THE IDENTIFICATION AND DESCRIPTION OF CHANGES IN MATHEMATICS
ANXIETY WHEN REMEDIAL MATHEMATICS COURSES ARE TAUGHT
USING CONCEPTUAL TEACHING METHODS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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* * * * *

The Ohio State University
1998

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ABSTRACT

This research explored and described the changes in mathematics anxiety when first-year college students in a remedial mathematics course were taught using conceptual understanding teaching methods. Two classes participated in the research; twenty-three students completed the Math Anxiety Ratings Scale (MARS), nine of these students were selected for individual interviews. Quantitative and qualitative data were collected to find reasons and explanations for the changes in mathematics anxiety.

Research questions for this study investigated the relationship between the instructional approach students' experienced and (a) their changes in mathematics anxiety, (b) their overall perceptions of contributions to or detractions from their anxiety towards mathematics, and (c) the factors they felt contributed to their change in mathematics anxiety.

The theoretical framework developed for this study was based on Skemp's (1976) analogy to learning in real life and his description of the differences between meaningful (or relational) and rote (or instrumental) learning.

Results from the MARS showed a decrease in mathematics anxiety that was significant at the .05 level. Interview and observational data indicated that instructional methodology played a key role in that reduction. Students expressed feeling a sense of responsibility for their own learning and noted that a higher level of understanding was expected from them in this course. Various instructional methods were incorporated, therefore providing a better match with students' preference for learning. Communication in the form of discussion and writing was found to enhance students' thinking.
This study suggests that students appreciated and enjoyed being able to think for themselves. Many students seemed to understand how to learn mathematics and realized understanding the content was more beneficial for them than memorizing. A number of students mentioned worries about entering the traditional style courses, yet when this transition was made they realized important ideas were imbedded in the conceptual learning philosophy that helped them keep lower levels of mathematics anxiety in future courses.
To my husband Wil and my children Trent and Kelsey,

thank you for all your sacrifices.
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CHAPTER 1

PROBLEM DEFINITION

Introduction and Background

We all know intelligent people who freely confess their lack of understanding in, and desire for, mathematics. In a restaurant you may hear someone say, "You figure out the tip; I was never good in math." Would this same person be as eager to admit he or she is "not good" in reading or is ignorant in geography? It seems not being good in mathematics is accepted in our society. In some cases mathematics avoidance is a deliberate and conscious effort. I once heard a famous journalist admit on national television that he selected a college because there was not a requirement in mathematics. Why do some people avoid mathematics to the point where they can affect their careers and their daily lives? Mathematics is not just an entry-level prerequisite for engineering, the physical sciences, and statistics. It is needed in many fields and aspects of real life, especially with our economy relying heavily on technology. Many researchers have discovered mathematics anxiety can be a factor that contributes to avoidance in mathematics (Dew, Galassi, & Galassi, 1984; Hembree, 1990; Reyes, 1980; Tobias & Weissbrod, 1980; Wiesenborg, 1994). Researchers believe that the avoidance habit began in an educational environment.
Mathematics anxiety is a factor that affects enrollment in mathematics courses (Hembree, 1990; Tobias & Weissbrod, 1980), thereby influencing a student's educational and career goals, as well as career growth. Students tend to avoid what makes them anxious, and the extent to which they avoid the subject or the situation depends on the level of anxiety (Tobias & Weissbrod, 1980). Some people may have such acute anxiety about mathematics that they avoid it at any cost with the ultimate effect of handicapping themselves both in their everyday lives and in their employment opportunities.

Many intellectually capable students avoid taking math courses in high school and in college and, consequently, restrict the range of careers from which they can choose to those that do not require quantitative skills. Many other students fail to perform as well in mathematics as they are capable and, again, do not attain the mathematics knowledge that would expand the range of career options available to them. (Betz, 1978, p. 441)

Hembree (1990) found high-anxious students took fewer high school mathematics courses and showed less intention in high school and college to take more mathematics. Tobias (1991) has spent most of her professional career trying to learn why otherwise intelligent students have difficulty in mathematics courses. She found that average students have the ability to perform well in college mathematics courses, but their anxiety keeps them from believing they can.

Mathematics anxiety has become a familiar topic to many mathematics educators. The principal reason is that anxiety serves as a hindrance to learning mathematics (Hunsley, 1987; Sherard, 1981). It is a term "used to describe the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem" (Tobias & Weissbrod, 1980, p. 65).

According to Richardson and Suinn (1972), "math anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of
mathematical problems in a wide variety of ordinary life and academic situations" (p. 551).

Some colleges require that a minimum level of mathematics be attained for all students, regardless of major. Many students enter college with the existing knowledge necessary for college mathematics, but others need to begin with remedial mathematics courses to achieve the requirement. Betz (1978) found that approximately one-half of the students in a college remedial mathematics course believed that math made them feel "uncomfortable, nervous, uneasy, and confused" (p. 446). Other research has shown that college remedial mathematics classrooms contain students with high levels of anxiety (Dew et al., 1984; Green, 1990; Hembree, 1990; Kagan, 1987). Mathematics educators are interested in practical solutions for decreasing mathematics anxiety in these students.

When mathematics anxiety is reduced, students find they can perform better in their mathematics courses (Betz, 1978; Hembree, 1990). Currently, special programs are offered at colleges to help with the reduction of mathematics anxiety. Betz (1978) summarized various types of mathematics anxiety programs as follows, "Math anxiety treatment programs occur in individual or group counseling settings and may include general anxiety management techniques, modification of irrational beliefs or negative attitudes toward math, and the development of more positive self-concepts and attitudes" (p. 441-442). Tobias (1978) recognized the need for mathematics anxiety reduction programs to help students overcome and control mathematics anxiety by supporting the use of math clinics. She set up a Math Anxiety Clinic that focuses on overcoming the helplessness that mathematics anxiety feeds on by stressing coping skills. Tobias (1991) states "You can't do anything about being 'dumb in math.' You can do a great deal about being fearful" (p. 91). Hembree (1990) found out-of-class
psychological treatments needed to include several components to be effective. He found "systematic desensitization along with anxiety management training and conditioned inhibition were highly successful in reducing mathematics anxiety levels. The literature (Hembree, 1990; Tobias, 1991) shows these programs to be successful for the students who take advantage of them. However, math anxious students tend to avoid mathematics courses and any extra curricular work involving it, even if it is a program designed to treat or help with anxiety. As in many other situations in life, those who need help the most are the least likely to seek it. It would be much more beneficial and more economical to try to reduce mathematics anxiety within the confines of the classroom. Williams (1988) believes that mathematics learning is strongly connected to mathematics teaching. In accordance with this, Greenwood (1984) feels mathematics anxiety is a problem whose solution lies almost entirely within the domain of mathematics education. He stated that the "explain-practice-memorize" teaching paradigm separates facts from reason and is the real cause of mathematics anxiety since memorization is promoted instead of understanding and reasoning.

The National Council of Teachers of Mathematics (1989) Curriculum Standards state "What a student learns depends to a great degree on how he or she has learned it" (p. 5). They learn when they are interested in what is being taught and can become actively involved. To paraphrase a Chinese proverb: "Tell me mathematics and I will forget; show me mathematics and I may remember; let me do mathematics and I will understand."
Statement of the Problem

College freshmen are experiencing problems in remedial mathematics courses. Stage and Kloosterman (1991) state that "The success rate of students in these classes is typically 50% or less" (p. 27). Insufficient mathematics preparation at the secondary level contributes to the large failure rate, underachievement, and lack of motivation of remedial mathematics students (Hackett, 1985; Stage & Kloosterman, 1991; Wieschenberg, 1994). In a study conducted by Betz (1978), approximately half of the college students in her study agreed with the statements, "Mathematics makes me feel uncomfortable and nervous" and "Mathematics makes me feel uneasy and confused" (p. 444). One possible reason for this could be the way these courses are taught. Some researchers feel the majority of remedial mathematics courses are taught with an emphasis on rote learning and memorization (Arriola, 1994; Cobb, Wood, Yackel, & McNeal, 1992; Greenwood, 1984). As mathematics learning progresses, the rules and procedures become overwhelming and the ability to recall the appropriate algorithm seems nearly impossible. Researchers (Lazarus, 1974; Skemp, 1979b; Williams, 1988) believe when students reach higher levels of mathematics, and can no longer survive on rote learning alone, mathematics anxiety appears. "Teachers of college remedial mathematics courses need to help students learn rules, but they also need to make sure learning is the result of conceptual development" (Stage & Kloosterman, 1991, p. 34).
**Purpose**

The purpose of this study was to explore the changes in the students' level of mathematics anxiety when conceptual understanding teaching methods (detailed later in this chapter in The Instructional View) are used and to explain or to seek understanding of what factors contributed to these changes. The more educators know about the conditions under which students experience high levels of mathematics anxiety, the better equipped they are to develop preventive measures. Greenwood (1984) believes the principal cause of mathematics anxiety lies in the instructional methods used. Since mathematics anxiety may be affected by method of instruction, any pertinent information leading to a relationship with mathematics anxiety is of interest to educators.

Are educators helping their students if their goal is to emphasize achievement in a course at the expense of developing understanding? There exist many students who desire the "just tell me how to get the answer" approach. Stage and Kloosterman (1991) believe this type of approach "promotes self-confidence and short-term learning, it may also be promoting a false sense of security" (p. 34). If students are not exposed to conceptual understanding teaching methods in low level mathematics, are educators setting them up for failure in future courses? Students deserve to be taught using methodologies that will treat them as thinking beings, thereby developing long-term mathematical learning.
Rationale and Significance

Because mathematics anxiety is viewed as a psychological problem, numerous studies (Betz, 1978; Gliner, 1987; Hembree, 1990) have been conducted to find causes and relationships with other variables. Causes of mathematics anxiety have been studied throughout the last 25 years (Hilton, 1980a, 1980b; Tobias, 1978; Williams, 1988). In the home, children may inherit a wide range of negative feelings toward mathematics. It is not uncommon to hear a parent say, "I was never able to do math." Students may encounter teachers who are not skillful in mathematics and may suffer from mathematics anxiety themselves. Through counseling hundreds of adults, Donady and Tobias (1977) found that interviewees often attribute the major influences in determining extreme attitudes towards mathematics to the attitudes of a particular teacher. Hodges (1983) believed failure in mathematics would lead to frustration, and with repeated failure the students would eventually develop mathematics anxiety.

Educators have been striving for centuries to achieve mathematical understanding in their students. Yet how one defines understanding varies from person to person (Lerman, 1989). Students typically believe their mathematics grade is a reflection of their understanding of the subject, but in many situations, understanding is not what is being measured. Instead, they are being assessed on superficial rote learning techniques with specific steps and procedures memorized (Skemp, 1976). Some students can be very successful with this method of learning and perform well on typical assessment measures, thereby allowing the teachers to believe their students are understanding mathematics (Gay & Thomas, 1993). This technique may work for these students until they advance in their studies, and then performance begins to falter (Lazarus, 1974; Skemp, 1979a). A Nation at Risk (National Commission on
Excellence in Education, 1983) reported only one-third of 17 year olds can solve a mathematical problem that requires several steps. Concentration is on producing rule-obeying answers and not on comprehending the underlying mathematics. Students believe they are trying to understand mathematics, yet they are usually trying to memorize steps to specific algorithms (Lazarus, 1974). Williams (1988) argues that this entire process, which may take years to develop, brings on anxiety and frustration associated with mathematics. These students find themselves afraid of mathematics because they are not prepared to incorporate new procedures into their old ways of learning (Skemp, 1979a).

Data from Hembree (1990) show mathematics anxiety peaks near grades 9-10, usually when algebra and geometry are commonly taught. These courses are more abstract and require more understanding and logical thought processes than the courses that preceded them. Results from the 1992 National Assessment of Educational Progress (National Center for Education Statistics, 1993) found about 50% of the twelfth grade students did not display an understanding of mathematics beyond simple problem solving. Only 6% of twelfth grade students showed any depth of mathematical sophistication, which is defined as reasoning and problem solving involving geometric relationships, algebra, and functions. These research findings show many students leave high school without the ability to perform mathematics with a conceptual understanding. Perhaps students are more inclined to develop anxiety when they are challenged in a mathematics course if they are lacking a conceptual base of mathematical understanding.

Students learn when they are taught meaningfully, showing connections to their previous knowledge when applicable (NCTM, 1989; Skemp, 1971). In a course where conceptual understanding is expected, students tend to become more
mathematically mature. Their thinking skills are heightened and more is expected from them. This method of teaching seems preferred for understanding; however, it is not known if conceptual understanding teaching methods will reduce mathematics anxiety in our students.

**Research Questions**

The following research questions have been formed to address the purpose of this study:

1. Is there a change in first-year college students' mathematics anxiety when taught using conceptual teaching methods?
2. What are students' overall perceptions of what contributes to or detracts from their anxiety towards mathematics?
3. What factors do students feel contributed to their change in mathematics anxiety?

**The Instructional View: Math 050A**

Math 050A was a course designed with a different emphasis from the mathematics course currently being taught, Math 050. The goal was to optimize learning for understanding. The philosophy for the new course was based on the idea that what a student learns depends a great deal on how a student learns. For various reasons, remedial mathematics students were not successful in their previous mathematics courses; yet educators continue to teach them the same material using the same pedagogy. Remedial college students have already seen most of the mathematics
being presented in the college classroom. The intent of this course was to build upon previously developed constructs and to make connections between these developed constructs and new knowledge.

Instruction was dominated by conceptual understanding teaching methods that includes fundamental components such as (a) inquiry-based investigations and questioning, (b) a teaching by not telling approach, (c) communicating mathematically, including reading, writing, and discussing mathematics, (d) large and small group discussions, and (e) use of manipulatives and current technology. According to the Curriculum Standards, developing the ability to think, reason, and solve mathematics problems is the principal goal when teaching mathematics. Because of this type of instruction, the weekly class schedule was changed from five 48-minute periods to three 80-minute periods. Activities were usually project oriented with small group activities being a norm. Depending on the situation and the activity, students sometimes selected their own groups and on occasion they were arranged by the instructors. Assessment included daily work (which on occasion was resubmitted after re-working), two midterms, and a final exam. Items that were collected for assessment emphasized communication through writing and explaining. The instructors for the course defined homework in the course syllabus by writing, "Homework assignments will help develop your mathematical intuition along with the relevant base of mathematical knowledge. You will often be challenged with mathematical problems that do not have unique solutions. These problems will build confidence and prepare you for additional college experiences in mathematics."

The restructured course reflected changes in terms of curriculum, pedagogy, and assessment. The curriculum for Math 050A was activity based with the mathematical content being similar to Math 050. Some of the activities in Math 050A included group
problem solving, that typically lead to presentations and explanations at the board, and
discovering at least three approaches to solving percentage problems. Another activity
involved small groups of students selecting topics to research such as square root,
properties of exponents, scientific notation, absolute value, and function notation.
These topics were then presented to the class and the other students were responsible
for questioning the groups presenting until they understood the concept. All of the
students were held equally accountable for the material.

Content that may receive minimal coverage at a remedial level was added to this
course. Unique topics included series, functions, analysis of graphs, and some
elementary ideas from number theory. Scattered throughout the activities were
discussions to optimize learning, trying to make connections between familiar topics
and recently acquired knowledge. Peterson, Fennema and Carpenter (1989) believe,
"Learning is the making of connections between new information and the learner's
existing network of knowledge—the construction of knowledge by the learner—and
instruction should facilitate these connections" (p. 43).

Communication in the form of discussion and writing was encouraged to enhance
student thinking. As students communicate about topics in mathematics, they focus on
and internalize these concepts.

"Communication in and about mathematics serves many functions. It helps to (1)
enhance understanding, (2) establish some shared understandings, (3) empower
students as learners, (4) promote a comfortable learning environment, and (5)
assist the teacher in gaining insight into the students' thinking so as to guide the
direction of instruction." (Mumme & Shepherd, 1990, p. 18)

Questioning was an important form of communication; asking questions and listening
to the answers. Often thought-provoking questions were left lingering by the
instructors when the students were not capable of grasping an answer. When class
resumed again, so did the questions.
This teaching and learning style is compatible with a constructivist perspective. According to Koehler and Grouws (1992), "if one subscribes to a constructivist view of learning, then the goal is no longer one of developing pedagogical strategies to help students receive or acquire mathematical knowledge, but rather to structure, monitor, and adjust activities for students to engage in" (p. 119). Brooks (1990) believes constructivist-based education features a primary activity, not a list of skills and objectives to be covered for that day. While learning this central activity, many opportunities arise to discuss related mathematics. The central activity during one Math 050A observation involved infinite series. In finding the next terms of the sequence, the students were reviewing fraction arithmetic without sensing the boredom usually associated with doing rote type calculations.

Alternative forms of assessment were implemented along with some of the traditional methods. The Standards (NCTM, 1989, 1991) stress the importance of alignment in assessment procedures. When educators change the way they teach they must concurrently change their methods of evaluation. Appropriate assessment opportunities are important for a variety of reasons. Webb (1993) states, "Different purposes are served by assessing students' knowledge in the mathematics classroom—measuring students' understanding and use of content, obtaining instructional feedback, grading, and monitoring growth in mathematical achievement" (p. 1). When students are being assessed inappropriately, all the purposes being served by assessment are misrepresented. The homework and exams in Math 050A emphasized open-ended problem solving situations and writing to convey the students' understanding. From these events, the instructors continually sought for understanding from the students and then used this information to guide instruction. Chambers (1993) raises a critical issue by writing, "The teacher's priority should be to attempt to
understand how the students are thinking rather than to get the students to understand how the teacher is thinking" (p. 25). This appeared to be an integral part of assessment for the Math 050A instructors because of their emphasis on oral and written communication of mathematical ideas in the daily work and on exams. Going beyond assessment in the classroom, the final exam included three take-home questions to allow students more time to explore the relationships between equations, graphs, and charts. Each assessment measure employed in Math 050A seemed to directly relate to the methods used when teaching and learning.

A typical class period in Math 050A began by returning homework that had been graded and looked at for understanding. Student papers were often covered with the instructors' writing if the students had not been clear in the explanations of their work. Then a topic may have been continued from the last class period or possibly a new activity would be started. The activities in Math 050A were not in alignment with the length of a class period, so many tasks took longer than one day. This flexibility allowed students to stay with one activity until they felt they had mastered the concepts. A student who did master the concept was usually asked to explain his/her thinking to those still searching for understanding. Students were not too shy to speak up and offer solutions with different strategies. These students seemed accustomed to taking risks and defending their answers.

The two instructors for the two Math 050A sections offered Autumn Quarter, 1996 were graduate assistants who expressed an interest in teaching these sections. Both instructors were working toward their doctoral degree in mathematics education. Much time was spent by these instructors in preparing materials for instruction, activities, and assessment. They were not teaching assistants for a recitation section; they both had full control over the entire course, including preparation, delivery of
material, and assessment. The enrollment for this course was limited to 24 students per section to be able to effectively use questioning techniques.

After successfully completing Math 050A, students could enroll in Math 075A, Math 075, or Math 104. Math 075A was similar in pedagogy and assessment to Math 050A, and Math 075 and Math 104 followed the traditional approach.
Definition of Terms

Alignment: when methods and tasks for assessing students' learning are in agreement with the curriculum.

Anxiety: distress of mind, uneasiness.

Conceptual Teaching Methods: instructional strategies that emphasize the understanding of the underlying principles of mathematics.

Conceptual Understanding: the ability to deduce specific rules or procedures from more general mathematical concepts and relationships (Skemp, 1979a).

Instructional Method: a way of teaching.

Math Clinic: "place where people can bring their personal learning problems with mathematics and seek remediation coupled with personal counseling and support" (Tobias, 1978, p. 8).

Mathematics Anxiety: the feelings of uncertainty and helplessness when faced with a mathematical situation.

Mathematics Anxiety Rating Scale (MARS): "provides a measure of anxiety associated with the manipulation of numbers and the use of mathematical concepts" (Richardson & Suinn, 1972, p. 551).

Paradigm: a general perspective, deeply embedded in the socialization of the researcher.
CHAPTER 2

REVIEW OF RELATED LITERATURE

Introduction

This chapter focuses on the literature that is related to mathematics anxiety and learning with understanding using conceptual teaching methods. The many variables found to be correlated with mathematics anxiety are considered first, especially the relationship between mathematics anxiety and instructional methods. Next, learning with understanding is defined using views from several different literature sources. Learning theories, such as constructivism, are discussed with regard to several prominent cognitive psychologists. This literature base led to the development of a conceptual framework for this study.

Correlates of Mathematics Anxiety

When mathematics anxiety occurs in the students there are a number of complications that can result. This section reviews the findings from the related literature pertaining to these complications. First, the relationship between mathematics anxiety and the avoidance of taking mathematics courses beyond the minimum required is explored. Next, the correlation between mathematics anxiety and mathematical
achievement is considered, along with other relationships that may cause lower achievement scores, such as values and self-efficacy. The last variable discussed in this section of the literature review is gender.

