

	Post-lo	Post-Mod	Post-Hi	Total	Percentage
Pre-Lo	12	5	0	17	21%
Pre-Mod	0	29	3	32	39%
Pre-Hi	0	0	33	33	40%
Total	12	34	36	82	100%
Percentage	15%	41%	44%	100%	

The cross tabs Table 18 illustrated the increasing trend in anxiety levels for the control group. From the pre-test to the post-test condition in the low anxiety category, there was a 6% decrease in students' scores. Those students that increased their anxiety levels pushed the numbers up in both moderate and high anxiety categories. The moderate anxiety increased from 39% to 41%, while the high anxiety category increased 4% from 40% in the pre-test, then to 44% in the post-test. Again, this analysis of score migration further validated the analysis of means presented in Table l8 where the upward trend in anxiety was characterized.

Comparison of the Treatment Group Data

The researcher compared the pre-test survey scores to the post-test scores of the treatment group. While all data indicated a reduction in math anxiety, this one-way ANOVA determined that the reduction was not enough to be significant (see Table l9).

Table 19: ANOVA Analysis of Pre-test Compared to Post-test Scores of the Treatment Group

ANOVA Analysis of Pre-test Compared to Post-test Scores of the Treatment Group					
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	225.7813	1	225.78125	0.652873	0.42061
Within Groups	43574.22	126	345.827133		
Total	43800	127			

Group Summary			
Group	*Count*	*Average*	*Std Dev*
Pre-test	64	61.703125	19.617517
Post-test	64	59.046875	17.5159154

Table 19 showed that the p-value was greater than .05. Thus, the researcher has accepted the null hypothesis stating there was no significant difference in the pre-test / post-test scores of the treatment group.

Comparison of the Control Group Data

The next logical comparison was the control group pre-test / post-test scores. All data to this point indicated an increase in anxiety scores. The purpose of the ANOVA was to determine if the increase was significant (see Table 20).

Table 20: ANOVA Analysis of Pre-test Compared to Post-test Scores of the Control Group

ANOVA Analysis Pre-test Compared to Post-test Scores of the Control Group					
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	99.90244	1	99.902439	0.302242	0.583238
Within Groups	53547.22	162	330.538392		
Total	53647.12	163			

Group Summary			
Group	*Count*	*Average*	*Std Dev*
Pre-test	82	65.292683	19.9700317
Post-test	82	66.853659	16.1948948

Table 20 showed that while there was an increase in the average score of the control group, it was not enough to be statistically significant. The reported p-value was greater then .05. Therefore, no significant difference was reported between the pre-test and the post-test of the control group.

Summary of Quantitative Findings

The quantitative data was instrumental in comparing groups to determine if there were significant differences in the means. The most important finding of the study to this point was that even though there was not a significant difference in the treatment group, there was, in fact, a decline in the scores that inhibited the anxiety from increasing. In the controlled condition, anxiety scores demonstrated the opposite trend. The control group experienced increased anxiety during the semester.

Summary of Chapter Four

Statistical analysis determined there was no difference between college algebra and developmental students' levels of math anxiety. Actually, the means analysis revealed that college algebra students in this study reported higher math anxiety than developmental students. Although this difference was not significant, it was contrary to the first hypothesis.

The second question of lowering math anxiety in a single semester was best characterized in Figure 5. Figure 5 illustrated the divergence in the treatment and control group post-test scores. This significant difference in the post-test scores was confirmation that the intervention indeed had an effect on the participants in the study.