Increasingly more attention has been paid to the construct of mathematics anxiety since it was first reported in the late 1950s. Dreger and Aiken (1957) reported 35% of a college population were believed to have "number anxiety." Since that time researchers have referred to mathematics anxiety as "mathophobia" (Lazarus, 1974) and "mathemaphobia" (Tobias & Weissbrod, 1980); so these feelings have been around for a long time but now have a new title. Results from a study conducted by Betz (1978) indicated "math anxiety occurs relatively frequently among college students" (p. 446).

Mathematics anxiety seems to be a major factor in the decline of students' interest in the study of mathematics, demonstrated by the avoidance of taking classes beyond the minimal requirements. Hembree (1990) found "high anxious students took fewer high school mathematics courses and showed less intention in high school and college to take more mathematics" (p. 38). The results from a study by Betz (1978) indicated a moderately strong relationship between the number of years of high school mathematics and mathematics anxiety. This relationship shows strong influences among high school mathematics preparation, feelings about mathematics, and success in a college mathematics course. Similar results were also noted by Hendel (1977). These studies show strong support for the documents that encourage four years of high school mathematics for all students (NCTM, 1989, 1991; National Research Council, 1989), not only for the hopes of lowering mathematics anxiety but also for the mathematical knowledge gained from participating in mathematics courses for one or two more years than previously expected.
Tobias and Weissbrod (1980) believed students avoided mathematics because it was their way of avoiding what makes them anxious. This is exhibited by many students who wait as late as possible in college to start their mathematics requirement; some students are able to postpone it until their senior year. This process can raise mathematics anxiety; "even able students who elect not to take courses for a number of years can lose skills and consequently self-confidence, and this can also cause anxiety when they are faced with mathematical problems again" (Tobias & Weissbrod, 1980, p. 65). This is also shown in a study by Betz (1978), who found older women expressed higher levels of mathematics anxiety than did younger women, as more time had passed since they had taken high school mathematics. A number of other researchers believe students are avoiding mathematics because of their performance in the course.

Mathematics anxiety and its effect on performance represents another anxiety related concern of interest. Several studies found mathematics anxiety to have a negative relationship with performance, but the strength of the relationship varied by study. An early study by Dreger and Aiken (1957) found students with high number anxiety tended to make lower grades in mathematics. These results were also supported by Clute (1984), who reported that generally students with high mathematics anxiety showed lower achievement than the students with low mathematics anxiety. In addition, her study found students with high anxiety performed better in a well-structured and controlled learning environment. In looking at the ACT Mathematics subtest, Betz (1978) found mathematics anxiety to be moderately related to mathematics achievement. She considered three groups of subjects and found the stronger correlation between achievement and mathematics anxiety existed for males in two of the three groups. Suinn (1972) found a strong negative relationship between
mathematics anxiety and achievement in college students while Norwood (1994) concluded there is only a slight negative relationship between them. In a meta-analysis conducted by Hembree (1990) it was found "higher mathematics anxiety consistently related to lower mathematics performance. In Grades 5-12, the inverse relation was stronger for males than females, a difference that disappeared among college students" (p. 38). However, Dew et al. (1984) concluded mathematics anxiety and performance had only a modest relationship. In a similar study conducted by Fulkerson, Galassi, and Galassi (1984), it was also found that mathematics anxiety was not significantly related to mathematics performance. They were trying "to pinpoint the dysfunctional cognitions of high math anxious male and female college students during problem solving to identify those cognitions that need to be changed" (Fulkerson et al., 1984, p. 380). It was found cognitions are only marginally related to mathematics performance. In terms of predictability, Gliner (1987) reported mathematics achievement was not a significant variable in predicting mathematics anxiety scores. Hembree (1990) concluded "higher achievement consistently accompanies reduction in mathematics anxiety... yet there is no compelling evidence that poor performance causes mathematics anxiety" (p. 44). Considering the many studies investigating the relationship between mathematics anxiety and performance, the general conclusion seems to show a low to moderate negative correlation, but not overwhelmingly a strong one.

Several of the studies that noted a relationship between mathematics anxiety and performance speculated that issues other than mathematics anxiety may cause the lower achievement scores. Wigfield and Meece (1988) concluded "the value students attach to math could moderate or augment the effects of poor performance on students' math anxiety" (p. 214). They believe students who do poorly in mathematics but do not find
the subject important may exhibit little, if any, mathematics anxiety. On the other hand, if a student values mathematics and wants to do well but is not successful, their mathematics anxiety level may rise. Aiken's (1972) study supported this conclusion by reporting low positive correlations between attitude and achievement variables in mathematics. However, Quinn and Jadav (1987) found in their study that no strong relationship exists between achievement and attitude in mathematics. They found high achievement "may cause either an increase, decrease, or no change in student liking for those areas. Also, a program to change attitudes toward a topic may or may not result in changes in achievement for that topic" (Quinn & Jadav, 1987, p. 371). For these reasons, the curriculum should be structured to include instructional methods that improve both achievement and attitude.

Mathematics self-efficacy has also been found to be related to mathematical performance (Cooper & Robinson, 1991; Hackett, 1985; Lent, Brown, & Larkin, 1984), and several studies have found a relationship between mathematics anxiety and mathematics self-efficacy (Betz, 1978; Cooper & Robinson, 1991). Mathematics self-efficacy is a person's perceptions of his or her effectiveness in a mathematical situation. Bandura (1977) postulates that a person's self-efficacy expectation is a reliable predictor of whether the person will attempt a given task, how much effort will be expended, and how much persistence will be displayed in pursuing a task when obstacles become involved. The selection of mathematics courses in high school and beliefs about mathematics self-efficacy appear to be related (Dew et al., 1984). Mathematics self-efficacy is somewhat similar to confidence in learning mathematics and locus of control in a mathematics course. According to Hackett (1985), confidence in learning mathematics is more of a global estimate of how well one expects himself or herself to do in mathematics courses in general, while mathematics self-efficacy is a
more specific estimate of confidence in one's ability to perform well with regard to particular mathematics courses or specific tasks. Locus of control is defined as individuals having generalized expectancies whose outcomes are determined by their own actions or external forces beyond their control (Matsui, Matsui, & Ohnishi, 1990).

Another variable that receives mixed results when looking for a relationship with mathematics anxiety is gender. Gender and mathematics anxiety have been studied by many researchers; some consider these major variables in their study, but more often they are looked at as secondary variables. In Hembree's (1990) meta-analysis, female students reported higher mathematics anxiety than males across all grade levels. He found that the higher levels of anxiety do not seem to reduce performance or lead to greater mathematics avoidance on the part of female students. However, studies by Fennema (1979) and Fennema and Sherman (1978) showed that there are no consistent significant differences between the mathematical abilities of boys and girls who have taken the same mathematics courses. Betz (1978) found "levels of math anxiety were found to be related to both the age of female students and to number of years of high school math background in both males and females" (p. 445). Her study considered the number of years of high school mathematics preparation, not how successful the students were in their high school mathematics courses. Again, this is important data supporting the literature that suggests that all students take four years of mathematics in high school (NCTM, 1989, 1991; NRC, 1989). In a study conducted by Wigfield and Meece (1988), female students in 5th through 12th grades "reported experiencing more negative affective reactions to mathematics than did boys" (p. 215). They also concluded there were no differences, in regard to gender, when looking at the structure of responses to a mathematics anxiety questionnaire, that implied both sexes were answering the items in similar ways. There were also no gender differences in their
reports of math worry. This indicated both boys and girls were concerned about their success in mathematics. Dew, Galassi, and Galassi (1983) concluded, "gender differences in mathematics anxiety may exist, but they are probably much smaller than has been suggested previously" (p. 445).

Mathematics Anxiety and Instructional Method

Several studies imply that researchers investigate the relationship between instructional methods and mathematics anxiety (Greenwood, 1984; Lazarus, 1974; Skemp, 1978). A review of mathematics anxiety research finds these studies to be the most closely related to this study.

Clute (1984) conducted a study involving two different instructional methods in college mathematics survey courses and their relationship with mathematics anxiety and the effect on mathematics achievement. The two instructional methods used were classified as direct instruction discovery method and direct instruction expository method. The discovery method was defined as asking the students questions, narrowing and directing the questions until students "discovered" the solution. These students were then encouraged to share their discovery with the other class members. The expository approach contained a review of the previous lesson, then developed concepts for the lesson of the day, followed by some illustrative examples that involved students' input.

She found students with low to medium levels of mathematics anxiety performed better with the discovery method, whereas the students with high levels of mathematics anxiety scored higher using the expository approach. When she categorized the items on the achievement test as low or high cognitive level, interesting results emerged.
Looking at the achievement scores when low-level items were evaluated showed the same pattern as before, with lower anxiety students performing better under the discovery method and higher anxiety students performing better with the expository approach. However, when analyzed using the high cognitive level questions, all students, regardless of anxiety level, scored higher on the achievement test using the discovery method over the expository method. "This result speaks to the value of using a discovery approach when high-level processes are the objectives of a lesson" (Clute, 1984, p. 57).

Several concerns surfaced when analyzing the results of this study. First, Clute was the instructor for both courses. Second, changes in the mathematics anxiety level could not be measured because a posttest was not given and gains in achievement could not be measured because a pretest was not used. This study suggests both instructional techniques have advantages, but which method has long term advantages for students?

A similar study conducted by Norwood (1994) found results that supported some of the findings in Clute's (1984) study. She also evaluated the effectiveness of two instructional methods and their effect on mathematics anxiety and mathematics performance. The subjects in this study were college students in a developmental arithmetic course. She classified her instructional methods as relational and instrumental, based on Skemp's (1971) terminology. The instrumental approach focused on the learning and memorization of rules and formulas used when solving computational problems. Skemp (1971) described this approach as rules without reasons. Relational instruction involved the development of concepts and their relationships to underlying mathematical principles. "The examples used in the learning of higher order concepts were lower order concepts already assimilated by the students"

Norwood (1994) found there was a decrease in the mathematics anxiety scores when using the instrumental approach. The mathematics anxiety scores were virtually unchanged when the relational approach was used. No interviews were conducted to explain any change in mathematics anxiety. The achievement scores increased for both groups with the students using the instrumental approach showing the largest increase in achievement scores. Lipsett (1987) and Lipsett, Carraquillo and Hughes (1988) also concluded that both relational and instrumental instructional methods raised mathematics achievement scores.

The problems concerning the Norwood (1994) study involved the methodology. All three instructors in her study (one of whom was the researcher) used the same textbook, lesson plans, handouts, quizzes, tests, and final examination for the two different types of instructional methods. The Standards (NCTM, 1989, 1991) and others (Chambers, 1993; Webb, 1992) stress the importance of alignment in assessment procedures. The conceptual understanding instruction method differs significantly in both content and instruction from the traditional approach. Therefore, instructional and assessment contents should be developed simultaneously. Since these two instructional approaches differ significantly, so should the course materials.

A study conducted by Lawson (1993) agreed with Clute (1984) and Norwood (1994) when she found high math anxious students in developmental mathematics courses performed better with direct (highly structured) instruction. "This does not mean that such instruction is most appropriate, which raises the serious issue of how we can make students more comfortable with the instruction that most current curricular recommendations support" (Norwood, 1994, p. 252). This quote stresses the need for
additional studies to expand upon these findings. There are more variables than achievement that need to be considered. Clute (1984) found all students taught using a discovery approach performed better, regardless of their anxiety level, when the analysis focused on high cognitive level questions. "This result speaks to the value of using a discovery approach when high-level processes are the objectives of a lesson" (Clute, 1984, p. 57). These studies are significant when educators are attempting to evaluate the students' understanding, not just their achievement in a course.

Lazarus (1974) believes mathematics anxiety has its beginning before college, but the problems are not as obvious because students in elementary and high school can survive by rote learning. He feels that mathematics anxiety does not appear until memorization falters and the student can no longer just get by. These feelings were reiterated by Skemp (1979b). He believed when students reach higher levels of mathematics, the instrumental approach begins to fail. At that point the rules and procedures have become too numerous, and the ability to recall the appropriate algorithm is nearly impossible.

**Learning with Understanding**

During the last century, meaningful learning has been a topic of interest pertaining to mathematics education. Learning theorists have discussed and debated the most efficient ways to teach and learn mathematics. Many theorists believe meaningful learning is the only viable method to learn mathematics, some believe rote learning is essential to build upon the basic skills, and yet a third sector feels a combination of the two types of knowledge is necessary for maximum learning potential. There is a
plethora of literature to review and decide which learning theory fits into an educator's framework for teaching and learning mathematics.

"Conceptual knowledge is characterized most clearly as knowledge that is rich in relationships. It can be thought of as a connected web of knowledge, a network in which the linking relationships are as prominent as the discrete pieces of information" (Hiebert & Lefevre, 1986, p. 3). The development of conceptual knowledge is based on the premise of linking relationships between pieces of information. The pieces of information may already be stored and a connection made between them, or one piece of information may be added to an existing piece of knowledge.

When two previously unrelated items are finally seen to be related in some way, Bruner (1961) characterizes this as discovery learning. When conceptual knowledge is gained through old information and a piece of knowledge that has just been acquired, this has been described as understanding or meaningful learning (Ausubel, 1967; Skemp, 1971). "Regardless of the term used, the heart of the process involves assimilating (Piaget, 1960) the new material into appropriate knowledge networks or structures. The result is that the new material becomes part of an existing network" (Hiebert & Lefevre, 1986, p. 4). "People continually try to understand and think about the new in terms of what they already know" (Glaser, 1984, p. 100).

Procedural knowledge is defined as a sequence of actions, such as computations and algorithms. Conceptual and procedural knowledge are both important when learning mathematics, but "the bulk of the theoretical arguments supports building meaning for written mathematical symbols and rules before practicing the rules for efficient execution (Hiebert & Carpenter, 1992, p. 78). The relationship between the two types of knowledge seems to be the key to understanding their interactive role in the development of understanding in mathematics. "All teachers are concerned about
learning as an outcome. However, it is the minority of teachers who are prepared to consider the processes of learning" (Simon, 1996, p. 37).

**Theories of Learning**

Recent research (Brooks, 1990; Lerman, 1989) has shown a dramatic increase in the number of mathematics educators who accept constructivism as a learning theory. Many believe in constructivism because it implies a solid foundation of concepts and a more natural way for students to learn. Constructivists believe that students develop their knowledge from constructing theories and rules to explain what has been observed, not just accepting procedures and algorithms from teachers and textbooks. As cited in Yackel, Cobb, Wood, and Merkel (1990), von Glasersfeld describes the constructivists perspective:

> If you believe that knowledge has to be constructed by each individual knower, ...teaching becomes a very different proposition from the traditional notion where the knowledge is in the head of the teacher and the teacher has to find ways of conveying it or transferring it to the student .... I'm primarily interested in developing ways of thinking in the student. And if you want to do that, you are constantly working with conjectures ... about what goes on in the student's head, and on those ... you base your strategies .... What you present is never something that you expect the student to adopt as it is, but what you present is something that you think will make it possible for the student to find his or her own way of constructing. (p. 34)

His perspective defines constructivism as a guiding framework, ways to help adjust teaching to maximize learning for each individual student. Students enter classrooms with many different levels of knowledge and certainly may enter with incorrect concepts, or misconceptions. Brooks (1990) believes:

*Misconceptions* refer to the theories students have generated to explain various phenomena, behaviors, interactions – theories that are wrong from the adult perspective. Although their thinking may be wonderful, it may be based on faulty assumptions, lack of information, or incorrect data. And, as most teachers know,
the rendering of "correct" explanations does not necessarily change the child's misconception. (p. 70)

As Kamii (1990) stated, the teacher's role becomes more indirect and difficult than in traditional instruction. How well can teachers identify their students' level in the understanding of concepts?

Carpenter, Fennema, Peterson, and Carey (1988) studied teachers' pedagogical content knowledge of children's solutions of addition and subtraction of word problems. They define the knowledge of pedagogical content as "knowledge of the conceptual and procedural knowledge that students bring to the learning of a topic, the misconceptions about the topic that they may have developed, and the stages of understanding that they are likely to pass through" (Carpenter et al., 1988, p. 386). The findings from their study showed most teachers were able to identify students' strategies, but this does not imply that they have adequate knowledge of their conceptual understanding. This is not easy for even the most experienced educators to grasp.

Lerman (1989) feels the process of coming to understand a concept is ongoing and mystical. He believes it takes place in the mind and is difficult for an outsider to know if the process has taken place. Brooks (1990) summarizes this process best in terms of representations. She feels the transformations of mathematical concepts into classroom practice is highly personalized. "To make these transformations ably and with insight requires content area knowledge, communication skills, and a vision of what intellectual autonomy in a developing thinker looks and feels like" (Brooks, 1990, p. 69). "We need to be able to continue with our belief that if we create the right environment, in the classroom, in our teaching, learning and understanding will take place" (Lerman, 1989, p. 221).
Ausubel states: "If I had to reduce all of educational psychology to just one principle, I would say this. The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (1968, p. vi). He believed there were two dimensions of learning: rote/meaningsful and receptive/discovery. Ausubel felt knowledge would always be a mixture of rote and meaningful learning, with each placed at the ends of a continuum. According to Ausubel, there is an improper belief that reception learning is always rote and discovery learning is always meaningful. He contends that these are actually two independent dimensions of learning. Both reception and discovery learning can be rote or meaningful depending on the conditions under which the learning occurs.

Rote learning is the memorizing of information or knowledge. Even if the material has potential meaning, the learning task will be rote if the intent of the learner is to memorize. For meaningful learning to occur, the learner must possess the ability to take information from the learning experience and relate that newly acquired knowledge and application in different words that express a complete understanding of meaning. Without connectivity to existing knowledge there is not meaningful learning. In reception learning, the content of what is to be learned is presented in final form. In discovery learning, the content to be learned is not given, but must be discovered by the learner before he/she can internalize the information.

Bruner (1960) advocates the discovery learning method. He refers to discovering learning as "methods that permit a student to discover for himself the generalization that lies behind a particular mathematical operation" (p. 21). Discovery learning takes place when the learner is required to organize information, rather than being presented the subject matter in its final form.

Some children approach problems as a listener, expecting to find an answer or at least some message there. At their best they are receptive, intelligent, orderly,
and notably empirical in approach. Others approach problem solving as a speaker. They wish to determine the order of information received and the terminus of their activity and to march ahead of the events they are observing. It is not only children. As a friend of mine put it, a very perceptive psychologist indeed, some men are more interested in their own ideas, others are more interested in nature. The fortunate ones care about the fit between the two. (Bruner, 1995, p. 331)

The emphasis of discovery learning focuses on the process in learning rather than the products of learning. His learning theory promotes the discovery method because it will increase transferability of information, require that the learner organize material in a meaningful way for ease of retrieval, and lead to a shift from reliance on extrinsic rewards to intrinsic rewards (Bruner, 1961).

According to Bruner (1960), learners are able to learn and intellectually grow when instructors are able to construct and represent knowledge in ways that are meaningful and useful in solving problems and meeting new challenges. His theory involves forming concepts from categories, that are used to decrease the complexity of the environment. Learners can respond to many different objects by categorizing them. He refers to this as a coding system. A coding system helps learners to remember, discover, perceive, and transfer information more effectively. The organization involved in developing a coding system can help to establish organization of thought processes when learning mathematics.

**Theoretical Framework**

A specific learning theory has not been associated with mathematics anxiety; therefore, after researching and reviewing the different learning theories, a theoretical framework for this study was derived. Based on the mathematics anxiety research, the theory will be explained and supported by the idea that learning mathematics for
understanding may help alleviate anxiety. The learning theories discussed provide the conceptual framework necessary to show meaningful learning is a more natural way to learn new material. When students are required to learn in a fashion that detracts from their natural process, anxiety may develop.

The theoretical framework for this study is based on Skemp's (1976) theoretical formulation. He gives an analogy to learning in real life to explain his underlying beliefs in the difference between meaningful and rote learning, or to use his terms, relational and instrumental learning. His story begins:

When I went to stay in a certain town for the first time, I quickly learnt several particular routes. I learnt to get between where I was staying and the office of the colleague with whom I was working; between where I was staying and the university refectory where I ate; between my friend's office and the refectory; and two or three others. In brief, I learnt a limited number of fixed plans by which I could get from particular starting locations to particular goal locations.

As soon as I had some free time, I began to explore the town. Now I was not wanting to get anywhere specific, but to learn my way around, and in the process to see what I might come upon that was of interest. At this stage my goal was a different one: to construct in my mind a cognitive map of the town. (Skemp, 1976, p. 25)

There is a large difference between these two events. Yet if someone saw him carrying out one of the activities, it would be hard to distinguish which one it was. Without asking him, it would not be possible to tell if he knew his way around the town, or was blindly walking from one point to the other. He had two different goals; one was to simply reach his destination, the other was to learn and understand all the different ways to get to his destination.

The characteristic of a plan is that it tells him what to do at each choice point: turn right out of the door, go straight on past the church, and so on. But if at any stage he makes a mistake, he will be lost; and he will stay lost if he is not able to retrace his steps and get back on the right path.

In contrast, a person with a mental map of the town has something from which he can produce, when needed, an almost infinite number of plans by which he can guide his steps from any starting point to any finishing point, provided only that both can be imagined on his mental map. And if he does take a wrong turn, he will still know where he is, and thereby be able to correct his mistake without getting lost; even perhaps to learn from it. (Skemp, 1976, p. 25)
How can an educator know if their students understand the mathematics they are doing when questions are asked that require only an answer, and no explanation needs to be provided to show their reasoning? Educators cannot tell if their students went from point A to point B with a set of directions, i.e. using an algorithm, or if they understood their way around, i.e. using underlying mathematical principles. Students' methods must be questioned and their thought processes need to be expressed and explained to help develop their thinking skills.

One of the most important parts of this framework is the discussion of making a wrong turn, or getting lost. If students do not have the necessary understanding needed to solve a problem, when they forget what they are doing, they usually freeze and can go no further on the problem, yet alone the rest of an exam. "Often they have learned isolated procedures and facts without conceptual understanding. They have developed ways of being effective in mathematics classes that have no mathematical value" (Simon, 1996, p. 39). When these skills are no longer useful, students may begin to question their knowledge of the material, and maybe realize they were not as prepared as they originally thought. Without the conceptual understanding to fall back on, these students are lost, and can no longer reach their destination. This process, that may allow anxiety to develop, has happened to many students because of their lack of conceptual understanding (Hodges, 1983; Lazarus, 1974; Skemp, 1979a, 1979b).

Skemp's (1976) analogy does a good job of describing how some of these frustrated students feel. Many people have been lost while driving or walking to a destination, and then they may start to get nervous at the thought of getting back on track. In this situation, however, they can ask for directions and hopefully be back on course before they become too anxious. "The learner is dependent on outside guidance for learning each new 'way to get there'" (Skemp, 1976, p. 25). Wouldn't an educator...
prefer that his/her students be able to build numerous plans to get where they need to be?

Conceptual and procedural knowledge are both important to adequately learn and understand mathematics. As students "walk" through different mathematical topics, they are sometimes told to turn left at one intersection, right at the next, but they can build on these step-by-step procedures. They can look down the streets and ask questions about what they see, such as, what if they turned left one road earlier, or one road later. This is the natural way one would learn how to get around a town, and should be a natural way for students to learn mathematics. "Educational research findings from cognitive psychology and mathematics education indicate that learning occurs as students actively assimilate new information and experiences and construct their own meanings" (NCTM, 1991, p. 2). When mathematics is taught in alignment with how students naturally learn, this theoretical framework suggests mathematics anxiety would be reduced.
CHAPTER 3

METHODS AND PROCEDURES

Research Design

This study was designed to investigate and describe the changes in mathematics anxiety in remedial mathematics students when conceptual understanding teaching methods were used. Math 050A, as described in The Instructional View in Chapter 1, incorporated conceptual understanding teaching methods and inquiry-based investigations built upon previously developed constructs with which to make connections. This descriptive and investigative research design was utilized to obtain information concerning conditions as they existed at the time of the study.

The nature of the study was quantitative and qualitative. Quantitative measures were used to rank the students by the change in their Mathematics Anxiety Rating Scale (MARS) scores and qualitative techniques were employed to find reasons and explanations for the quantitative measures. The purpose for using both methods was "expansion, wherein the mixed methods add scope and breadth to a study" (Creswell, 1994, p. 175). Limited information was gained by considering the survey instrument alone. The interview process provided additional information regarding students' perceptions of what contributes to or detracts from their anxiety towards mathematics. Miles and Huberman (1994) state, "We have to face the fact that numbers and words
are both needed if we are to understand the world" (p. 40). Details of the methodology used in this study are described in this chapter. This chapter ends with the limitations of the study.

Subjects

The participants in this study were the students enrolled in a college remedial mathematics course that was taught using conceptual understanding teaching methods. There were two remedial mathematics sections at The Ohio State University Columbus campus during Autumn Quarter 1996 that were using the conceptual understanding teaching methods. For most of the students, this was their first quarter of college.

During orientation, placement exams were given to all of the students to determine their entry level in mathematics. The particular level in this study was Math 050, the first of two remedial mathematics courses offered at The Ohio State University and is a review of arithmetic and basic algebra. The students are required to take at least one more mathematics course to fulfill their mathematics requirement. Depending on their major, there are two choices following this course. The students who have placed at the level for the course used in this study were given the choice of the traditional lecture approach, Math 050, or the conceptual understanding approach, Math 050A. These students had therefore self-selected to be enrolled in one of the two sections involved in this study. There were 31 sections of the Math 050 course offered at the Columbus campus during Autumn Quarter, 1996, two of which were being taught using conceptual understanding teaching methods.

Math 050A met three days a week, Monday, Wednesday, and Friday for 80 minutes each day. There were 30 days of instruction. The MARS survey was
distributed on the first day of class to the 44 students in Math 050A. The students who completed and returned their MARS by the following week formed the sample for this study. The sample consisted of 23 students, 6 males and 17 females.

**Instrumentation**

Several methods of data collection were utilized in this study. In examining the research questions that guided the study, a combination of survey, classroom observations, and interviews with both the students and instructors were selected based on the type of information sought. Marshall and Rossman (1995) write, "Limitations in one method can be compensated for by the strengths of a complementary one" (p. 99). Details involving validity and reliability are shown for the survey questionnaire used. Also, the format selection for the interviews is discussed, along with the evolution of the reasoning for the interview guides. Development of topics of focus for classroom observations are discussed. This section ends with an important aspect of data collection, the perspective of the researcher.

**Survey Questionnaire**

The instrument that was used to assess mathematics anxiety was the Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972; Suinn, 1970). This scale "was constructed to provide a measure of anxiety associated with the single area of the manipulation of numbers and the use of mathematical concepts" (Richardson & Suinn, 1972, p. 551). The MARS was designed for diagnosis and research with college students (Llabre, 1984). This questionnaire is a 98-item self rating Likert-type scale.
Each item on the scale represents a situation that may arouse anxiety within a subject, for example, "listening to another student explain a math formula". The subject decides on the degree of anxiety by using the categories "not at all", "a little", "a fair amount", "much", or "very much". The scores were summed by assigning the values of 1 for "not at all" anxious through 5 for "very much" anxious. The summated score can range from 98 to 490; high scores indicate high levels of mathematics anxiety. A copy of a portion of the instrument is in Appendix A.

Richardson and Suinn (1972) have reported an internal consistency reliability coefficient alpha of 0.97 for the MARS. This shows that the average intercorrelation of the items in the test is quite high. Confirmation that the test is highly reliable has also been shown by Dew et al. (1983), reporting a value of 0.96 for their sample. A test-retest reliability coefficient for the MARS was shown by Richardson and Suinn (1972) to be 0.78 after two-weeks and 0.85 after seven-weeks. "The stability of the MARS over intervals of short duration compares quite favorably with that of other measures of anxiety" (Llabre, 1984, p. 438). Evidence of the validity of the MARS comes from several sources. They find the MARS may not be a unidimensional measure of a specific anxiety, instead measuring both testing or evaluation situations and numerical or arithmetic manipulations. Llabre (1984) finds "the picture that emerges indicates that the MARS, although not unidimensional, is heavily dominated by a factor related to evaluative situations" (p. 439). Richardson and Suinn (1972) looked at three different studies where students were given behavior therapy and their scores on the MARS decreased as expected. Assuming the treatment did reduce the level of mathematics anxiety, the lower MARS scores were viewed as providing construct validity. Brush (1978) conducted a study that provided further validity by finding the 'students' scores on the MARS were correlated highly with measures of dislike and anxiety about
mathematics" (p. 489). "The ease of administration and scoring of the MARS, coupled with the availability of psychometric data, make it the best instrument for measuring mathematics anxiety that is currently available" (Llabre, 1984, p. 441).

**Development of Interview Formats**

Since interviews were one of the methods of data collection employed in this study, the development of the formats used for interviews follows. Student interviews were conducted four times during this study; twice during Autumn Quarter 1996 and once each Winter and Spring Quarters 1997. Nine students were interviewed twice Autumn Quarter, seven of those same students were interviewed Winter Quarter, and five Spring Quarter. The purpose of the interviews was to investigate the students' feelings and beliefs regarding their anxiety towards mathematics and any changes in their anxiety that may have taken place throughout the year. To do this, various interviewing techniques were used. Interviews were conducted face-to-face with the exception of the telephone interviews that occurred during finals week of Autumn Quarter, 1996. Face-to-face interviews were chosen because of the personal feel and the ability to match the interview style with the individual for optimal information. All interviews were conducted by myself and they were all audio-recorded, again with the exception of the telephone interviews, where field notes were used instead. Briggs (1986) favors the use of recorders during interviews by stating, "tape recordings are also interpretively open-ended...notes are frozen at the level of competence possessed by the researcher at the time of their writing" (p. 99).

Initially the interviews were semi-structured with questions written as a guide to stay focused on the topic. "Even when an interview guide is employed, qualitative
interviews offer the interviewer considerable latitude to pursue a range of topics and offer the subject a chance to shape the content of the interview" (Bogdan & Biklen, 1992, p. 97). To aid in the development of questions for the interview guide, field notes were kept throughout the quarter from the classroom observations and meetings with the instructors. A list of approximately ten questions were organized to guide the first interviews during Autumn Quarter. The sequencing and wording of questions were not important as long as the general questions were asked to all the students participating in this mode of data collection. This approach is described by Patton (1990):

> The interview guide simply serves as a basic checklist during the interview to make sure that all relevant topics are covered. The interview guide presumes that there is common information that should be obtained from each person interviewed, but no set of standardized questions are written in advance. The interviewer is thus required to adapt both the wording and the sequence of the questions to specific respondents in the context of the actual interview. (p. 280)

The interview guides were discussed with peer reviewers and most of the questions were used in a pilot study that focused on problems caused by mathematics anxiety. Revisions and adjustments of the interview guides were therefore based on comments and recommendations from the peer reviewers and the pilot study. The semi-structured interviews allowed for flexibility to ask questions based on the natural flow of the students' answers, yet the guide was incorporated to request each student think about the same topic in-depth. Certain comments and beliefs needed probing for a more clear explanation. The interview guide shown in Figure 1 was used to help assemble the questions for the first interviews.
1. Why did you take Math 050A?
2. Is it what you expected? If not, what did you expect?
3. How do you feel about this course compared to other math courses you've taken?
   a. Do you feel more/less comfortable?
   b. Do you feel more/less anxious (regarding math)?
4. Do you feel any activity or situation in this class relieved (or brought on) anxiety?
5. Would you rate yourself low, medium, or high, regarding anxiety toward math?
6. Do you feel your math anxiety has changed this quarter?
7. Do you remember feeling anxious in (or about) a math class? When do you first remember feeling this way?
8. Did your parents/home life influence your opinion or performance in your past math classes?
9. Can you remember your favorite and least favorite math teacher? When did you have him/her?
10. Do you plan on taking Math 075A? Why or why not?

Figure 1: Guide questions for first interview with 9 students, Autumn, 1996
The questions shown in Figure 2 were used to guide the interviews via the telephone. Interviews conducted during Winter and Spring quarter, 1997, were informal and conversational with questions arising from the students' comments.

1. How did you feel about the Math 050A final exam?
2. How do you feel about taking Math ____ next quarter?
3. What type of student would you recommend to take Math 050A?
   Describe them.
4. If you had to rate your math anxiety from the beginning of the quarter
   until the end of the quarter, do you believe your math anxiety has increased,
   stayed the same or decreased?
5. What factors do you feel contributed to this change?

**Figure 2:** Guide questions for second interview with 9 students, Autumn, 1996
Interviews were also conducted with the two instructors for Math 050A. Both of the instructors were interviewed twice Autumn Quarter, 1996 and there were many informal conversations involving one or both of the instructors throughout the 1996-1997 academic year. These conversations were documented in the field notes as soon as possible. The first interview was conducted midterm of Autumn Quarter, 1996 and the other interview occurred after final grades were calculated for Autumn Quarter. Both of these interviews were conducted via the telephone and notes were taken during and after the interviews.

Again questions were written as a guide, but given the expertise of the instructors, they were encouraged to add their beliefs and opinions regarding the students and the effect Math 050A had on their anxiety. The guide questions used when interviewing the instructors were similar to the questions asked of the students. This was intentional to see if the students and the instructors viewed mathematical topics and situations pertaining to anxiety similarly or differently. Guide questions for the first and second interviews are shown in Figure 3 and Figure 4.
1. What activity do you feel brought on the most anxiety so far?
2. What activity do you feel caused the least anxiety so far?
3. Did the students seem more or less anxious about this exam versus the typical math exam?
4. Does the attendance seem to differ for the students who seem to be more anxious from the students who do not appear to be anxious?
5. Did many (or any) students express levels of anxiety in their journals or to you personally?
6. Of the students who took the MARS, does anything come to mind regarding behavior, comments, attendance, or noticeable signs of mathematics anxiety?

**Figure 3:** Guide questions for first interview with instructors, Autumn, 1996

1. What activity do you feel brought on the most anxiety in the students?
2. What activity during class time do you feel caused the least anxiety?
3. Did you notice a difference in attendance for the students who seemed to be more anxious from the students who did not appear to be anxious?
4. What type of student would you recommend to take this class?
5. What factors do you feel contributed to the change in the students' math anxiety?

**Figure 4:** Guide questions for second interview with instructors, Autumn, 1996
Focus of Observations

The two Math 050A sections were observed nine times throughout Autumn Quarter, 1996, with one section being observed four times and the other section being observed five times. The main objective was to focus on the social environment and how the students adapted to the planned activities of the course. During observations, field notes were taken regarding the students and their interaction, or lack of interaction, with other students and the instructor. Days where students sat quietly and worked alone were also excellent times to gather data. Patton (1990) makes reference to the importance of nonverbal communications.

For each class I arrived early to access a seat in the back of the classroom so I could view most of the students and not become an intrusion on the class. By arriving early, I was also able to observe informative dialogue in the hallway before class began. Some of the students exchanged honest views in the halls that were not observed in class. Patton (1990) notes the importance of data collection during informal interaction. The two classrooms for Math 050A were next to each other and the classes started at the same time so both groups of students could be observed before classes began.

Areas of interest during the observations varied throughout the classroom visits. Much of my attention was focused on the 23 students who completed the Math Anxiety Rating Scale. Field notes were taken on the students who were presenting, those who asked questions, and how the other students in the class responded. I quickly learned the names of the students involved in my sample. If a student not included in the sample did or said something of interest to me, I included that event in my notes after inquiring the name of the student from the instructor. Observations that focused solely
on the students were helpful when students were selected for individual interviews later in the quarter.

Discussions with the instructors allowed me to schedule observations for optimum data collection. Lincoln and Guba (1985) suggest that selection of events to observe follow a procedure similar to that used in defining a purposeful sample. Groups of students presented their homework and taught lessons to the class on several different occasions. Observations were scheduled when the majority of students in my sample presented. Watching a student present mathematical material indirectly revealed elements of the students' comfort level in mathematics. In addition, observations were scheduled for days before and after exams to see how the students reacted during assessment procedures.

Classroom visits also provided information on the type of instruction and content of the material. The instructors shared their course materials with me since there was no required textbook for this course. However, since much of this course focused on group teaching and learning, without classroom observations, many of the students' comments during the interviews regarding anxiety would not have been fully understood. When students were discussing specific situations in the classroom that effected anxiety, I wanted to be aware of the situation and not rely on the student's perception of the situation.

**Researcher as Instrument**

Since the nature of this study is a blend of quantitative and qualitative methodology, it is important to include the opinions, prejudices, and considerations that I brought to the research process. All research, whether quantitative or qualitative,
includes some beliefs and opinions of the researcher, but as Bogdan and Biklen (1992) state, "we are talking about limiting observers' biases, not eliminating them" (p. 46). I do not believe there is research without researcher's bias, so I am including my background and beliefs so the reader can acknowledge this section and take it into account while reading this study.

Gaining access for this study was relatively easy since I was an instructor in the mathematics department at The Ohio State University for approximately six years. Most of the courses I taught were remedial so I am very familiar with the material typically covered and the types of students who enroll at this level. I have also taught some remedial courses at three additional colleges or universities throughout the last 13 years. Students at any level, but particularly the remedial level, are usually willing to discuss their problems in mathematics if it may help themselves or other students in the future.

I have been interested in mathematics anxiety since I first noticed the frustration it can cause students. Many students have expressed their fear and dislike of mathematics long before they have truly attempted what one thinks of as mathematics. They develop a fear of arithmetic and the algorithms attached to them because they cannot possibly remember all the steps involved in a process. I try to explain that understanding a concept can relieve some of the pressure in memorizing, but this is a foreign idea to them. Most of them have been taught rote procedures their entire lives and I am suggesting a method that is different, therefore frightening to them. The purpose of this study is to see if the students will benefit from this type of learning and build confidence in their mathematical skills, thereby reducing anxiety when they are submerged in an atmosphere where conceptual understanding teaching methods are used.
Data Collection Procedures

Permission was obtained from the Mathematics Department's Undergraduate Committee and from the Human Subjects Institutional Review Board in September, 1996 to conduct this study starting Autumn quarter, 1996. Data collection began in late September, 1996 using several different data sources. Explicit details regarding each type of data collection procedure are described in this section. A summary and timetable of the data collection follows.

All of the students in the two sections of Math 050A were given the Mathematics Anxiety Rating Scale (MARS). This questionnaire was distributed for the first time at the end of the period on the first meeting of the quarter. Because of time limitations, students were asked to complete the MARS on their own time and return it to their instructor one of the next two class meetings. All of the information needed to complete the questionnaire accurately and completely was printed on the form, and space was included for the students to enter their age and sex. In the case of missing data, the instrument was reviewed and returned to complete the next class meeting. The students then completed the questionnaire immediately and returned them directly to me. If a student was absent the day the questionnaire was distributed, the MARS was given to them the following day of class. Scores were tabulated but the students were not aware of the results until after the second administration of the MARS. The MARS questionnaire was anticipated to take between 20 and 30 minutes. There was a total of 44 students in the two sections of Math 050A, 21 in one class and 23 in the other. Of these 44 students, 21 returned the first questionnaire. In an attempt to get more MARS returned, I asked the instructors to remind their students to return their MARS to them and encourage their students to participate in the study. I was then present the next day
during class and again explained the purpose and advantages of the study and encouraged the students who had not completed their MARS to do so and return them the next class period. After these attempts, two more students returned their MARS, for a total of 23. The percentage of students to complete the first distribution of the MARS questionnaire was 52.3%.

A letter was sent the sixth week of the quarter to all of the students who completed the first MARS. The intent of the letter was to remind them of the events involved while participating in this study and inform them of the date when the second MARS would be distributed. A copy of the letter is included in Appendix B.

The MARS was distributed a second time on the eighteenth day of class, the seventh week of the quarter, to the 23 students who had completed it earlier in the quarter. Again, the MARS was to be completed at the students' convenience because of available class time and returned within a week after distribution. The same procedures were used to retrieve a larger percentage of the MARS, that is having both the instructors and myself encourage the students to return the completed MARS. These attempts brought in three more MARS for a total of 13. The sample of students who completed both administrations of the MARS was 13. This was 56.5% of the students who completed the first MARS. After the second administration of the MARS, the difference between the two MARS scores was calculated for each of the 13 students and ranked from the largest change in scores to the smallest change in scores.

Selection of students for interviews was based on several factors; largest changes in MARS scores, conversations with the two instructors, and classroom observations. After analyzing the paired MARS scores, students were selected with increasing and decreasing mathematics anxiety scores. Input from the instructors was important to select students that could add insight to the study. Observations were also an aid in the
structuring of the interview process. According to Patton (1990), "the logic and power of purposeful sampling lies in selecting information rich cases for study in depth" (p. 169). Students were called to be interviewed after the second MARS scores were tabulated, which was approximately the eighth week of the quarter. The first interviews were conducted at the end of the eighth week of classes, between day 21 and 22 of the 30 class sessions scheduled during Autumn Quarter.

All of the interviews were conducted in a private room with the door closed. None of the students seemed to mind when asked if the interviews could be audio-recorded; they all quickly agreed without reservation. The tape recorder was usually situated next to an object, such as a computer or backpack so it did not appear to be an intrusion during the interview. The interview participants appeared comfortable with me from the start of the interview and the interviews started with general conversation about the course, their majors, and eventually their feelings and attitude about mathematics in general. Most students were not shy or embarrassed to admit mathematics is not their favorite subject. This allowed a natural transition toward helping the students uncover the reasoning behind their feelings, and the interview guide was employed when appropriate. The interviews were 30-60 minutes long. All of the nine interview participants were asked if they would agree to a telephone interview during finals week, after their final exam in Math 050A. Each of the students agreed to be interviewed again and were contacted the day after their final exam for a second interview. These interviews were 10-15 minutes in length. The guide questions shown in Figure 2 were more heavily relied on during the telephone interviews.