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

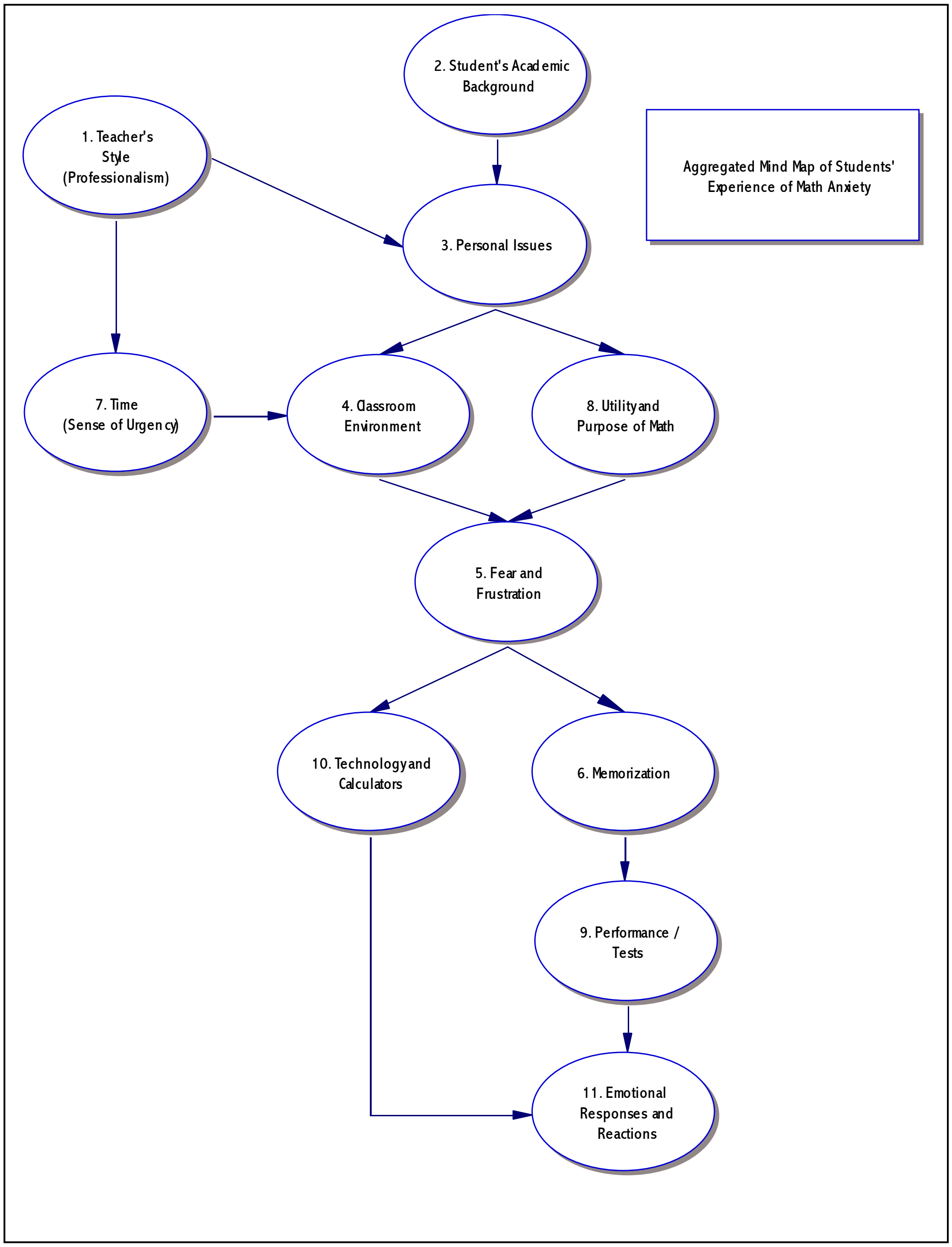
This study was conducted to investigate the phenomena of math anxiety and to determine if it was possible to reduce anxiety in a single semester. The researcher measured math anxiety in a population sample that represented typical developmental and college algebra students. This study focused on developmental and college algebra students. But, the issue of math anxiety reaches a much larger population. When the question was asked, "'Who suffers from math anxiety?' the answer was at least 50% of the adult population" (Hackworth, 1992, p.7). "Math anxiety is not limited to unsuccessful people who never completed arithmetic. Doctors, lawyers, teachers, and business executives often admit (sometimes proclaim most proudly) to math anxiety even though they have all survived education systems and vocations which impose some mathematics requirements" (Hackworth, 1992, p.7).

Therefore, the conclusions and recommendations of this study could be applicable to other math programs in community colleges across the country.

Conclusions of the Focus Groups

The focus groups' aggregated data produced a visual representation of the themes presented in Chapter Four and illustrated the relationships between the affinities. This model represents the different components at work that contributed to the student experience of math anxiety. The information students offered in the focus groups was the rationale used by the researcher to integrate each independent mind map into the final aggregated mind map of the student math anxiety experience.

Figure 6: Aggregated Mind Map of Students' Experience of Math Anxiety



Discussion of Student Math Anxiety Mind Map

The analysis of this Mind Map illustrates students' experience of math anxiety. This representation shows the top part of the diagram as drivers and the lower half of the mind map as outcomes of math anxiety. The critical components that drove this phenomenon were 1) Teacher's Style (professionalism) and 2) Students' academic background. It was clear to the researcher during the focus groups that these two components must be addressed if current anxieties experienced by students are to be reduced.

According to the map, students' backgrounds influenced their entire math anxiety experience. A critical factor coupled with the students' background was the teacher. The teacher's style and professionalism were fundamental to student success. What this indicates is if teachers were more aware of their power and influence over the students' math experience, they might then take greater care in planning and pacing the semester, as well as become more sensitive to the way they interact with students. Teacher professionalism covered topics related to the manner in which teachers called upon students for answers, kept pace in class, and communicated ideas clearly. Students were personally influenced in relation to teacher effectiveness in these areas. These personal issues were fundamental self-esteem questions about confidence and ability. The answers to these questions equipped the student with an emotional disposition to engage in the classroom environment and evaluate the utility and purpose of math for themselves. Students are presented with new concepts and ideas in the learning environment. If this is done successfully, the student will experience minimal frustration and the ability to accommodate new information. However, if the previous influences have been substandard, then the student will experience pronounced fear and frustration at this point. This elevated state of fear and frustration directly influence the students' ability to learn new technology that could be helpful in the classroom. This fear and frustration also inhibit the utilization of efficient memory. The natural consequences in learning when memory efficiency is reduced are that test scores and performance measures suffer as well. As these dynamics influence each other, and the student produces test scores that are less than their perceived abilities, the student then experiences emotional responses and reactions that are characterized as anxiety towards the subject area, in this case, math.

Implications for Mind Map of Math Anxiety

The most important finding for this mind map was Teacher positionality. Each student brings his/her own background of positive and/or negative experiences to the classroom, but it is the teacher who ultimately shapes the learning experience. Therefore, the teacher is a critical variable in student performance. The teacher has the power to influence students in ways that increase anxiety, such as through poor organization and insufficient communication skills. Or, on the positive side, the teacher can begin to change student attitudes with successful experiences in the once dreaded subject of math.

The identification of these mind map components is necessary not only to give voice to the phenomenon of math anxiety, but to also remedy the anxiety as much as possible. The findings of this mind map illuminate the components of anxiety that interfere with working memory and performance. As Ashcraft and Kirk (2001) reported, "researchers have found substantial evidence for performance differences as a function of math anxiety" (p.224). If this model of math anxiety were understood by more education professionals, then the researcher believes that the current trend of abysmal math performance could be redressed. This, in turn, could positively influence individual and, ultimately, national economic competitiveness.

Carnevale and Desrochers (2003) wrote an article entitled, "If America's So Dumb, Why Are We So Rich?" This article is important to the discussion of math anxiety due to our national human capital concern. The explanation for successful performance by American students compared to those in other counties was attributed to the sheer strength of enrollment numbers. The United States had the largest number of students enrolled in postsecondary education reported in their study, but when data were corrected for size and presented as percentages, America slipped in its performance rankings. Carnevale and Desrochers (2003) also studied enrollment increases in postsecondary education in 13 other countries over the past decade. In this case, America came in dead last with only a .3% increase in enrollments, as compared to a 13.2% increase in the United Kingdom. The authors concluded that these trends suggest that America will lose its standing as a first-rate economic power with mediocre human capital. Since math is the "critical filter" leading to success in a number of career paths, one must therefore use all information available to invest in our educational process and to improve student learning (Schoenfield, 2002, p. 13).

Discussion of Math Anxiety Intervention

The intervention conducted in this study was successful. The one-hour session created a significant difference between the post-tests of the control group and the treatment group. The quantitative data supported the significant difference between the scores. While the data did not yield a strong enough reduction in anxiety scores for the treatment group to have a significant reduction in anxiety, it did serve as a powerful *inhibitor* when compared to the control group. The anxiety of the treatment group did not increase while the control group's did.

The following reasons for the success of this intervention are offered. First, the Yerkes-Dodson (1908) Performance Curve Model demonstrated that putting excessive pressure on oneself negatively impacts optimum performance.

In the researcher's experience, the performance curve represents the reality of many developmental math students who encounter overwhelming feelings of math anxiety. When students understand and internalize this model, a sense of emancipation and empowerment can result. In turn, students begin to manage anxiety instead of allowing that anxiety to overwhelm them. And, as the literature presented in Chapter Two of this study indicated, when students experience increasing levels of anxiety without relief, the result is the phenomenon of learned helplessness.

Second, the intervention appeared to have produced a change in the students' thought process. The student transitioned from the vicious cycle to the successful cycle through refutation of irrational thinking. This resulted in a new confidence in and perspective on math.

Third, during the intervention, the researcher acknowledged and validated the math anxiety expressed by students through the seven-statement survey. Again, in the researcher's experience as a community college developmental math instructor, acknowledgement and validation are often powerful antidotes that allow students to understand they are not alone. Feelings of isolation can perpetuate the vicious cycle documented in the REBT irrational thought process.

Moreover, the researcher was careful to communicate that anxiety was not an excuse for poor performance and provided students with a series of solutions to take responsibility for the anxiety experienced. This was a critical component of the anxiety reduction intervention. Rather than allowing students to rely on the well-worn excuse of, "I can't do math," students were encouraged to internalize their locus of control and work productively toward success in the discipline.