The same interview participants were contacted the ninth week of Winter Quarter, 1997 by phone to schedule an interview the following week. These students were
interviewed the last week of Winter, 1997. Seven of the original nine students were available for and agreed to participate in the interviews. These interviews were again conducted in a private setting and were audio-recorded. No questions were written in advance because each student was unique in their selection of their next Mathematics course. Conversation was focused on how they viewed Math 050A in comparison to their current course and on how it prepared them, not necessarily content preparation but the skills that were acquired for learning mathematics. These interviews lasted 30-60 minutes.

These students were contacted once again Spring Quarter, 1997 for one final interview. Interviews were again scheduled for the last week of the quarter with five of the students and followed the same format as the interviews conducted during Winter Quarter, 1997. The interviews were 30-45 minutes long.

After each interview, notes were taken on the general attitude and body language of the interview participants. Any information that was gained from a face-to-face interview, that would not necessarily be revealed in listening to the tapes, was attempted to be recorded while it was stored in short term memory. All interviews were conducted and transcribed by myself. Only the parts of the interviews that related to this study were transcribed. There was conversation toward the beginning and sometimes throughout the interview that pertained to relaxing and enjoyable conversation and therefore was not included in the transcripts. Each interview tape was listened to at least twice before transcribing and was also listened to twice after the transcripts were typed to look for any missed or incomplete data. Typed transcriptions were filed with an observer's comments sheet written after every interview.

The instructors were interviewed midway through Autumn Quarter, 1996. The second interview was a few weeks after the final grades were completed for the course.
Sufficient time was allowed to pass so the instructors were viewing the course as a whole and not necessarily focusing on the last few weeks of the quarter. These interviews were 20 to 30 minutes in length and were conducted via the telephone. Figures 3 and 4 contain questions that were used as a guide but the instructors were encouraged to dictate the interview material since the goal of the interview was to gain information regarding the students and the course through their eyes. Notes from the formal and informal meetings with the instructors were recorded by hand. The instructors were not formally interviewed Winter and Spring Quarters since some of the original Math 050A students were no longer in their Math 075A courses and new students, who were not in the original Math 050A, were taking Math 075A. Neither instructor taught during Spring, 1997.

Observations were spaced throughout the term, from the second week to the eighth week. The two classes were observed a total of nine times, with all data observed and noted by myself. Detailed field notes were taken during each observation. The total number present for the session was noted to give an indication of the students who missed class and I made note of the students who were late. A description of the instructional activity for that day was included. To distinguish between the two classes, they are referred to as class C and class D.

Data collection was completed by the middle of June, 1997. Following is a timetable of the data collection.
## Time Table

### AUTUMN QUARTER, 1996

**First Week**
- Sept. 25: MARS distributed first time
- Sept. 27: Collected MARS

**Second Week**
- Sept. 30: Collected MARS; observed class C
- Oct. 2: Observed class D

**Fourth Week**
- Oct. 16: Observed class D
- Oct. 18: Observed class C

**Fifth Week**
- Oct. 23: Observed class C

**Sixth Week**
- Oct. 27: First interviews with instructors
- Oct. 28: Observed class D; mailed letters to students

**Seventh Week**
- Nov. 4: MARS distributed second time; observed class C
- Nov. 6: Collected MARS
- Nov. 8: Collected MARS; observed class D

**Eighth Week**
- Nov. 13: First interviews with students; observed class D
- Nov. 14: First interviews with students (cont.)

**Finals Week**
- Dec. 10: Second interviews with students

- Jan. 5, 1997: Second interviews with instructors

### WINTER QUARTER, 1997

**Tenth Week**
- Mar. 12: Third interviews with students
- Mar. 13: Third interviews with students (cont.)

### SPRING QUARTER, 1997

**Tenth Week**
- June 2: Fourth interviews with students
Methods of Data Analysis

Descriptive statistics were used for the data collected from the MARS. The results from the administrations of the two MARS were displayed using frequency tables and histograms. This presentation was used to aid in seeing changes between the two data collection periods. The figures and tables are accompanied by a general description of the data in words. Means and standard deviations were calculated for both administrations of the MARS. To analyze the difference between the paired scores on the MARS, the t-test for nonindependent samples was used. This procedure is used for the interval level of measurement but the distinction between ordinal and interval scales is not sharp, so many summated scales yield scores that are only mildly distorted versions of interval scales. Careful interpretations need to be made when ordinal data are analyzed with procedures suitable for interval data (Baker, 1994; Gardner, 1975). Statistical operations on measurements of a given scale are not appropriate or inappropriate, but only relative to the kinds of statements made about them (Adams, Fagot, & Robinson, 1965).

The data collected from the interviews were coded. All student interviews were transcribed and the interviewed students were shown a copy of their transcribed interview for them to verify the content and check to see if their true meaning was captured. While reviewing the data, I tried to discover and focus on the topics that kept surfacing. The transcripts and the field notes were read completely three times to totally immerse myself in the data and to develop codes for the repeating topics. The codes were then grouped into categories, as suggested by Miles and Huberman (1994). Some of the categories used were pedagogical knowledge, value of mathematics, transitional feelings, and mathematical behavior. "The development of a set of
categories allows the data to be organized through a variety of different distinctions" (Dey, 1993, p. 96). While exploring the data again for clarity and completeness, themes emerged based on the distinctions in the data. The categories were not organized or situated before the data collection period; the data collected was used to form the categories. According to Dey (1993), "Categories should not be imposed upon the data arbitrarily; the categories adopted should reflect the data. The distinctions established through categorization should be meaningful in terms of the data being analysed" (p. 98). The analysis contained in the next chapter of this study includes the various emergent themes used for summarizing the data.

**Trustworthiness**

To establish trustworthiness, several techniques were employed. Triangulation of multiple sources of data and methods were used whenever possible to strengthen the study.

Triangulation is a powerful solution to the problem of relying too much on any single data source or method, thereby undermining the validity and credibility of findings because of the weaknesses of any single method. Using triangulation is recognition that the researcher needs to be more open to more than one way of looking at things. A corollary to this insight is that purity of method is less important than dedication to relevant and useful information. (Patton, 1990, p. 193)

By combining several data collection sources, such as observations, interviews with students, interviews with instructors, and document analysis, there were situations when more than one data source revealed the same conclusion. "Data from different sources can be used to corroborate, elaborate, or illuminate the research in question" (Marshall & Rossman, 1995, p. 144). Triangulation also occurred by using both quantitative and qualitative methodologies. Attacking the same problem using different
methods provides trustworthiness of the data. "While the idea that researchers can transcend some of their own biases may be difficult to accept at the beginning, the methods researchers use aid this process" (Bogdan & Biklen, 1992, p. 46).

In addition there was prolonged engagement. I was introduced to the students the first day of class and was a continued presence until the end of the quarter. The students who were involved in the interview process were in contact with me throughout the 1996-1997 academic year. This allowed the students adequate time to express concerns regarding the course and their insecurities with the change in teaching and learning styles from their traditional style.

Another strength was the checking of the transcribed interviews with the students to see if their thoughts clearly stated and revealed what they had intended to say. Not every student was able to be contacted but 16 of the 21 transcriptions were verified. An audit trail was used whenever an excerpt from the transcripts was included in the analysis. Meloy (1994) expresses the importance of an audit trail when including excerpts from the transcripts. Since interviews were conducted twice Autumn Quarter, 1996 and once each Winter and Spring Quarter, 1997, the transcripts are referenced with Au1 or Au2 to decipher between the first and second interviews conducted Autumn Quarter. Winter and Spring Quarters are referenced by Wi and Sp. These notations appear at the end of every excerpted comment in Chapter 4.

According to Miles and Huberman (1994) some data are "better" than others. They write, "if the data on which a conclusion is based are known to be stronger, more valid than the average, then the conclusion is strengthened" (p. 267-268). They give a partial list of stronger versus weaker data and suggest the stronger data be given more weight during analysis. This weighting of the evidence was also used in this study. The MARS scores were very helpful in locating potentially interesting interview
candidates, however, it was only a numerical indicator. When the scores from the MARS did not concur with the comments during the interviews, I further questioned the students and the interview data then became "stronger" than the MARS data.

One last assurance of credibility was gained by looking at outliers. Miles and Huberman (1994) believe "the outlier is your friend" (p. 269). By interviewing the outlier one can possibly eliminate selection bias and can strengthen the original conclusions. They can also point out something different in the original conclusion.

Throughout the study, I tried to incorporate thick detailed description. This adds to the credibility ". . . in such a way that others reading the results can understand and draw their own interpretations" (Patton, 1990, p. 375). He goes on to say,

Description is thus balanced by analysis and interpretation. Endless description becomes its own muddle. The purpose of analysis is to organize the description so that it is manageable. Description is balanced by analysis and leads into interpretation. An interesting and readable report provides sufficient description to allow the reader to understand the basis for an interpretation, and sufficient interpretation to allow the reader to understand the description. (p. 430)

**Ethical Issues**

Ethical issues are worthy of concern when conducting any type of research. This concern becomes heightened when human subjects are involved. According to Bogdan and Biklen (1992), "two issues dominate recent guidelines of ethics in research with human subjects: informed consent and the protection of subjects from harm" (p. 49). In this study I tried to guarantee honesty and respect with the students and in some way, have the students benefit from participating in the study.

The students were told the nature of the study, the purpose for conducting the research, and what will be done with the data in a consent form. I clearly explained their grade would not be affected by their decision to participate in the study or their
desire to withdraw from participation once the consent form was signed. All of the students who participated in this study signed a consent form voluntarily. A copy of the consent form is included in Appendix C.

Also mentioned in the consent form was the option to choose a pseudonym or a code. The purpose was to help establish trust and promote honesty from the students. None of the students responded to this when signing the consent form so I brought this topic up at the beginning of the interviews. Again, none of the students seemed to care if I used their real name yet I told them I would prefer to keep their names confidential and would choose a pseudonym for them. All of the subjects were fine with that decision.

Reciprocity was also a concern in this study. The subjects opened up and invited me into their daily life and the benefits to them seemed so small. Some of the benefits for the students involved were being listened to, achieving a better understanding about their anxiety level in mathematics, and tutoring at the end of interview sessions. Most of the students were interested in knowing their scores on the MARS and trying to evaluate the change in their scores. In discussing these issues with the students, both the subject and researcher were seeking information and satisfying the other's questions at the same time. When I thanked the students at the end of the data collection, they were quick to say this was not an intrusion and was an interesting experience for them also.

Limitations of the Study

Limitations of this study include the number of students involved in the study, method of data collection, and the newness of the course. The number of students
involved in the population of this study was limited to 44 since there were only two classes offered using the conceptual understanding teaching methods. Also, all of the students self-selected to be enrolled in these two courses, so these results may not be the same when compared to sections where students randomly enrolled in these courses. Those students may not prefer to try a different style of instruction.

Limitations related to data collection concerned the response rate. Because of time limitations in the classroom, the quantitative instrument was not permitted to be completed during scheduled class time. Since the students completed the instrument on their own time, this contributed greatly to the low response rate. This problem was compounded because the quantitative instrument needed to be completed twice from the same population.

Another limitation was related to the newness of the course. This was only the third quarter this type of course was offered at this University and these instructors were teaching this course for the first time. Materials for the course were designed by these instructors and were not used the previous year, so they would need to be evaluated and adjusted for future courses. During the interviews, comments were made regarding aspects of the course that needed refinement instead of focusing on the type of material being presented or the conceptual teaching methods that were used. However, these comments were an important part when assessing how the students felt about the course but they were sometimes misleading while trying to interpret the results.

One last limitation applies to the willingness of instructors to participate and teach these courses. Both of these instructors were eager to teach these courses and were interested in learning about the conceptual understanding teaching methods. Teaching with the intent of developing conceptual understanding requires more time in the form
of planning lessons, organizing activities for the classroom, and developing challenging assessment methods. These results may not be the same if the instructors did not appreciate and agree with the benefits gained from this type of instruction.
CHAPTER 4

RESULTS AND ANALYSIS

Introduction

This chapter contains analyses of the results from the Math Anxiety Rating Scale and analyses and comparisons of student interviews. The results from the Math Anxiety Rating Scale are presented first. The analysis of results contains the score distributions from the two administrations of the Math Anxiety Rating Scale and an analysis of the paired scores.

The analysis of the student interviews are needed to expand and enhance the interpretation of results presented from the MARS. Included throughout these analyses are details from the classroom observations and excerpts from the two interviews with the instructors. Also, copies of the syllabus, class activity guides (including the instructor's and student's guides), homework, and copies of the exams were shared with me. These were important and helpful documents when observing classes and interpreting students' comments when they referred to classroom materials. The document analysis is interspersed throughout this chapter for triangulation purposes. Analysis of the data is segmented into six emergent themes and a summary of a few individual cases completes this chapter. The following Table provides a summary of the data collection process. All of the students are referred to by their code name.
<table>
<thead>
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<th>CODE NAME</th>
<th>Participation Au '96, Enrolled in Math 050A</th>
<th>Participation Wi '97, Enrolled in Math ...</th>
<th>Participation Sp '97, Enrolled in Math ...</th>
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<td>Interview, 104</td>
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<td>Interview, 075A</td>
<td>No math</td>
</tr>
<tr>
<td>Olivia</td>
<td>MARS1, MARS2</td>
<td>Interview, 075A</td>
<td>Interview, 104</td>
</tr>
<tr>
<td>Paul</td>
<td>MARS1, MARS2, Interview</td>
<td>Interview, 075A</td>
<td>No math</td>
</tr>
<tr>
<td>Quint</td>
<td>MARS1, MARS2, Interview</td>
<td>Interview, 075A</td>
<td>Interview, 104</td>
</tr>
<tr>
<td>Ron</td>
<td>MARS1</td>
<td>Interview, 075A</td>
<td>Interview, 104</td>
</tr>
<tr>
<td>Scott</td>
<td>MARS1, MARS2</td>
<td>Interview, 075A</td>
<td>Interview, 104</td>
</tr>
<tr>
<td>Tina</td>
<td>MARS1</td>
<td>Interview, 075A</td>
<td>Interview, 104</td>
</tr>
<tr>
<td>Ursula</td>
<td>MARS1, MARS2, Interview</td>
<td>Interview, 075A</td>
<td>Interview, 104</td>
</tr>
<tr>
<td>Victoria</td>
<td>MARS1, MARS2</td>
<td>Interview, 075A</td>
<td>Interview, 104</td>
</tr>
<tr>
<td>Will</td>
<td>MARS1</td>
<td>Interview, 075A</td>
<td>Interview, 104</td>
</tr>
</tbody>
</table>

**Table 1:** Summary of data collection
Quantitative Results: The Math Anxiety Rating Scale

The Math Anxiety Rating Scale (MARS) was administered twice during Autumn Quarter, 1996. The MARS was distributed on the first day of class and then again during the seventh week of the quarter. The sample was comprised of the 23 students who completed the first MARS. Table 2 contains the results from the first distribution of the MARS, displayed with the students' code names. The lowest possible score (indicating low anxiety) is 98 and the highest possible score is 490. Also included in Table 2 is the age and sex of each student and the code for which of the two Math 050A classes they were enrolled in. The age variable was not too interesting, with 21 out of the 23 students all being 18 years old. The sample was divided with 13 students from class C and 9 students from class D. Table 3 shows the participation of males and females by population and by sample.
<table>
<thead>
<tr>
<th>Code Name</th>
<th>Score on MARS 1</th>
<th>Age</th>
<th>Sex</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paul</td>
<td>171</td>
<td>18</td>
<td>M</td>
<td>D</td>
</tr>
<tr>
<td>Harry</td>
<td>179</td>
<td>18</td>
<td>M</td>
<td>D</td>
</tr>
<tr>
<td>Scott</td>
<td>199</td>
<td>18</td>
<td>M</td>
<td>C</td>
</tr>
<tr>
<td>Janet</td>
<td>205</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Ursula</td>
<td>213</td>
<td>18</td>
<td>F</td>
<td>D</td>
</tr>
<tr>
<td>Kelsey</td>
<td>222</td>
<td>18</td>
<td>F</td>
<td>D</td>
</tr>
<tr>
<td>Erin</td>
<td>240</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Imie</td>
<td>251</td>
<td>18</td>
<td>F</td>
<td>D</td>
</tr>
<tr>
<td>Cathy</td>
<td>259</td>
<td>40</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Olivia</td>
<td>265</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Linda</td>
<td>276</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Becky</td>
<td>284</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Quint</td>
<td>293</td>
<td>19</td>
<td>M</td>
<td>C</td>
</tr>
<tr>
<td>Victoria</td>
<td>309</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Ron</td>
<td>310</td>
<td>18</td>
<td>M</td>
<td>D</td>
</tr>
<tr>
<td>Tina</td>
<td>318</td>
<td>18</td>
<td>F</td>
<td>D</td>
</tr>
<tr>
<td>Mandy</td>
<td>320</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Debra</td>
<td>321</td>
<td>18</td>
<td>F</td>
<td>D</td>
</tr>
<tr>
<td>Wil</td>
<td>331</td>
<td>18</td>
<td>M</td>
<td>C</td>
</tr>
<tr>
<td>Abby</td>
<td>333</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Nicole</td>
<td>340</td>
<td>18</td>
<td>F</td>
<td>D</td>
</tr>
<tr>
<td>Francie</td>
<td>348</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>Gayle</td>
<td>386</td>
<td>18</td>
<td>F</td>
<td>C</td>
</tr>
</tbody>
</table>

Table 2: Scores on the first distribution of the Math Anxiety Rating Scale
Soon into the study I knew the names of, and could recognize, which of the students were included in my sample. During classroom observations I continued to observe and note all of the students in the population, not just those participating in my study. In reflecting on the participants and nonparticipants, no obvious differences were displayed in the classroom. The vocal, and sometimes more confident appearing students seemed equally divided between the participants and nonparticipants, as well as the less vocal students. While looking through the final grades given in Math 050A, I noticed the participants and nonparticipants grades were slightly different. The participants averaged a 2.75 GPA on a 4.0 scale and the nonparticipants averaged a 2.18 GPA in Math 050A. Since the MARS was completed outside of the classroom, the difference between the sample and population could be attributed to lack of motivation in some students to complete and return the survey. Female students had a slightly higher participation rate. The difference between the number of males and females involved in the population and sample is noted in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>POPULATION</th>
<th>SAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALES</td>
<td>36.4% (N=16)</td>
<td>26% (n=6)</td>
</tr>
<tr>
<td>FEMALES</td>
<td>63.6% (N=28)</td>
<td>74% (n=17)</td>
</tr>
<tr>
<td>Total</td>
<td>100% (N=44)</td>
<td>100% (n=23)</td>
</tr>
</tbody>
</table>

Table 3: Percentage of males and females in population and sample
The results from the second distribution of the MARS are displayed in Table 4 along with the corresponding scores from the first MARS. Since 23 students completed MARS 1 and 13 of those completed MARS 2, I decided to see if there was a notable difference in anxiety between participants of MARS 2 and nonparticipants of MARS 2. In Table 4, the MARS 1 scores are listed in ascending order to show the participants and nonparticipants of MARS 2 are well distributed in terms of low and high anxious students (as indicated by MARS 1).

In addition, when comparing the mean and standard deviation of the scores from the MARS 1 from the entire sample (n = 23), with the scores from the MARS 1 students who also completed the MARS 2 (n = 13), the numbers were similar. The mean of the MARS 1 (n = 23) was 277.1, with a standard deviation of 59.0 and the mean of the MARS 1 (n = 13) was 278.9, with a standard deviation of 57.4. This shows the difference between the participants of MARS 2 and the nonparticipants of MARS 2 in terms of anxiety is minimal. To ease distinction between the two groups that form the sample, the term sample will refer to the 23 students who completed MARS 1 and the term subsample will refer to the 13 students who completed MARS 1 and MARS 2. In other words, the sample was comprised of the 23 students who completed the first MARS and the subsample was comprised of the 13 students who completed both the first and second MARS. These data are analyzed separately; first a comparison and analysis of the scores formed by the sample (n = 23 for MARS 1 and n = 13 for MARS 2), and then a comparison and analysis of the scores formed by the subsample only (n =13 for MARS 1 and n = 13 for MARS 2). Similarities and differences are then explained between the two groups.
<table>
<thead>
<tr>
<th>Code Name</th>
<th>MARS 1</th>
<th>MARS 2</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paul</td>
<td>171</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Harry</td>
<td>179</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Scott</td>
<td>199</td>
<td>201</td>
<td>+ 2</td>
</tr>
<tr>
<td>Janet</td>
<td>205</td>
<td>233</td>
<td>+ 28</td>
</tr>
<tr>
<td>Ursula</td>
<td>213</td>
<td>191</td>
<td>– 22</td>
</tr>
<tr>
<td>Kelsey</td>
<td>222</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Erin</td>
<td>240</td>
<td>168</td>
<td>– 72</td>
</tr>
<tr>
<td>Imie</td>
<td>251</td>
<td>176</td>
<td>– 75</td>
</tr>
<tr>
<td>Cathy</td>
<td>259</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Olivia</td>
<td>265</td>
<td>270</td>
<td>+ 5</td>
</tr>
<tr>
<td>Linda</td>
<td>276</td>
<td>215</td>
<td>– 61</td>
</tr>
<tr>
<td>Becky</td>
<td>284</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Quint</td>
<td>293</td>
<td>312</td>
<td>+ 19</td>
</tr>
<tr>
<td>Victoria</td>
<td>309</td>
<td>311</td>
<td>+ 2</td>
</tr>
<tr>
<td>Ron</td>
<td>310</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Tina</td>
<td>318</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Mandy</td>
<td>320</td>
<td>282</td>
<td>– 38</td>
</tr>
<tr>
<td>Debra</td>
<td>321</td>
<td>214</td>
<td>– 107</td>
</tr>
<tr>
<td>Will</td>
<td>331</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Abby</td>
<td>333</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Nicole</td>
<td>340</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Francie</td>
<td>348</td>
<td>207</td>
<td>– 141</td>
</tr>
<tr>
<td>Gayle</td>
<td>386</td>
<td>296</td>
<td>– 90</td>
</tr>
</tbody>
</table>

| n = 23 | n = 13 |

*Table 4:* Ranked MARS 1 scores paired with the MARS 2 scores and the change in scores
The difference between the number of males and females involved in the population, sample, and subsample is displayed in Table 5. The females' percentage rate increased for each new level of participation compared to the males.

<table>
<thead>
<tr>
<th></th>
<th>POPULATION</th>
<th>SAMPLE</th>
<th>SUBSAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALES</td>
<td>36.4% (N=16)</td>
<td>26% (n=6)</td>
<td>15% (n=2)</td>
</tr>
<tr>
<td>FEMALES</td>
<td>63.6% (N=28)</td>
<td>74% (n=17)</td>
<td>85% (n=11)</td>
</tr>
<tr>
<td>Total</td>
<td>100% (N=44)</td>
<td>100% (n=23)</td>
<td>100% (n=13)</td>
</tr>
</tbody>
</table>

Table 5: Percentage of males and females in population, sample, and subsample

Table 6 displays a grouped frequency distribution to show the difference in scores from the first administration of the MARS (MARS 1) to the second administration of the MARS (MARS 2) for the entire sample. Low scores indicate low levels of mathematics anxiety while high scores indicate higher levels. The lowest possible score on the MARS is a 98 and the highest possible score is a 490. The data displayed in Table 6 show a shift toward lower levels of mathematics anxiety on MARS 2. This implies lower levels of mathematics anxiety were measured during the seventh week of the quarter than were measured during the first week of the quarter in Math 050A. These same data are also expressed in Table 7 using histograms.
| Score Interval (Range 98-490) | MARS 1 | | MARS 2 | |
|-----------------------------|--------|------------------|--------|
|                             | Frequency | Percentage | Frequency | Percentage |
| 98-136                      | 0       | 0%            | 0       | 0%         |
| 137-175                     | 1       | 4.4%         | 1       | 7.7%       |
| 176-214                     | 4       | 17.4%      | 5       | 38.4%      |
| 215-253                     | 3       | 13.0%      | 2       | 15.4%      |
| 254-292                     | 4       | 17.4%      | 2       | 15.4%      |
| 293-331                     | 7       | 30.4%      | 3       | 23.1%      |
| 332-370                     | 3       | 13.0%      | 0       | 0%         |
| 371-409                     | 1       | 4.4%       | 0       | 0%         |
| 410-448                     | 0       | 0%          | 0       | 0%         |
| 449-490                     | 0       | 0%          | 0       | 0%         |
| Total                       | 23      | 100%        | 13      | 100%       |

Table 6: Grouped frequency distribution of MARS 1 and 2 scores for sample
Table 7: Histograms of the scores on MARS 1 and MARS 2 for sample

Scores on the MARS 1 ranged from 171 to 386, with a sample size of 23 students. The distribution of scores is negatively skewed. The mean of the data is 277.09, with standard deviation of 59.00 and median of 284. Scores on the MARS 2 ranged from 168 to 312, with a sample size of 13 students. The distribution of scores is positively skewed with a mean of 236.62, standard deviation of 51.25 and median of 215.

The grouped frequency distribution and histogram are again used to display the data for the subsample, comprised of the 13 students who completed the MARS 1 and 2. Table
8 shows the grouped frequency distribution and Table 9 shows the histograms for the subsample.

<table>
<thead>
<tr>
<th>Score Interval (Range 98-490)</th>
<th>MARS 1</th>
<th>MARS 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percentage</td>
</tr>
<tr>
<td>98-136</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>137-175</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>176-214</td>
<td>3</td>
<td>23.1%</td>
</tr>
<tr>
<td>215-253</td>
<td>2</td>
<td>15.4%</td>
</tr>
<tr>
<td>254-292</td>
<td>2</td>
<td>15.4%</td>
</tr>
<tr>
<td>293-331</td>
<td>4</td>
<td>30.7%</td>
</tr>
<tr>
<td>332-370</td>
<td>1</td>
<td>7.7%</td>
</tr>
<tr>
<td>371-409</td>
<td>1</td>
<td>7.7%</td>
</tr>
<tr>
<td>410-448</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>449-490</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 8: Grouped frequency distribution of MARS 1 and 2 scores for subsample
Table 9: Histograms of the scores on MARS 1 and MARS 2 for subsample

Scores on the MARS 1 ranged from 199 to 386, with a sample size of 13 students. The mean of the data is 278.92, with standard deviation of 57.37 and median of 276.
Scores on the MARS 2 ranged from 168 to 312, with a sample size of 13 students. The mean of the data is 236.62, standard deviation of 51.25 and median of 215. These data show there are greater occurrences of lower levels of mathematics anxiety on the MARS 2 score.
A t-test for nonindependent samples was used for an analysis of the paired scores. This test is used when the measure to be analyzed is the difference between the paired scores. Using the 13 paired scores from the MARS 1 and MARS 2, a t-value of −2.87 was obtained. This tells us that the observed difference is 2.87 times as great as the difference that would be expected under a true null hypothesis. The difference between the two means is significant at the .05 level but not at the .01 level. Table 10 displays the mean and standard deviations for the MARS (n =13) and the t-ratio.

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARS 1</td>
<td>278.92</td>
<td>57.37</td>
<td>−2.87</td>
</tr>
<tr>
<td>MARS 2</td>
<td>236.62</td>
<td>51.25</td>
<td></td>
</tr>
</tbody>
</table>

Table 10: Mean and standard deviation for the MARS (n= 13) and t-test value

Analyzing the difference between the MARS 1 and 2 scores, the largest change in scores was 141 points while the smallest change was 2 points. In all, 8 students measured a decrease in mathematics anxiety and 5 students’ scores increased. Table 11 shows the code name, score on MARS 1 and MARS 2, and the amount of change and the direction of change in their mathematics anxiety. The mean of the change in scores was −42.31, with a standard deviation of 53.07.
<table>
<thead>
<tr>
<th>CODE NAME</th>
<th>MARS 1</th>
<th>MARS 2</th>
<th>MARS 2 - MARS 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abby</td>
<td>333</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Becky</td>
<td>284</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cathy</td>
<td>259</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debra</td>
<td>321</td>
<td>214</td>
<td>-107</td>
</tr>
<tr>
<td>Erin</td>
<td>240</td>
<td>168</td>
<td>-72</td>
</tr>
<tr>
<td>Francie</td>
<td>348</td>
<td>207</td>
<td>-141</td>
</tr>
<tr>
<td>Gayle</td>
<td>386</td>
<td>296</td>
<td>-90</td>
</tr>
<tr>
<td>Harry</td>
<td>179</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imie</td>
<td>251</td>
<td>176</td>
<td>-75</td>
</tr>
<tr>
<td>Janet</td>
<td>205</td>
<td>233</td>
<td>+28</td>
</tr>
<tr>
<td>Kelsey</td>
<td>222</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linda</td>
<td>276</td>
<td>215</td>
<td>-61</td>
</tr>
<tr>
<td>Mandy</td>
<td>320</td>
<td>282</td>
<td>-38</td>
</tr>
<tr>
<td>Nicole</td>
<td>340</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olivia</td>
<td>265</td>
<td>270</td>
<td>+5</td>
</tr>
<tr>
<td>Paul</td>
<td>171</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quint</td>
<td>293</td>
<td>312</td>
<td>+19</td>
</tr>
<tr>
<td>Ron</td>
<td>310</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scott</td>
<td>199</td>
<td>201</td>
<td>+2</td>
</tr>
<tr>
<td>Tina</td>
<td>318</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ursula</td>
<td>213</td>
<td>191</td>
<td>-22</td>
</tr>
<tr>
<td>Victoria</td>
<td>309</td>
<td>311</td>
<td>+2</td>
</tr>
<tr>
<td>Will</td>
<td>331</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 11: MARS 1, MARS 2, and the change in paired MARS scores
When analyzing the data by class, class D had a greater reduction of mathematics anxiety than class C, however, the participation rates differed greatly. Class C included 23 students, with 14 completing MARS 1 and 10 of those completing MARS 2. Class D included 21 students with 9 completing MARS 1 while only 3 of those completed MARS 2. Table 12 displays the participation numbers by class. The students in Class D had an average initial anxiety of 258, with the average change in mathematics anxiety showing a decrease of 68 points. Class C had an average initial anxiety of 289 points with the average change decreasing by 35 points. The data from classroom observations and interviews did not support these findings, and with the return rate being so low in the one class, it was not an informative comparison.

<table>
<thead>
<tr>
<th></th>
<th>Class C</th>
<th>Class D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number enrolled</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Returned MARS 1</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Returned MARS 2</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 12: Participation in the sample by class
The quantitative data was also analyzed by females and males. Since the
difference in the numbers of males and females in the study grew larger as the study
progressed (see Table 5), rankings of the scores were considered instead of a
comparative analysis by sex. Of the 23 students who completed the first MARS, 6
were males. Three of these men ranked the lowest in mathematics anxiety in the sample
while the other three were ranked 13th, 15th, and 19th. The two who ranked the
lowest did not complete MARS 2, while the one who ranked 3rd on MARS 1 showed
an increase in anxiety by 2 points. The other male to complete MARS 2 ranked 13th
from the MARS 1 score, and showed an increase of 19 points. This male, referred to
by the code name Quint, participated in the interviews and he believed his anxiety
decreased, not increased as the MARS indicated.

One last item that was analyzed pertained to the lowest and highest scores from
MARS 1 and how these students were affected by the course as detected on their
MARS 2 score. When the changes in mathematics anxiety based on the MARS data
were reviewed, the three largest changes in mathematics anxiety occurred with the two
highest ranking MARS 1 scores and the student with the third largest change had the
sixth highest score on MARS 1. There was no detectable pattern with the other
changes in paired MARS scores.

The results from the MARS were an integral part in selecting students for
interviews. Students with significant changes in their MARS scores were interviewed
and two students were selected based on information provided by the instructors and
from notes taken during classroom observations. Figure 5 was useful in interpreting
the data from the MARS and to aid in the selection of students for interviewing. The
letters in Figure 5 represent the first letter of the code name selected for each student in
the sample. The axes represent the scores on MARS 1 and MARS 2. There are eight
data points that fall below the line; this represents a decrease in the measurement of their mathematics anxiety during Math 050A. The data points above the line represent the five students that had an increase in their mathematics anxiety as measured by the MARS. The data points with circles around them represent the students who completed both MARS and were scheduled for interviews during Autumn Quarter, 1996. Two students who did not complete MARS 2 were also interviewed. In Figure 5, the distance the data are from the line correlates with their change in mathematics anxiety, the farther the data point is from the line, the larger the change in anxiety.
Figure 5: Relationship between MARS 1 and MARS 2 scores
Selection Process for Student Interviews

Based on the changes in MARS scores, conversations with the two instructors, and classroom observations, ten students were selected to be interviewed. Eight students' MARS scores showed a decrease in mathematics anxiety and interviews were scheduled with six of those students. One student however, did not show up for the interview. Five students' MARS scores showed an increase in mathematics anxiety and interviews were scheduled with two of those students. There were more students chosen with decreasing mathematics anxiety scores because those changes were more substantial. The distribution of both the MARS scores and the changes in their scores are shown in Table 13. The rows are positioned according to changes in the MARS scores starting with the largest change. Of the ten students selected to be interviewed, six had a decrease in MARS scores (Francie, Debra, Gayle, Imie, Linda, and Ursula), two had an increase in MARS scores (Janet and Quint), the other two only completed MARS 1 (Nicole and Paul).

The two who only completed the first MARS were asked to participate in the interviews for the following reasons. Nicole was chosen because her behavior tended to show traits of mathematics anxiety and her attendance patterns were sporadic. Her instructor also thought that she could contribute to the data because of her honesty displayed in conversations with him. Paul was selected because he had the lowest MARS 1 score and his anxiety appeared low during classroom observations. His instructor expressed how this student seemed frustrated by some of the discussion in Math 050A. All ten students who were called agreed to participate. One student, denoted by the code name Gayle, did not show up for the scheduled interview and could not be contacted that day so she was not interviewed.
<table>
<thead>
<tr>
<th>Code Name</th>
<th>MARS 1</th>
<th>MARS 2</th>
<th>MARS 2 - MARS 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Francie</td>
<td>348</td>
<td>207</td>
<td>-141</td>
</tr>
<tr>
<td>Debra</td>
<td>321</td>
<td>214</td>
<td>-107</td>
</tr>
<tr>
<td>Gayle</td>
<td>386</td>
<td>296</td>
<td>-90</td>
</tr>
<tr>
<td>Imie</td>
<td>251</td>
<td>176</td>
<td>-75</td>
</tr>
<tr>
<td>Erin</td>
<td>240</td>
<td>168</td>
<td>-72</td>
</tr>
<tr>
<td>Linda</td>
<td>276</td>
<td>215</td>
<td>-61</td>
</tr>
<tr>
<td>Mandy</td>
<td>320</td>
<td>282</td>
<td>-38</td>
</tr>
<tr>
<td>Janet</td>
<td>205</td>
<td>233</td>
<td>+ 28</td>
</tr>
<tr>
<td>Ursula</td>
<td>213</td>
<td>191</td>
<td>-22</td>
</tr>
<tr>
<td>Quint</td>
<td>293</td>
<td>312</td>
<td>+ 19</td>
</tr>
<tr>
<td>Olivia</td>
<td>265</td>
<td>270</td>
<td>+ 5</td>
</tr>
<tr>
<td>Scott</td>
<td>199</td>
<td>201</td>
<td>+ 2</td>
</tr>
<tr>
<td>Victoria</td>
<td>309</td>
<td>311</td>
<td>+ 2</td>
</tr>
</tbody>
</table>

Table 13: Distribution of both MARS and the changes in MARS scores for subsample
The same nine interview participants were contacted Winter Quarter, 1997; only seven agreed to participate. One student had left The Ohio State University after Autumn, 1996. She had indicated during her interview Autumn Quarter that she wasn't interested in continuing her education at this time. Another student withdrew from her classes in the middle of Winter Quarter for health reasons. Seven of the original nine students were left and they all agreed to participate. Four of those students were in the follow-up course Math 075A. This course was designed to follow the same style of teaching and learning as Math 050A. One student was taking Math 075 that was taught using traditional methodology and pedagogy. One student continued on to Math 104, a slightly higher level than Math 075, but the Math 050/Math 104 series is only recommended for the students who do extremely well in Math 050. The other student started taking Math 104 Winter Quarter and switched to Math 075A after 2 weeks.

Of the seven students interviewed Winter Quarter, five were taking Mathematics courses Spring Quarter. The two students who were not taking Mathematics courses during Spring Quarter were contacted for an interview but neither of the students felt they had any more information to offer since the last interview. Four of the remaining five students were taking Math 104 and the other one was taking Math 116, a course designed for social science majors. One student was unable to schedule an interview so she was quickly interviewed for approximately 10 minutes on the telephone. The other four students were interviewed in the same manner as Winter Quarter.
Results from Qualitative Analysis

Coffey and Atkinson (1996) believe "Thinking about how to represent our data also forces us to think about the meanings and understandings, voices, and experiences present in our data" (p. 109). After reading the transcripts and field notes, a list of codes were created. Themes emerged based on the coding scheme that was discussed in Chapter 3. The six emergent themes that organize this chapter are:

1. Mathematics background and prior mathematical experiences,
2. Expectations and realizations of Math 050A,
3. Favorite and least favorite activities or events in Math 050A,
4. Comfort level in Math 050A,
5. Transition from Math 050A and/or Math 075A to other Math courses,
6. Realizations of other Math courses.

The first theme, mathematics background and prior mathematical experiences, is important in understanding where the students have been and how their anxieties may have been formed. The second theme, expectations and realizations of Math 050A, was useful in interpreting the reasons these students chose to enroll in this course, what their expectations were, and whether or not they were fulfilled. The third theme, favorite and least favorite activities or events in Math 050A, was helpful in distinguishing between the types of activities that were enjoyable and/or relaxing and those that might have been frustrating and/or anxiety producing. This theme was also a benefit in terms of understanding preferences in learning styles. The fourth theme, comfort level in Math 050A, was needed to aid in explaining changes in their comfort and anxiety. It became easier to analyze how the students defined their anxiety change throughout the quarter (or year) when paired with their comfort level throughout that
same time period. Once again, this theme was useful in determining how the students felt about their own mathematics anxiety. The fifth theme, transition from Math 050A and/or Math 075A to other Math courses, was beneficial in describing the students' feeling about leaving their "comfort zone" and going into the classroom with the traditional lecture approach. The sixth and last theme, realizations of other Math courses, described how the students felt after the transition to the traditional classroom. How did things go in your traditional Math courses? Are you happy you followed the Math sequence that you chose? Each of these emergent themes shed light on the underlying feelings of students' mathematics anxiety. Looking at the data from several different angles helped to clarify the analysis and solidify the findings.

Following is the analysis of data within the different themes. This chapter ends with a compilation of the data across themes and a summary of a few individual cases.

**Mathematics Background and Prior Mathematical Experiences**

Following is a brief introduction to the nine interview participants. Each of the students brought a unique perspective to my study and these descriptions can provide a reference while reading through the data.

**Debra:** She seemed to lack confidence, and not just in mathematics. Of all the students interviewed, she seemed to be the weakest mathematically.

**Francie:** Very happy, always seemed to be smiling, even when she was discussing bad situations in math courses. She was mature and appeared confident and comfortable in math, even though she said it was not always that way.
Imie: I was impressed with her desire to learn. She tried to find the good in several bad situations. She seemed to enjoy our interviews, they usually lasted twice as long as the other interviews.

Janet: She was a Philosophy major and it came through in our interviews. She tended to view the ideas and class activities from a different, usually more mature, angle.

Linda: Always appeared casual and happy. She seemed to work hard in this class; I noticed new material did not always come easy for her. I got the impression she was a genuinely dedicated student.

Nicole: She was very strong and stubborn toward something she believed in. She absolutely refused to do class presentations but she enjoyed public speaking classes. She appeared laid back and comfortable during our interview but despondent and withdrawn in class.

Paul: Very nice person, appeared honest and sincere. His foundation in math seemed to be solid. He made comments in class several times that the rest of the class did not agree with but he stood his ground because he believed in it.

Quint: Gave the appearance of having a bad attitude but he was one of my favorites to interview. He was able to clearly explain his beliefs and positions and managed to combine humor in addition to this. He was brutally honest sometimes.

Ursula: She was interesting to interview because she was completely open and honest about the course and her feelings. She was polite, but did not seem to mince words when discussing her feelings. She did not appear weak mathematically and she seemed to be able to learn in different types of environments.
For all but two of the nine students in the interview sample, Math 050A was their first Math course at the college level. Quint took the traditional version of Math 050A, Math 050, the quarter preceding his enrollment in Math 050A and did not pass the course. Nicole took an Algebra I course at a Community College between her Junior and Senior year in high school. This was the first time all of the students interviewed were exposed to teaching for conceptual understanding. A few of the students expressed how this form of teaching was not foreign to them, yet when they were questioned further, it became clear that group work and board work satisfied their definition of conceptual understanding teaching methods.