Recommendations for Further Research

The first recommendation to improve this study includes extending the length between pre-test and post-test administrations. The rationale for increasing the time frame is to allow a greater opportunity for the cognitive-behavioral techniques to intervene and reduce anxiety. Based upon the descriptions from focus group participants, some students have experienced math anxiety for many years. Significantly reducing this anxiety might take longer than a single semester with a single intervention.

A second recommendation to improve the results of this study is to create an instructor training session for the treatment group, the goal of which is to increase teacher sensitivity to student math anxiety. This training should include the intervention described in Chapter Three, along with the results of this study. The rationale of this recommendation is if teachers are privy to student feedback, they can in turn become more aware of their own communication styles and more sensitive to students' feelings.

In fact, the researcher recommends that community college developmental math faculty engage in regular professional development activities designed to enhance pedagogical practices and increase student empathy. Because the community college is a teaching and learning, rather than a research-based, institution of higher learning, effective teaching is the heart of student success. Developmental math faculty can benefit from the work of Roueche, who, since 1970, has written 34 books and more than 150 articles and monographs on teaching and learning in the community college. In *Practical Magic: On the Front Lines of Teaching Excellence*, Roueche, Milliron and Roueche (2003) outline a series of core strategies that should be adopted by all developmental math faculty, as follows:

- Show Respect. (Teachers must maintain a classroom environment based on respect: student to teacher, teacher to student, and student to student.)
- Be Enthusiastic and Share Joy. (Teach with enthusiasm, present a can do attitude.)
- Demonstrate Care and Empathy. (Be compassionate and patient.)
- Hold to High Expectations.
- Walk your Talk. (It is important to be honest with students so they will trust you. Be someone they can count on.)

- Foster Student Motivation and Success Skills. (Encourage students to push themselves to success. Communicate positive messages building students up to meet the challenge of math.)
- Make Contact with Students. (Teachers that transform students touch their souls not just their minds.)
- Listen to Students.
- Encourage Humor and Humanity. (Students need to see teachers as approachable and playful at appropriate times. Embrace teachable moments with a sense of humor and model opportunities for personal growth in class.)
- Praise, Celebrate, and Reward Students. (Teachers should utilize every opportunity to use positive reinforcement with students. Be generous with smiles, congratulations and pats on the back.)
- Be Flexible. (Teachers should remember every student is different and presents a new situation) (pp. 81-94).

In addition to these suggestions, the researcher recommends that developmental math faculty cultivate a warm and welcoming atmosphere from the first day of class. Beginnings are always important. To this end, the instructor should memorize all student names by the end of the first class session. In fact, the first session is *the most* critical of the entire semester as the instructor sets the tone for class interactions as well as expectations. She or he also lays the foundation for academic success through engaging in a serious “sales pitch” that students can indeed be successful in math. Perhaps most important is the willingness on the part of the developmental math instructor to go in pursuit of the student whenever she/he misses a class. A phone call or email to show concern and offer assistance can positively impact student self-esteem and persistence.

Conclusion

This study of math anxiety revealed that anxiety levels were not statistically different between college algebra and developmental students. This finding answered the first research question. The next question related to the reduction of math anxiety for students. Although there was not a significant reduction of math anxiety in the treatment group, the trend decreased. The reason this was important was due to the fact the control group’s anxiety was increasing. As these two groups’ anxiety went in opposite directions, this demonstrated a main effect between groups. This study demonstrated that a one-hour cognitive behavioral intervention addressing math anxiety may not be enough to significantly reduce math anxiety in a single semester, but the intervention did serve as an inhibitor. This one-hour intervention did change the pattern of anxiety scores and perhaps needed more time to work.

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VITA

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Sarah received her Associate's Degree from Mountain View College (Dallas County Community College District) in 1995. She transferred to The University of Texas at Arlington and obtained a Bachelor's in Psychology in 1997. She completed her Master's Degree in Counseling from Texas A&M – Commerce in 2000. Currently Sarah is pursuing a Ph.D. in Educational Administration (Community College Leadership Program) from The University of Texas in Austin.

Sarah has worked in many capacities financing her education over the years. She has learned to value teamwork and to advocate for cooperation. Her challenging schedule has allowed her the opportunity to develop efficiency and discipline while committing herself to her educational goals.

Before attending UT-Austin in the spring of 2000, Sarah worked as an adjunct math instructor and instructional associate at Mountain View College since 1998. She used her counseling skills to help students overcome math anxiety. Sarah is a Nationally Board Certified Counselor and has logged over 1,000 hours as a Licensed Professional Counselor Intern at Dallas area counseling centers, including the Dallas MHMR. Currently, Sarah is a Visiting Scholar at Eastfield College teaching psychology, sociology, and developmental math.

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