High school math is typically not a pleasant memory for students in remedial mathematics courses in college. Even when students believe they are mathematically prepared for college, the reality is that many are still placed into a remedial level mathematics course. Table 14 shows the courses the nine interview participants were enrolled in throughout their high school years.
<table>
<thead>
<tr>
<th>NAME</th>
<th>FRESHMAN</th>
<th>SOPHOMORE</th>
<th>JUNIOR</th>
<th>SENIOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imie</td>
<td>Algebra I</td>
<td>Geometry</td>
<td>Algebra II</td>
<td>Trans. Math</td>
</tr>
<tr>
<td>Debra</td>
<td>Algebra I</td>
<td>Geometry</td>
<td>Algebra II (dropped)</td>
<td></td>
</tr>
<tr>
<td>Paul</td>
<td>Algebra I</td>
<td>Algebra I (retake)</td>
<td>Geometry</td>
<td>Alg II/Trig</td>
</tr>
<tr>
<td>Quint</td>
<td>Algebra I</td>
<td>General Math</td>
<td></td>
<td>Algebra I</td>
</tr>
<tr>
<td>Francie</td>
<td>Intro to Alg</td>
<td>Algebra I</td>
<td>Geometry</td>
<td>Algebra II</td>
</tr>
<tr>
<td>Ursula</td>
<td>Intro to Alg</td>
<td>Algebra I</td>
<td>Geometry</td>
<td>Algebra II</td>
</tr>
<tr>
<td>Linda</td>
<td>Prealgebra</td>
<td>Algebra I</td>
<td>Geometry</td>
<td>Algebra II</td>
</tr>
<tr>
<td>Janet</td>
<td>Algebra I</td>
<td>Geometry (passed 2nd half)</td>
<td>Geometry (passed 1st half)</td>
<td></td>
</tr>
<tr>
<td>Nicole</td>
<td>General Math</td>
<td>Consumer Math</td>
<td>Algebra I (failed)</td>
<td>Algebra I (at Comm. Coll.)</td>
</tr>
</tbody>
</table>

**Table 14:** High school courses of interview participants
Each of the nine students that were interviewed took Algebra I, some their Freshman year in high school and two did not enroll in a high school course above that level. Geometry was the final course for two of the students; four students completed high school with an Algebra II course being the highest level attained. Paul reached the highest level in the sample by completing an Algebra II/Trigonometry combination course. Paul and Linda expressed their feelings of placing into the remedial level mathematics course by saying:

Paul: I kind of figured I was going to do that bad because I didn't have my calculator. Even if I did have my calculator, I wouldn't have remembered how to use it or how to do the problems. (Au1)

Linda: I felt pretty stupid when I got placed in 050. Then I talked to lots of people and lots of my friends got placed in 050 so then I didn't feel quite as bad. (Au1)

(As stated in Chapter 3, since interviews were conducted twice Autumn Quarter and once each Winter and Spring Quarters, the transcripts are referenced with Au1 or Au2 to decipher between the first and second interviews from Autumn Quarter with Winter and Spring Quarters referenced by Wi and Sp. These notations appear at the end of every excerpted comment.) A few of the students were comfortable, even relieved with the idea of starting in a lower level course. They knew their math skills were weak and wanted to build a stronger mathematical foundation:

Imie: I was kind of down realizing I had to start out at the basic level in college and I thought why did I put all this work in high school? Number one I didn't bring a calculator to the test. And once I saw the scheduling and saw that I could retest I thought to myself, no, you've always been overwhelmed by math. Why not ease yourself into it? This is college; this is the big leagues. Ease yourself in and you might have a better footing. (Au1)
Debra: I knew math was always difficult for me so I asked the counselor during orientation what the best math course was for me to take. I told her I was terrible at math and needed to finally learn it. (Au1)

Some understanding of students' feelings towards mathematics can be achieved by asking questions that make them think about what they like and dislike. In doing so, it became helpful to figure out how they preferred to learn mathematics. When the students were asked to recall their favorite, and least favorite, teacher in a mathematics class and describe why they felt this way, some were quick to answer, as if they had already given this topic much thought. The excerpts below were typical responses from those who could remember their favorite teacher:

Ursula: He was real organized. He took the quizzes from the homework, the test from the quizzes. You had something to refer to, you knew what you were learning. He had one person go to the board once they figured it out, because you know how a teacher can go too fast. He was one of my favorite teachers. (Au1)

Paul: Well, I had two really. The one was really nice and she would make sure I understood and I felt like I understood. The other teacher was just so hard. She just flew through stuff, she just flew. But she was a good teacher. (Au1)

Debra: He was kind of like my instructor in Math 050A. I remember our class was having such a hard time figuring out equations. Finally he made this thing that made everybody learn. He's kind of like the same in the way he would go into details and make everybody know what they were learning. (Au1)

Quint: My Senior year in high school. He was pretty good but by then I had such a sultry grasp of math that it didn't seem to matter. But he was pretty good. (Au1)

The least favorite teacher seemed to stir up stronger emotions. This is revealed by the following statements and actions that made students uncomfortable in a math course:
Francie: On the first day he looked at us and said you guys aren't stupid, you're just lazy. That kind of set me off. My geometry teacher pretty much just stood up there and talked about what he knew. He didn't really try to make us understand. (Au1)

Debra: She was horrible. She was so bad. She would race through the book spending no time on anything. She thought her job was to get from the beginning of the book to the end of the book by the end of the year. If you didn't get it, you didn't get it. That's too bad. (Au1)

Paul: When she covered things she covered it in a different way. Like she would just put stuff on the board and expect you to know it, she didn't really talk. And I was always the one to get mad and ask questions. (Au1)

Linda: I had a teacher that just went up to the board and just did a lecture, gave us problems and that was it. He never asked anyone if they had any questions or if they understood and everyone was scared to death of him so they didn't say anything. It was just dead silent. Dead silent. (Au1)

Imie: When it came to math it was her way or no way. Her way was a lot of structure. We went to the board and her style was that she would go from problem to problem and if you were still up there at the board she'd say do that over again. It was like you would be the last one up there and everyone was staring at you. (Au1)

These students' comments show the importance placed on teachers to thoroughly explain material and then take the time to help the students understand. These quotes focus on the fast pace of some teachers and the lack of interest in what their students comprehend.

The embarrassment of being the student left standing at the board and having the class watch you while you tried to understand the problem reverberated from several of the students. The idea of the entire class becoming aware that you were not able to do the material seemed to release feelings of helplessness, as revealed in these students' comments:
Nicole: In high school, each student would go up to the board and do one homework problem. I didn't know what I was doing so I'd stand up there and have no idea, no idea. It was just that, over and over again. And I was so embarrassed.(Au1)

Francie: I remember in the 5th grade when we had the speed multiplication tests. I was always the last one. I mean everyone would be sitting around watching and staring at me so I'd run through the last ones and write whatever I wanted to just so I could get done. I felt really embarrassed.(Au1)

Linda: When I was younger I hated Math because I didn't know what was going on half the time. I was scared to death they were going to ask me a question and I was going to look stupid in front of the whole class.(Wi)

The look of fright and disappointment on the faces of these students when they revealed these stories told how instrumental these situations were in their mathematical history. It seems as though the least favorite teachers carved a deeper scar than the favorite teachers could possibly repair. Vastly different confidence levels were displayed when these students reported on situations in their previous classrooms.

When the instructors were interviewed, one of them commented on how a couple of the students wanted the instructor to know that they were strong in their other subjects; Math was the only course in which they seemed to struggle. The instructor mentioned how the students specifically mentioned this, as if to say I'm not a stupid person, I can succeed in my other courses. Both of the instructors said the students' journals revealed the lack of confidence from situations like standing at the board and being questioned without knowing the answers. The students wrote in their journals about their teachers and situations that caused anxiety in their previous mathematical experiences. This information was useful in understanding why these students chose to enroll in a course that was taught using nontraditional methods.
Expectations and Realizations of Math 050A

When freshmen students enroll in classes at The Ohio State University, they are given a mathematics placement exam during their orientation session on campus. During these orientation sessions, advisors are available to speak about different types of courses and help students with their class selections. All of the advisors were made aware of the Math 050A course and were asked to share this information with the students who placed at the Math 050 level. One of the items I was interested in knowing was why the students decided to enroll in Math 050A instead of the traditional Math 050. Some of the responses follow:

Janet: A counselor explained a new math class about an experimental math class and the way that they taught it was different. You would have a lot of group work and not as much individual work. And that it may be more compatible to learning and I thought that I might as well try it because I'm not very good at math.(Au1)

Debra: The advisor told me the difference between the two and she told me this was more like learning how to do everything than just doing it. So I'd understand what I'm doing instead of just trying to do it.(Au1)

Ursula: The advisor suggested it since I had a hard time with math anyway. She said they use a lot of visuals and it's different.(Au1)

Francie: I found out about it in orientation and I decided to take it because they said it was an experimental class, not experimental exactly but new. For people who have difficulties in math, they teach slower or better. I just took it because I didn't want to take math. Just because I hate math, it's hard. I like it now.(Au1)

Quint: My instructor called my house.
Myself: You had a personal invitation from her?
Quint: Yeah, I didn't do so well in the regular 050 class during the summer. She called me and said there had been a couple of openings in the class. She explained how the class ran. I know I wasn't looking forward to taking regular 050 again so I said this couldn't be any worse.(Au1)
Nicole: Nobody told me about it. I just picked a math randomly.
Myself: And you happened to pick the one with the A on the end of it?
Nicole: Yeah, I figured it was probably the lowest math.
Myself: How did you realize it was different?
Nicole: On the first day when they started talking about it.
Myself: Why did you decide to stay in this course?
Nicole: Hopefully it was going to be different from the rest of the math classes.
        I was just hoping it was going to be something I could pass.(Au1)

The reasons that were given for enrolling in the course varied and I was interested to see if each student was satisfied they enrolled in these sections, regardless of their original reasons for selecting them. Most of the students were eager to admit that they were ready to try to learn math a different way. Having all been through this same level of math in high school, they did not want to see the same material taught with the same teaching strategies of old. After completing seven weeks in the Math 050A course, were they satisfied with the way things were going? Do they feel that their original expectations of the class have been met? This was the next question asked during the interviews and some typical responses were:

Imie: Yes some expectations have been filled, some not so. I guess I was expecting more of a higher level. I do like the reemphasis on the word problems though because that was one of my weakest points.(Au1)

Linda: Yeah, I like it a lot actually. I always know I can call the people in my class or else I can talk to the teacher. I just feel comfortable with the group as a whole. They are all as bad as I am in math.(Au1)

Quint: Yeah, I'm passing so yeah, I guess. It's like getting your teeth drilled. You don't want to but you've got to do it.(Au1)

Francie: No, it's not. It's better. I expected the normal everyday math where I would have to listen to a lecture and then struggle through all my homework and flunk all my tests like I usually do.(Au1)
        I took 050A because they said it was a slower class.
Myself: Do you view it that way now?
Francie: No, it's a more relaxing class. Not slow.(Wi)
Ursula: Yes and no. I like all the experiments that we do which helps me because I learn better by looking at it rather than reading it from a book. Not so much as lecture and do this problem, do that problem. So that's what I like about it. Sometimes I wish things were more routine. I like an organized way of learning, like this is lesson 1 and we are learning about this.

Myself: So when you study for your test you have it all nicely broken down?

Ursula: Yeah, that's how I study easy.

Myself: So the part you don't like is that it's not as organized?

Ursula: Right, I expected all the experiments but I wish it was a lesson and then group work inside of that. I mean he follows a pattern but it's not as organized. (Au1)

Ursula: I pictured we had a book, but with more visuals and more group activities. I wasn't expecting a notebook and all the ditto work. I was expecting the teacher to interact with the students though. (Wi)

Janet: In a lot of ways, yeah. I mean, I didn't really have a big expectation of what it was going to be like. I can understand a lot of what we actually learn. I was hoping it would be something I was able to learn better with and I think it is. (Au1)

As the students were evaluating their expectations of the course, it made me think about what kind of student they thought this course would benefit. The morning after the final exam was given (the eleventh week of the quarter), each student was interviewed a second time. They were asked to describe the type of student they would recommend take this course:

Debra: If you want to know WHY to do something take this course. If you only want to know HOW to do it, take regular 050. This course is good for people who like to do one problem many ways. But don't take it if you get confused easily. (Au2)

Paul: If you're not willing to put forth the effort, you will do bad in 050A. The instructor looks at all work very closely. (Au2)

Quint: DEFINITELY anyone would be more successful in Math 050A. (Au2)
Well, if you want it to stick in your head, I would imagine Math 050A would be better than Math 050 because it makes you learn it. (Au1)
Francie: Math 050A seems to be an easier way to do Math, not an easier Math.(Au2) I think this course would be better for anyone. Even if you are really good in math, you have to find some pressures on it.(Au1) If you're comfortable with math you don't need Math 050A. Math 050A was like a comforting thing. It was a new approach to teaching that I had never seen before. I don't know many teachers that will actually try to make you understand. They just say do it this way, this is how you do it, no other way.(Sp)

Ursula: This would be a good course for somebody having a hard time understanding the concepts.(Au2)

Janet: Anyone could do well in this course. You need to learn to get the most out of it and I think you need to be self motivated to maximize the benefits.(Au2)

Imie: By the end of Math 050A, I was looking at it as a mystery that I had to reveal. That's why I would recommend 050A to anybody.(Wi)

The same question, what type of student would you recommend take this course, was also asked of the instructors and one of the instructors felt it had more to do with the type of environment than any particular type of student. The other instructor recommended a person who is in touch with their own thinking; someone who is not satisfied with following an algorithm without knowing why; someone who wonders if there is a different way of understanding and is interested in thinking, not just about mathematics, thinking in general. These statements show the students and instructors felt this was a different way of teaching and learning, not simply the same methods with some new ideas incorporated into the daily activities.

In trying to uncover the underlying reasons for some of the students' statements, I thought it would be helpful to know what their favorite and least favorite activities were in Math 050A. When observing students in the classroom, it became apparent when they were enjoying and actively participating in an activity. Yet it was not easy to interpret why or what made these activities better than others. It is more enlightening to
know why, or what made an event more enjoyable or more frustrating; this lends to understanding the types of activities that are producing and encouraging anxiety or preferable relieving anxiety.

**Favorite and Least Favorite Activities or Events in Math 050A**

By talking with the students, instructors and through observations, I could better interpret what activities and events the students found interesting, motivational, or useless. I drew my opinions from watching their reactions and participation during classroom observations. The instructors shared their perceptions through observation, and conversation in the classroom. Without individual interviews, some ideas would have gone undetected.

The course was organized into approximately ten activities, such as problem solving, percents, reading and understanding sections of a mathematics textbook for class presentation, graphing, and a pendulum activity. See Appendix D for a sample of classroom activities. In one activity, groups of three or four students were able to select a topic, typically presented at the high school level, then review and research this topic and be completely responsible for presenting it to the class. As discussed earlier, several students mentioned their fears of appearing unintelligent in front of their peers so I thought any discussion of or presentation of material to their peers would be a least favorite activity. This was not the case as revealed in the students' comments:

**Quint:** I liked when we did the group thing, when we all got a different section of math to present. That was pretty fun. I knew my area pretty well but I missed everybody else's.

**Myself:** Why did you like this? Presentations in a math class typically doesn't sound appealing to a lot of students.
Quint: No, it doesn't. And it doesn't even really sound appealing to me. I didn't like to do it because it's hard to teach math. If people don't get it you're like, I can't help you. I just know what I know.

Myself: But yet you liked it?

Quint: Yeah.(Au1)

Linda: I was really worried about the presentation because I didn't want to get up and talk in front of class but it went really well.(Au1) I liked the presentations. I don't think that was bad at all learning from others. When others explain it, they explain it using simpler terms.(Wi)

Myself: I remember you were in the group that chose the function notation and I was really impressed you guys chose that topic.

Francie: We just chose it because we didn't know what it was.

Myself: And you weren't afraid of it?

Francie: Not really. I was at first until I sat down and worked on it for 2 1/2 hours one night trying to figure out what I was going to say. Because the worst part about what I do is trying to make other people understand. After I've understood it I don't know how to make other people understand what I'm saying. I had my instructor read through it before I did the presentation. I wanted someone to read through it who knew math. I had my dad read it and he said I should be a teacher (laughing).

Myself: I was in your class the day she told you guys about the group presentations. No one seemed nervous. Don't you think that in a typical class people are afraid to go to the board and have to present something and speak to the class?

Francie: I think it's mostly because we are comfortable with each other, because it's a small group. I don't understand how you can sit in a lecture hall with 150 some people, not even knowing peoples faces.(Au1)

As the last comment states, the students appeared comfortable in their environment and with what was expected of them during the class presentations. One of the instructors commented on how the students asked several questions regarding the class presentations and were worried about being put "on the spot". Several of the students commented on not gaining much knowledge from the other students' presentations. Part of that was due to the students not asking the necessary questions of the other students to make the topic more clear. One of the instructors believed this activity caused anxiety because the students felt they had to be responsible for the other
students' presentations. This topic also appeared on the least favorite activity list, but it seemed to be there for reasons other than being nervous talking about mathematics in front of other people:

Paul:  I learned a lot about my subject in the group presentations but I didn't learn a lot about other people's subject.

Myself:  Why do you think that is?

Paul:  My guess is they didn't...the way the instructor asks questions makes you think about certain things you need to know. Some just tried to run through it, explain it, and get their projects done.(Au1)

Ursula:  One thing that I wish would have gone a little better was the group presentations. Because we went through all that trouble to learn about something but then it didn't really seem like people took that much time to present it, people didn't participate. It was kind of like you went to the board, you said what you had to say and were you really teaching something?(Au1)

Debra:  The thing I didn't like at all was when we did those group projects. I mean I learned from my group but I didn't learn from any of the other groups. I don't know why I didn't learn it but it didn't sink in like when he would teach it.(Au1)

Janet:  I didn't like the group activities where you present the stuff. I can see where maybe it was a little bit beneficial because even if I didn't understand it, it did force me to try to read something and try to figure it out myself. That's where I have the biggest problem in math. If I just try to look at a whole bunch of math, I just...I can't do this and if I can't do it I just get really frustrated and then I just quit. If I don't know how to do it, I just won't do it. I'm used to doing everything really quick and picking things up really quick. And if I don't get it, it's like, I don't even care.(Au1)

These excerpts are similar to the comments regarding least favorite teachers. The students are consistent in explaining how the presentation of material alone is not sufficient to develop understanding. Janet voices her opinion on the need to have mathematics explained to her because she gets frustrated trying to figure it out for
herself. If she does not understand the concepts quickly, she stops trying and she
stops caring. Janet and I continue our conversation:

**Myself:** Do you think that your attitude changed during this quarter?

**Janet:** I don't think it's really changed but I think I've been a little more open
to try to do it different ways. But the opportunity hasn't arisen because
I haven't felt really frustrated with the stuff we've done. I don't know
if it's just the concepts, like it's stuff I already know, or if it's the way
it's presented that makes it easier for me to understand. Some of the
stuff I feel is pretty basic and pretty easy to me. That is a weird thing
for me to say because math never seems easy to me. (Au 1)

This comment shows Janet cannot easily put her feelings into words. She knows
something is different in Math 050A but she is not able to distinguish if it is the review
of the material or the presentation that makes it more clear.

Another important aspect regarding the presentations were the comments focusing
on the faults. Although many of the students enjoyed the presentations, many also
discussed the problems associated with them. This was an important assessment
opportunity to evaluate the students and also to better design the group presentations for
the next Math 050A course. Conversations between the students and instructors were
held in the classroom to explain and understand the positive and negative aspects from
the presentations.

Other activities or events that were enjoyed throughout Math 050A varied. Some
of these activities have been presented to the students numerous times in the past and
now they have found them to be a favorite activity as noted in the following excerpts:

**Imie:** The activity I liked the most was when we all got together and worked
on percentages. And then he split us up into four different groups and
we had to find three different ways to solve the problem. And then he
mixed us up again and we had to teach each other in our groups the way
we thought was our best way or end result in each of the problems.

**Myself:** Why did you like that?

**Imie:** We got different opinions and we saw better ways to add onto our ways
that might be quicker or might be more understanding. And then once
we got to the board, I know because that was one of the days that I actually spoke out more readily...I actually went to the board and explained a problem and everybody was understanding it clearly and I believe it was effective for the whole class.(Au1)

Janet: The percents, I loved doing that. I really did like that.
Myself: Why?
Janet: Because I've never been able to figure out percents. I can figure out 10% by just moving the decimal over one place. I've never been able to do it if I had this number and wanted 33% or just pick some random percent.
Myself: So you liked this procedure, that's why you liked this particular activity?
Janet: Yeah, I liked the method we used. That makes it a lot easier because that's like a concept I can kind of do. That just made it a lot easier for me to understand.
Myself: When you read the problem you knew where to put the numbers?
Janet: I would feel so much more comfortable doing this than like a formula. With a formula I just get totally confused because I don't know where the numbers go. It just doesn't make any sense. This is something I can visualize more. You can see your answer in terms of all possible answers. Then you can get a better sense of how good your answer is.
Myself: I bet you've been presented percents at least three other times in your life. And yet this is a good activity because now you feel comfortable?
Janet: Maybe I'm at a point personally where I'm able to understand it better. And that combined with the teaching maybe makes it better.(Au1)

Imie did not necessarily like the activity but she felt the instructional method worked well for her. Janet valued a visual procedure for solving percentages (See Appendix D). She could not feel comfortable with the methods she has seen in the past but this method was new to her and it helped her to finally understand this concept.

Francie: The very first day when we did the problem solving activities. It's the first time I've sat down in a group and been able to figure out an answer for myself instead of having to just listen to other people and get the answer that way.
Myself: How many people were in your group?
Francie: Three.
Myself: And you guys were all working on the problem and you solved it first?
Francie: Um-hum.
Myself: And that's the first time that has happened?
Francie: That's the first time it's happened in a math class. If I've sat down and thought about it really hard I could do it. But we only took half an hour to figure it out.(Au1)
Francie appreciated the length of time allotted for her to solve the problems. She enjoyed doing the work for herself instead of watching how others got the answer.

Nicole and Ursula both liked doing an experiment, an activity that required active participants as expressed in the following quotes:

Nicole: The pendulum thing.
Myself: Why?
Nicole: Because it's not just sitting there listening and looking at the overhead and I'm not falling asleep. It's something you can figure out. It's something you can work with. I'm better with that in math. There was a problem like cut these pipes, and do it on paper. I was like, give me the pipes and give me a ruler and I can do it.
Myself: You're a hands on person, not visual?
Nicole: Very much. (Au1)

Ursula: The pendulum one we did because we actually used something. (Au1)

Debra: When we added 1 through 10 and then 10 through 1.
Myself: Why did you like that?
Debra: Because I thought it was neat how you could add them. I thought it was real interesting that there was some way to figure it out. If I was in another math class I would have sat there with the calculator and tried to figure it out. (Au1)

The variety of preferences expressed in these comments shows the importance and necessity of different teaching methods. Using the traditional lecture format is effective with some students but as these excerpts from the interviews show, students prefer different ways of learning for personal reasons. There was also variety in the type of assessment measures used. Students were asked to submit weekly journal entries throughout the quarter. Some of the entries were asking them to explain why certain mathematical methods worked and other entries discussed their course goals and feelings. I was interested in how the students viewed these writing assignments:

Linda: It's kind of hard to explain what you're feeling on a piece of paper, or explain how you did a certain problem. But some of them make me
think what I thought of math when I was younger and how it progressed through high school and now college. (Au1)

Quint: I loved it, I loved it. It's venting, that's what it is. You get to say I hate math, I hate it. (Au1)

The responses were varied as depicted in these two excerpts. Writing in a mathematics course was a new event for most of the students.

**Comfort Level in Math 050A**

This was a necessary and important theme in terms of understanding the students' change in anxiety throughout the quarter. The student interviews were crucial to support and enhance the quantitative results. The level of comfort in a course is difficult to detect with quantitative measures alone. Many of the students may not be able to determine why their anxiety levels changed, so it was necessary to ask them questions that would be helpful in revealing and interpreting this information. By asking the students to compare their Math 050A course with their previous mathematics courses, it became apparent which course was more comfortable. Their responses to my initial question allowed me to follow many avenues while trying to interpret their various levels of comfort and what made them feel that way. The following quotes are representative of comments made about Math 050A compared to their previous mathematics courses:

Francie: I don't care that I have to come to class. I don't mind coming. I like it actually. I can actually talk out in class without having to think that I'm saying something that everyone else knows and I'm the only one that doesn't know it. (Au1)
Imie: If I could have a recitation or something that's designed like this class but also have the comfort of doing those repetitious 30 homework problems, I'd be in seventh heaven. Math 104 (the course she is scheduled to take next quarter) wouldn't bother me a bit if it was designed towards this type of teaching style. I hope the 104 instructor reemphasizes and does what my instructor now does, that's the one thing I really like.(Au1)

Debra: I feel more comfortable with this style of teaching. I don't feel as anxious as I did before because this I understand. In my other classes I'd be scared to ask a question because I'd be so far behind. Everybody else would know what they were doing and now it's like if I have to ask a question, I can ask a question and I don't feel stupid.(Au1)

Ursula: In some ways I like this better. I guess one reason why it's not so comfortable as my other math classes is because I don't know very many people. I like the size of the math class and I really like the group work. You get to know people that way.(Au1)

Janet: I guess I feel more comfortable. I like the idea that you have to think for yourself.(Au1)

Quint: Definitely more comfortable because it seems to move along more at my pace (Failed Math 050 last quarter).(Au1)

Linda: Oh definitely more comfortable. I actually have a clue of what's going on. I think the instructor goes slower and makes sure that everyone has it before she moves on to something new. Everyone asks tons of questions during class if they don't understand. This course is more like explanation and you don't have to have formulas memorized. It's just kind of like if you know how to solve a problem, there's no specific format you need to follow to come up with an answer. Like story problems; there's no specific way to know how to do it. You just do it and come up with an answer.

Myself: And do you feel more comfortable with that?
Linda: Yeah.(Au1)

Overall, these students expressed a higher comfort level in Math 050A than in previous mathematics courses. They expressed feelings of comfort with the teaching style and with the other students. Several students remarked on the choices available when
solving problems. They express how in the past they felt forced to use formulas and follow the same format the teacher did as denoted in these quotes:

Janet: I'm so used to having to do math with certain formulas and it has to be so limited. I'm just a real individualistic person, I like to do things my own way. When I was in high school if I didn't understand how to do a math problem, I would create my own way to do it, even if it wasn't a right way, just so I could understand it. I think maybe now, being taught to do it your own way makes me more relaxed with the idea that it's OK to do it your own way. That it's effective to do it your own way.

Myself: When you were in high school, if your method was correct but not the way they were looking for, did they give you a hard time?

Janet: Yeah, definitely.

Myself: Even if you got the right answer and could explain what you were doing?

Janet: Yeah, a lot of times I didn't get the right answer and it didn't make sense. But sometimes I might draw pictures to understand and not use the formula but still get the right answer. They would say you have to follow the formula. That was a great source of frustration. If I didn't know how to do the problem, I would randomly pick a number and put it in and see how far away it was. Sometimes it took like 30 times.(Au1)

Imie: I think I'm more comfortable because of the way the class is being taught because I've seen word problems all through high school. The way this class has been taught, to just take it step by step, trial and error, what works for me to get to the final result.(Au1)

These comments show the importance of allowing some freedom to discover methods and procedures that make sense and work best for each student. However, there will always be items in every course that are discomforting and I also wanted to pursue some of those.

One of the items that caused discomfort in the students and is an aspect of teaching for understanding is the way questions are posed and not always answered. When the instructors were asked what they felt brought on the most anxiety, the one instructor mentioned how two to three weeks into the quarter the students were frustrated with the idea that they were not being told what to do or being told the
answers when they wanted them. This is an unfamiliar concept for most of the students and benefits aren't always readily seen as expressed by the following students:

Imie: His questions, I understand why he does it but I think it would be helpful to the entire class....because it seemed before the midterm we were doing great, we were moving along at a nice pace. After the midterm it just seemed like although we were getting into the harder things we were slowing down way too much and he was asking the more open ended questions and when it comes to harder things...there are different aspects of each problem and I guess I would have liked a little bit more direction with his questions. (Au1)

Paul: I was finally getting used to him not answering questions and it was kind of helping me and because the students complained he seems to be doing something different that I don't get. (Au1)

Nicole: This is pretty much what I expected except for the exception of him not telling us an answer. That's the biggest complaint I hear from all the students. That's what I told him the other day. He won't give you definite answers. He was telling me that the idea is not to go to him and say what is the answer. He wants us to be the authority and go that is the answer. Like to be more sure of ourselves. But if you're bad in math, I would think you're still not going to be that confident. Because no one ever reassured you at the end of whatever topic you were doing saying that is the answer. (Au1)

Quint: The course is taught backwards. You're given a problem and he won't give you the answer. He won't do it (laughs). It's real frustrating sometimes. Real frustrating. Sometimes the class won't have the answer, they just don't know.

Myself: You don't sound the least bit frustrated when you're telling me.

Quint: Yeah, I'm used to it now.

Myself: You seem to be more challenged by this.

Quint: Yeah.

Myself: And so therefore is it more interesting?

Quint: Yeah, because in math class you're just kind of taught how to do it. It doesn't really require much thinking. It's just the picking up of OK, I do this here but like we learn like there's way more than one way to solve a math problem. In any context, you can take many directions.

Myself: Do you think you will take that and apply it to your next math course?

Quint: Wow, scary question because I have wondered that myself. (Wi)
Feelings of frustration ran through the students because of the act of asking questions and not receiving an answer until much thought has passed. Several of the students became accustomed to this way of teaching. The other students expressed various degrees of frustration such as not enough direction or reassurance.

Some students are so uncomfortable with different procedures and ways of learning that they will not change. Nicole had such strong feelings about going to the board and presenting material that she would not even try it once. Whether she was teaching new material or simply explaining an answer that she understood, she was not going to do board work as she clearly states:

Nicole: He makes you go to the board in this class and we had a talk about it awhile ago. I will not do that. Will not. I cut his class three days in a row. He knew why I wasn't there in those classes. How is he going to take a class of 25 students and say 24 of you have to go to the board. He can't do that and I know he can't do that. So it's easier if I just don't show up.

Myself: Would you go to the board and explain something you completely understand in math?

Nicole: NO. When I go to the board something happens to me. It's like I love talking in front of people. Love it. I took public speaking courses and it was great. Because you get to talk about stuff I know about. You put me in front in math where people can question what I'm talking about and I lose it completely.

Myself: But you've seen the other students in the class look at him like they don't know the answer.

Nicole: Right, but I think they also have an idea and be able to think back. As soon as I get put on the spot like that I just lose it. I mean it's all out of my head. Do you think I'm going to put myself in that position? No way. (Au1)

It is easy to see Nicole has confidence in herself in other academic areas but will not do mathematics at the board. She views herself as the one in the class that does not understand while she assumes all the others are comprehending the material. When I asked if she felt anxious about mathematics she replied:
Nicole: Here in the classroom, I'm probably less anxious because I know he's not going to call on me. In high school I was scared to death because I knew I didn't know it no matter what.

Myself: You got a 96% on the midterm so you must know this material. Could you explain that test to me if you had to?

Nicole: Yes.

Myself: But you wouldn't go to the board and explain it to the other class members?

Nicole: No way. (Au1)

She was not planning on changing her mind about going to the board but she stated she would explain a test to me, a mathematics teacher. Her extreme fear of discussing or displaying mathematics publicly is seriously affecting her attendance and grade.

After discussing the students' mathematics history and comfort level in Math 050A, they were shown their scores from the first week of the quarter. Before doing this, they were asked to rate their level of anxiety at that time as low, medium, or high. Their scores on MARS 1 and 2 were then revealed and discussion focused on the change in the scores and what they felt may have caused some of those changes. This part of the interview was interesting for them because they wanted to hear the results from the MARS scores. Most, but not all of the students agreed with the direction of change and were not surprised by the results. These are excerpts from some of those conversations:

Myself: You went down 75 points from the first MARS to the second MARS. Do you think the course has reduced any anxiety you may have had?

Imie: I do believe it has. If I were to take the MARS at the beginning of 104 I would have a bit more anxiety. Once I get back into the groove of math, I think it will start leveling off. I think this course has helped me.

Myself: Do you feel more nervous about math than you do English or geography?

Imie: Yes, I don't know. Nervous isn't really the word I would use to describe it.

Myself: Uncomfortable?

Imie: Yes, I'm a cashier and I rely on the computer so much and once I have to go back and actually find a mistake that I may have put into the computer, and I see a customer looking over my shoulder and he wants to get out of there, then I start becoming anxious and I want to make
sure that I don't make any mistakes. I get nervous and I have to tell myself to slow down, you can do this. (Au1)

Linda: I'm definitely less anxious in this class.
Myself: Even though you're responsible for a lot more. You have to go to the board and present things, you have group work. Does that bother you?
Linda: No, because I know everyone in that class is kind of in the same boat as I am. They all have a lot of problems with math.
Myself: Your MARS score went down 61 points. Do you think this class has helped reduce your anxiety in math?
Linda: Definitely. I learned more in this class than I think I learned all through high school.
Myself: Did you feel anxious when it was coming time for the exam?
Linda: Always, because I knew it was a math exam and I'm so terrible at math.
Myself: How about when you were taking it?
Linda: No, that wasn't bad because I actually understand this stuff. (Au1)

Myself: Do you think you would feel more or less anxious in this 050A compared to the regular 050?
Ursula: It's lower. It's lower.
Myself: Would you rate your anxiety as low, medium, or high?
Ursula: I'd say medium.
Myself: You fell in the low range.
Ursula: Oh, did I?
Myself: Your anxiety went down 22 points. Do you think that was due to this course?
Ursula: Yeah, it kind of helped me learn how to work out problems. We did a lot of word problems in this course. More that I've ever done in any other class before. Because mostly it's just regular problems. That helped me out a lot because I hated word problems.
Myself: You're planning on taking regular 075 next quarter. Do you think 050A will help you to do any better in 075?
Ursula: Yeah, because it helps you learn how to get stuff organized in your head. (Au1) I think my anxiety decreased because you were able to explain what to do. I was glad we had to do that because I was forced to understand but I hated it while I was doing it. (Au2)

Myself: Do you feel more or less anxious in this class compared to other math classes?
Francie: Less anxious because I've actually sat down and tried to think it through without having to worry about memorizing things. I can try to teach myself rather than try and listen to someone, then take notes instead of learning and understanding. In regular math classes, they give you 50 questions, you just take notes and the examples they give you, and you use those. In the past teachers have tried to explain it to people who understood math. Like they would understand it.
Myself: Do you think that your anxiety has changed throughout the quarter?
Francie:  Yes.
Myself:  You had the second highest score on MARS 1. You really changed, you had the biggest change of anyone. You seem to be consistent in what you're saying with what your score showed.

Francie:  I think this class really helped because yesterday when I was at work, our machine was down and we have to take care of the customers ordering carry out food and she gave me $20 and I had to give her change. Before I would have freaked out. I would have given the money to somebody else. Just to make sure I would do it right I'd have to write it down on a piece of paper. But I did it in my head and I got it right. I now figure out how much change they should get back and check it with the register.

Myself:  And it's because of this class?
Francie:  Yeah, it's because I'm actually enjoying it. You know how when you get those high school notebook things that you write your schedule in and they have those little mind busters and math questions? I actually sat down with one of them from last year and I worked it. I did them, I couldn't believe it, it's crazy. I don't even usually look at them. (Au1) I believe my anxiety decreased this quarter due to having to think for yourself instead of memorization. The atmosphere in this class was very comfortable. (Au2)

The next two students both had an increase in their MARS scores, however they both stated that they believed their anxiety decreased. Quint attributes his decrease to figuring things out for himself and Janet believed this course helped develop her confidence which helped to decrease her anxiety.

Myself:  How do you rate your anxiety in math, low medium, or high?
Quint:  Medium.
Myself:  That is exactly where your MARS score fell. Your anxiety went up 19 points. Do you feel your anxiety has changed throughout this quarter?
Quint:  I didn't start out to anxious in math once I learned I was taking this class. I hate the daily math so this is much better (class 3 days a week). I had a meeting with my teacher and I didn't even realize that I only missed one class.

Myself:  Typically you would have missed more?
Quint:  Yeah, on a daily class I would have missed more.
Myself:  Do you mind coming to class? Do you enjoy it?
Quint:  Once I'm up. Once I'm awake it's OK.

Myself:  Were you nervous about taking the test in this course?
Quint:  No, I got a B on the test and I was shocked. I could study for a math test all day and when the test comes there's always going to be a question that I don't remember studying. (Au1) I believe my anxiety has decreased throughout this quarter because of the pace of the class and we were made to figure things out for ourselves. (Au2)
Myself: Do you think you feel more or less anxious in this course versus a regular 050 or your high school courses?
Janet: I think I feel less anxious. In a regular 050 course I picture this teacher real far away and pointing at a formula with a stick (laughs).
Myself: Do you believe you tested low, medium, or high with regards to math anxiety?
Janet: Probably the low to medium range of the spectrum.
Myself: That is where you tested. Your score went up 28 points, do you believe your anxiety has gone up?
Janet: No, I think it has pretty much stayed the same. (Au1) I think my anxiety has decreased this quarter because we had more freedom to think for ourselves and discovering how to do the problems gave me confidence which helped decrease anxiety. (Au2)

Paul only took the first MARS so a change in his score could not be measured.

Paul: I'd rate myself medium to high.
Myself: You had the lowest score on the first MARS.
Paul: Really. It depends on what you're talking about in math. In this class pretty low, but in other math classes... (Au1)

These comments overwhelmingly favor this course in terms of anxiety being reduced. Several of the students believed their anxiety decreased because they had to do and were able to figure things out for themselves. The comments expressed by these students show the interest in learning to understand mathematics. One of the instructors commented that the material that the students were familiar with, such as the algorithms, brought on the least amount of anxiety. Because this course was designed differently and the students were not familiar with this instructional method, it seemed to bring on a certain measure of anxiety. By the seventh week of the quarter, these students welcomed a change from the traditional style of teaching, even though it was unfamiliar. The instructors felt the factors that contributed to the change in the students' math anxiety was communication. The one instructor commented that with all the written and verbal communications, she knew what the students were anxious about. The other instructor also emphasized how the course was very conversational.
He believed anxiety was reduced because the students own thinking was validated. They became less anxious about the right way to do problems because now there were several ways to do things. He also felt the slower pace allowed for deeper understanding.

When the interviews conducted during the seventh week of Autumn Quarter were completed, the students were asked if there were any comments they wanted to add. Most of the student had no additional comments but a couple of them made some profound statements, such as:

Debra: I really like the class. I've learned a lot more this quarter than I've ever learned before.(Au1) I feel good about doing math.(Au2)

Francie: I just think it's a real good course. I think it's helped a lot. I think it's helped a lot of people, if they enjoy it, if they actually get something out of it. This is the first math class where I haven't fallen asleep. I think I like this course because I'm one of those language people, not scientific. I get a chance to explore exactly why I'm doing what I'm doing. I understand it so I can look through it and say why it is this way instead of memorizing it.(Au1)

Janet: I don't know the intention of the person who created the course, what inspired them. I think it is really valuable that people are trying to do different things, try different methods. I don't know how successful it can actually be for a lot of people because they are so used to being told how to do stuff, sad as it is. I would love for everyone to learn the way I like to learn and to learn independently but people don't want to think for themselves. They just want to know what to do and get the answers and I think that would account for why a lot of people get frustrated in this class. I think the course is a good idea and I think it's valuable but I think it's a real slow process. That it's actually going to be able to impact the way that education works and the way people learn.(Au1)
Transition from Math 050A and/or Math 075A to other Math courses

As described in Chapter 1, when a student successfully completes Math 050A, they can continue on with the Math 075A sequence or they can opt for the regular Math 075 or Math 104 that is also taught with traditional teaching methods. It is recommended to take Math 075/075A after completing Math 050/050A unless you received an A or B in Math 050/050A, then Math 104 is a possibility. Some students are more comfortable taking Math 075 than Math 104 because it is at a slightly lower level. Five of the nine interview participants enrolled in Math 075A, one in the regular Math 075, two in Math 104, and the other student left the university. One of the Math 075A students dropped the course after being in the hospital and one of the students who enrolled in Math 104 switch to Math 075A a couple of weeks into the quarter. Table 15 summarizes their course enrollments for Winter Quarter, 1997.

<table>
<thead>
<tr>
<th>CODE NAME</th>
<th>COURSE ENROLLMENT WINTER QUARTER, 1997</th>
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<tbody>
<tr>
<td>Debra</td>
<td>Math 075A</td>
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<td>Francie</td>
<td>Math 075A</td>
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<tr>
<td>Imrie</td>
<td>Math 104</td>
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<tr>
<td>Janet</td>
<td>Math 075A/In hospital/Dropped course</td>
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<tr>
<td>Linda</td>
<td>Math 075A</td>
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<tr>
<td>Nicole</td>
<td>Left the University</td>
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<tr>
<td>Paul</td>
<td>Math 104/Switched to Math 075A 2 weeks into the qtr.</td>
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<tr>
<td>Ursula</td>
<td>Math 075</td>
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Table 15: Course enrollment Winter Quarter, 1997 for the nine interview participants
Discussion was geared to some of the reasons these students selected their Math course for Winter Quarter. The reasons were as shown:

Myself: Why are you taking Math 104?
Paul: Anymore I'm not really sure. I was going to take up to Math 150 (Trig) and I thought it might better prepare me. (Au1)

Myself: Why did you decide to take Math 104?
Imie: I think if I go into Math 075 it's just going to slow me down in my ultimate results in the future. The reason I took Math 050A was to just kind of slow in. But once I realized what this course was about.... although I did like some aspects of it, I want a much faster pace. The major that I'm taking requires a great deal of science and all that. I need to get some of the math out of the way so I can start on my sciences and not actually go into my sixth year here.
Myself: So basically it's not the way the class is being taught that's causing you to not take Math 075A, it's more the pace? You want to move faster?
Imie: Yes. (Au1)

Typically students select Math 104 instead of Math 075 in hopes of advancing more quickly. If their major requires more mathematics courses, they would like to complete the prerequisites and move on to their major courses.

Myself: Are you going to take Math 075A next quarter?
Ursula: No, I'm taking regular 075. I wish it would be a smaller class like it is now. I'm not taking 075A because I figure when I get into the other math classes it's not going to go as slow. To me, we are learning a lot and I'm really impatient. If I can't get a problem, I'm not going to sit there for 2 hours to try to figure it out. It's going to go at a faster pace and I can't be so used to the slow paced thing that I won't be able to catch up. I've talked with other people I know who take the regular 075 and they say it goes fine and the teacher does go by lesson plans.
Myself: If the pace was faster...
Ursula: It's not so much the pace, I guess it's the understanding. I understand all this material and I wish if he knew everybody understood it, he kind of sticks with the same thing, he should move on to something else. There is a point where you move on. (Au1)

Myself: Are you taking Math 075A?
Nicole: Yes.
Myself: Are you sure you're comfortable with taking 075A if you have to go to the board?
Nicole: If I went to a regular math class that would even be more of a mistake. I might be dropping out after this quarter and not going back to school. I'm only going because it seemed like the thing to do. Everybody else was doing it. (Au1)

Nicole did leave the University after Autumn Quarter and therefore did not participate in the rest of the interviews.

Pace was mentioned by several of the students, some liking the pace and some believing the course was moving too slow. This was an important concept to consider when these students moved on to the traditional style of teaching. If the pace was too slow, would they be ready for their next math course? This topic is revisited in the next section titled Realization of other Math courses.

There is no major offered at The Ohio State University where Math 075 (or Math 075A) can be the last math course. Some majors allow a philosophy course to be substituted for Math 104, but each student in this interview sample was planning on taking a math course outside of the A sequence. The following discussion pertains to the students being anxious or not anxious regarding the transition from the course taught using conceptual teaching methods (Math 050A and Math 075A) to one using traditional teaching methods (Math 075, Math 104, Math 116). Here are some of the comments regarding that subject:

Myself: After taking Math 075A next quarter, are you worried about going on to Math 104?
Francie: I don't know yet. It might be different at first but I'm going to have to work harder than I usually do. (Au1)

The next participant, Quint, is the one who took the regular Math 050 before enrolling in Math 050A. These are some excerpts from his interview discussing how the Math 050 course went:
Myself: How do you feel about this 050A compared to your regular 050?
Quint: My teacher in Math 050, he was very good. He knew his stuff and ... I was really with the class for about the first two weeks. I could understand what was going on but very soon the class moved along very, very fast and within about two weeks I was really lost and he kept going on. There were kids in the class who were able to just pick it up, they moved right along with him. I was just kind of, I got left behind.
Myself: Did you tell him that?
Quint: Yeah, I did. I explained I was having a lot of trouble in his class. I didn't even pass one midterm, not even in the neighborhood.(Au1)

Next Quint discusses his feelings involving his transition out of Math 075A:

Myself: When you leave Math 075A, are you nervous about taking Math 116?
Quint: Absolutely.
Myself: For what reasons?
Quint: New level, new level of math.
Myself: Math 075A is a new level.
Quint: Yeah, it is, but it will be taught more like this class.
Myself: Are you nervous about the 116 course because you know it will be taught like the 050 was, or, I guess what I'm trying to get at is are you afraid that you will be at a disadvantage because of the pace and the material you've covered or do you think that this way of teaching is teaching you something different therefore you might be at an advantage?
Quint: I understand what you're saying but I don't know.
Myself: She gave you a copy of the regular 050 exam. Did you look at it?
Quint: Yeah, I've got it.
Myself: Do you think you would have passed it right now?
Quint: Tough to say. The first midterm, yeah, I think I would have passed it.(Au1)

These next excerpts were taken from the transcripts of Autumn Quarter, 1996 when all of the nine interview participants were taking Math 050A. I asked them about their feelings in making the transition to the classes they were going to be enrolled in Winter Quarter, 1997. (Refer to Table 15).

Myself: Are you worried about going from the 075A to the 104?
Debra: Yeah.
Myself: Why?
Debra: Because my roommate is very smart in math. She loves math and she's struggling in 104. Sometimes she will understand it and sometimes she won't. I try to look at her stuff and there is just no way.

113
M: Do you think this course will prepare you adequately to get there?
D: I don't know. I do not know. I'm going to be scared to go into 104 just because I'm not going to be used to going into the lectures and recitations. I'm used to sitting down one on one. I've had a tutor ever since I was in high school. I would understand it when she would sit there and do it with me but when she would leave and I had to do the rest of my homework by myself, I couldn't do it.
M: And she didn't make you do it on your own. She told you how to do it?
D: Somewhat. She'd walk me through the steps. If she was sitting right there I could do it but as soon as she would leave I didn't know how to do it anymore.
M: It sounds like you weren't understanding why you were doing the steps and procedures.
D: Right. (Au1)

M: Are you worried about going on to 104?
P: Kind of, kind of not.
M: What's the part that makes you worried?
P: I know it's probably going to be taught like he's teaching now, or probably worse. Like they're just going to fly through stuff and expect you to know it. That's the part I'm worried about most. And then I won't be able to catch up. (Au1)

Debra is concerned with the lecture/recitation format in the next course. She has relied on tutoring for step-by-step procedures in the past and she fears the format in Math 104 is not conducive to her learning style. Paul is more concerned with the pace and the fear of falling behind given the expectation of quick comprehension.

The following set of excerpts were taken from the Winter Quarter transcripts discussing how the transitions actually went. Some of the students in Math 075A are still discussing their fears of the next Math course and others are realizing the transition process went smoother than they had anticipated. The following comments are from students currently taking Math 075A:

M: How are things going this quarter?
F: I don't want to go to 104. I really wish they would make a 104A. Like maybe for the people who are having trouble so they don't have to go all the way back to 075. You could go to 104A instead.
M: But are you saying 104A is a step down from 104?
Francie: No, it's not a step down. You'd be learning the same things, you'd just be learning them in a different way.

Myself: Are you worried about the content in 104A or is it the way it's set up?

Francie: I know all the stuff in 104, I'm just worried that if I don't understand everything I won't be able to sit down and personally talk with my teacher. (Wi)

Linda: I think this class is great but I'm worried about next quarter because she's letting us resubmit homework and we don't have deadlines. I'm just worried next quarter, I know it's not going to be that easy.

Myself: But do you think that makes it easy? You're still doing the work.

Linda: It doesn't make it easy I guess it just makes me, um... I don't know what the word is. If just makes me... I don't know.

Myself: It sounds like maybe you're leery of the deadlines. So if they won't let you resubmit next quarter is that going to affect your grade or your understanding?

Linda: Both because when I do resubmit I do understand more. So I'm learning when I'm resubmitting. In 104 you have a huge class and I know they are speaking really fast and I'm just going to be worried I'm going to get behind and once you get behind in math you just can't catch up. One thing builds off of another. (Wi)

Myself: How are things going this quarter?

Debra: I don't know (very frustrated look on her face). Not very good. Well, they're going OK. I thought taking this would prepare me for 104 and I just don't feel like that.

Myself: You're worried about the content that you're getting as opposed to the way the class is taught?

Debra: Yeah, I'd like it if there was a 104A.

Myself: Why?

Debra: Because I'm nervous about all these people in 104. I just feel like I'm not going to get the attention that I need.

Myself: Are you comfortable asking questions in a class of 30?

Debra: It just kind of depends on the class. I failed out of every math class in high school and I have no idea what's going on. I need to have somebody explain things step by step or I won't get it. I always go to the extended instruction (similar to a tutor room) and when I leave there, I always know how to do things but my grade never shows that. (Wi)

Quint accidentally enrolled in the Math 075A course with the other instructor so it was interesting to see if he felt a different instructor changed the style of the course:

Quint: This class is a lot different. The best way to describe it is in 075A you're like a lawyer almost, and you've got to like work the problems backwards. It's not like he gives you the problem and shows you how
to do it. He gives you the problem and you know you have no idea how to do it.

Myself: You don't feel the other instructor did that?
Quint: No, it wasn't her style. After the first week I was wondering if we were getting anywhere and then by the first midterm I thought, Wow, I guess we did cover a lot.

Myself: So which style do you prefer?
Quint: Tough to say. This is definitely harder. Just different styles, like Letterman and Leno.(Wi)

The next student, Paul, was the one who started the quarter in Math 104 and then switched to Math 075A. These are his feelings regarding this transition:

Myself: Can you give me a general feeling what you thought 104 was going to be like and what it was like for you?
Paul: Well, I pretty much thought it was going to be what it was like for me. You know, pretty hard. Then as the weeks went by and the midterm came and went I started to get worried about my grade point average. Then I found out I didn't even need 104, I need 105 (Math for Elementary Education majors).

Myself: Did you move to 075A so you could get a good grade because it would be easy, or did you move there...
Paul: I understand what you're saying...basically I moved there because I thought it would be easier than 104. I knew his teaching style. I just based my decision on whether I wanted to pass math this quarter or fail it and take it next quarter. I have a scholarship that I'm concerned about keeping.

Myself: What didn't you like about 104?
Paul: I think they're just pretty much geared on memorization. Like if you memorize the steps on how to do something, for just that little bit of time, they're happy. In a class like this (Math 075A) or Math 105 you have to learn how to teach it.

Myself: Are you happy you made the switch at this point?
Paul: I don't know. Things aren't going real good but better than 104 so far.

Myself: How do you think they have the time in 075A to show you several different methods and make sure everybody understands and go at the pace you need?
Paul: Probably because once he shows us three different ways to do it you don't have to sit there and go over it anymore. You pretty much know it by the time you do three different methods.

Myself: If there was a 104A would you take that over 104?
Paul: Yeah, because that's more my speed. To do good on things I have to actually learn it. I can't memorize it.(Wi)
Overall, these students are nervous about their transition to the next course. Even though the 050A/075A courses made them feel more comfortable toward mathematics, they do not seem to be taking this confidence with them. These students express a satisfaction with the learning the material and therefore understanding it. They have the impression they will be memorizing steps and procedures in their next math course and the instructor will not take the time to explain the concepts.

Most of the students enjoyed seeing the various approaches presented to solve problem. It relaxed them knowing they were not searching for the one and only algorithm, that there could be several different types of methods to reach the solution. This section discussed the fear of the transition to other math courses, the next section focuses on those realizations one quarter later.

Realizations of other Math courses

During Winter Quarter, 1997 only two of the original nine interview participants were taking a course using the traditional teaching methods. Ursula was the only student to enroll in Math 075 with the traditional teaching style. She was happy and felt she made the right decision. Imie opted for Math 104 and seemed to be struggling. They discussed how the courses were going and their feelings regarding their decision below:

Myself: How do you like Math 075?
Ursula: Better than the 050A.
Myself: Why?
Ursula: Because the pace is right for me. Since the way that it's structured, I'm used to that. They go by the book, they go by chapters. I know exactly what we're doing, it helps me understand what I'm working on. In 050A it was kind of chaos. It was all chaotic but it was just...rather than working from dittos and stuff we work from the book.
Myself: Which do you think is easier?
Ursula: 075. In 050 we worked on a lot of word problems. One reason why I didn't want to do the homework is because it was so long and word problems are just really difficult for me. I tried to do what I could but...in 075 you do 1 through 31 odd. If you have any difficulties with any of them you just go back to an example and look at it.

Myself: Do you think it took longer to do the 050A homework even though you only had two or three problems to do?

Ursula: Yeah, it took a lot longer.

Myself: What is your opinion of changing all the 050 courses to 050A?

Ursula: I think 050A would probably be a good idea, just change a little bit in the way that it's taught. You could do a lot with it, with a special class like that. I don't regret taking it but it's not even like I'm glad I took it.(Wi)

Myself: How is 104 going this quarter?

Imie: The recitation is going great but my lecturer is a little bit difficult to follow. (She then told me her grades and she seemed to be averaging a 60-70% but she is hoping for a curve).

Myself: Do you think the 050A class helped you?

Imie: Oh yes. The emphasizing on writing everything down, even though how minuscule it was. That emphasizing, which I don't think happened in regular 050, helped me coming to this class. I finished the first two exams early and I decided to go back and look over my work to make sure, and I caught a couple of mistakes. I have a feeling I would just have been content to turn in my midterm in the past and go home. In the past I was frustrated with the midterm and just wanted to go home. I had a better grasp of the word problems because they were emphasized in 050A. I don't think I had the full security with them yet but I had a little bit more patience with them. Before I would just look at a midterm and pick out things that I thought were right and just scribble something down and go on. This time I was a little bit more patient to read it through carefully and think about it and then write everything I knew to be correct.

Myself: One of the purposes of Math 050A is to give you the confidence with what you're doing and the whole reasoning ability. To take that and apply it in the next math class and you seem to be doing that.

Imie: Yeah. Through high school I was kind of hopeless. I wanted something to change, that's why I chose 050A.

Myself: Do you think it has?

Imie: It's given me patience. I would just worry about a test and worry about it after I turned it in. Now when I take tests I don't zip through it anymore, I take my time, work through every problem and then when I turn it in I have the confidence, even though I might have missed something that I've done my best.

Myself: You've slowed down, you're thinking about problems, do you find yourself running out of time?

Imie: I still have time. I wrote a couple of notes down on the second midterm and I went on to problems I knew and then I came back and patiently worked through the problems and tried different things.
Myself: How do you feel about the content in 050A? Do you feel you've covered enough content?
Imie: Well, coming into 050A I was so desperate to try something different, to get that better grade. I wasn't as worried about taking a step beyond. I think for me personally, if the momentum in the class was picked up a tad bit more, I think I would be getting a better grade in 104. Looking back, I'm glad I took 104, even with these bad grades. I felt with the level of math that I'd gone through in high school, I thought I would feel frustrated because of being held back. (Wi)

Both of these students appeared happy with their decisions. Ursula was satisfied with the predictable structure in the traditional style course and Imie wanted to move on to a higher level of math.

Of the seven students available for interviews Winter Quarter, 1997, only five were taking a math course during Spring Quarter, 1997. The other two students declined to be interviewed Spring Quarter believing they had nothing more to contribute. Four of the other five students were enrolled in Math 104 and the fifth was enrolled in Math 116. All of these remaining interviews were conducted Spring Quarter, 1997.

Debra was currently taking Math 104 and was not confident with the way she was progressing in Math 075A during our last interview. She was very nervous with the transition to Math 104 and it was time to see how the course was actually going for her now. This interview was conducted during the last week of the quarter while she was taking Math 104. Here are some comments from the interview:

    Myself: How is Math 104 going for you?
    Debra: Well, I don't know. It's OK.
    Myself: Is it what you expected?
    Debra: Yeah, it's not as hard as I thought it would be at first. I did really good, like I got a B on the first midterm but I'm slowly but surely going downhill.
    Myself: How do you think the 050/075A sequence helped or hurt you in Math 104?
    Debra: I personally liked 050A and 075A a lot better than I like 104. Today I was sitting in class and I think I just realized that like 104 and above are
just about passing the test, you know, passing the midterm, passing the final. I think 050A/075A are more about learning how to pass the test, you know, learning the material. Whereas here it's like memorize this formula, put it down and you'll be done. You'll be fine. Whereas before like well you can memorize the formula, you know...

Myself: Do you think 050A/075A prepared you better? I know it's hard to say because you weren't in the regular 050/075, but do you feel it did a good job of preparing you for 104? Regardless of whether or not you like the way 104 is going, do you feel mathematically you walked in at the level you needed to be?

Debra: Um, I walked in at a higher level than I was before but I think because I never paid attention until 050A/075A, I'm not completely ready for 104. I walked in understanding more math than if I would have just taking 104 the first quarter.

Myself: Do you like the recitation/lecture format?

Debra: No, I don't like it. (Sp)

She talked through this part of the interview with a level of frustration in her voice.

After the focus became her 050A/075A experience she appeared more calm and comfortable. The conversation continues:

Myself: If you had to start all over, would you do the 050A/075A again.

Debra: Yes.

Myself: If they were going to offer 050A again next fall and came to you for your opinion, what would you recommend they change?

Debra: I don't know if I would change anything because I really liked that class. I don't know, maybe it was just because it made me feel like I could do math or whatever, like it was a confidence booster. I guess in some ways I could have been more prepared for 104 but I don't really know how.

Myself: That's what I was going to ask, how could they have?

Debra: I don't know. My roommate would help me with 050A and 075A and she would get so frustrated. She was like, "I hate this math, it's stupid. This isn't preparing you for anything." But I guess that just shows the two different kinds of people that learn math. I'm like I understand it this way, you understand memorizing formulas. I wish there was a 104A. Because the way I look at it, in those classes I wasn't learning like 6 + 7, but I was. I wasn't learning it straight. For me that's how I learn better. I need eight other things to go along, eight other ideas just to get one in my head. If you're the type of person that can just go in there and understand why you add 6 + 7, then that's fine.

Myself: So in your opinion some students just simply learn math differently. So maybe math is a subject that students seem to learn differently?

Debra: (shakes head yes).

Myself: Is there anything else that you can think of to say one way or the other to help future students?
Debra: I guess just if you've done bad in math, I don't know what to tell them besides like, learn how, figure out how you learn math best. Because like I guess what I can say is I don't hate math. I guess I can say all through high school I hated the way it's been taught to me. Because in Math 050A/075A math didn't bother me. (Sp)

Here is a student who felt terrible about herself in any math class and now she can say she does not hate math, just the way it has been taught to her. This math student was one of the weakest mathematically that I interviewed but she has made significant gains in her thinking.

The next interview was with Francie who elected to take Math 104 at night because of her work schedule but she was also trying to avoid the lecture/recitation format that is used for the day classes. She received a 100% on her first two exams and her third exam was the night of the interview. She was happy and calm during the entire interview:

Myself: Do you feel Math 050A/075A prepared you for 104?
Francie: Yeah.
Myself: Material wise you felt prepared?
Francie: Yeah, we had just gone over the same stuff in 075A.
Myself: Do you think that you would have done as well in 104 without having gone through the A sections?
Francie: No.
Myself: You really don't?
Francie: No because I would have been so paranoid. I would have stressed myself out. My math class is the only class I'm not stressed out about now.
Myself: Why? Why did you go into it feeling comfortable?
Francie: I didn't go in feeling comfortable because it's a new class. I didn't know how it was going to be. But once I got in there, even the first day, and I saw how he talked, I was comfortable because he reminded me of the 050A/075A instructor. (Her Math 104 instructor was a graduate teaching assistant working on his Ph.D. in Mathematics Education. He was aware of the advantages of teaching for conceptual understanding and from talking with Francie, it sounded as though he was incorporating these methods in his Math 104 classroom).
Myself: What if this person would have taught 050A exactly the way he is teaching 104, more the traditional style but he just stops and makes sure you're comfortable every step of the way. Would you prefer that or would you still prefer the way 050A/075A went?
Francie: The 050A/075A way. Because I would have gotten stressed with the way he's teaching had I not gotten comfortable before. I think if you're comfortable with math, if you know you know what you're talking about, if you don't get stressed out then regular 050 is fine. I used to get stressed out at the littlest thing with math. I would just sit there and not even do anything because I thought I was stupid.

Myself: So for the most part you came here anxious about math, you're not now, what changed that?

Francie: Probably the interest. Because when you're getting told what to do and not given a choice of really thinking about it, being a robot, automatic, is boring so you just sort of shut it off and don't concentrate.

Myself: So this stirred up interest?

Francie: Yeah, I paid attention, concentrated. I mean this is a night class and I haven't even once thought about falling asleep.

Myself: Do you like math? If someone were to ask you now?

Francie: Better than I used to. I wouldn't take it for my major.(Sp)

Ursula did not feel she had much to add because she made the transition to a traditional style learning last quarter in 075. She is currently in 104 and she said everything is going well. Her comments were limited but interesting:

Myself: Do you think if I were to ask you in two years what you remember more of, 050A, 075, or 104, which do you think would stick in your head?

Ursula: The only thing that would probably stick in my mind would be the activities in 050A. The only thing that I can really remember what he taught was the one activity with the pendulum. The 050A class doesn't even cross my mind anymore. I don't even think about that class. It wasn't really that big of a part of my education or anything.(Sp)

Linda was having an extremely busy quarter and we could not find a convenient time to get together even though she was willing to participate so a short interview was conducted via the telephone. Her Math 104 class was going well. She was glad she took the 050A/075A series and felt it was instrumental in her success in 104. Here are some of her comments on the 104 course:

Linda: I just think that some parts of math are just so ridiculous that you're never going to use them. I just don't understand what the point of half of it is. I think lots of it is just rules, you just do it, you don't ask why.

Myself: Do you feel like you've learned better studying techniques from 050A/075A?
Linda: Yeah, she always gives out those handouts with studying techniques and stuff. Basically I think I knew everything before. I think, I don't know. (Sp)

Quint was the only one of the interview participants to take Math 116. This course is required for a limited number of majors so it is more typical for a student to follow up Math 075 with Math 104. His situation was unique also because a student on his floor in his dorm taught a different class of 116 students so he was available for personal assistance. Following is our conversation on his transition from Math 075A to Math 116:

Myslef: How are things going in Math 116 this quarter?
Quint: OK. The first part of the quarter was a little bit of review of 075A. Then it went into matrix algebra. Wow, there are so many opportunities to screw up.

Myslef: Was your 116 friend much help?
Quint: Yeah, he was much help.

Myslef: Do you think you would have done well without him?
Quint: It's tough to say because I didn't do that well even with him. I tried to use him to the full advantage. Yeah, it's a tough course, I probably would have put in less time.

Myslef: Are you nervous at all about being in Math 116?
Quint: No, I mean I don't know. It was a little intimidating at first but it really started off like 075A at first. The course for the first week and a half was 075A stuff.

Myslef: What happened in the 050A/075A classes to help prepare you for 116? What changed between when you started out in regular 050 and didn't do too well until now? The rules and everything are the same in 050 and 116 as far as being successful in the class.

Quint: Here's the story. I know that I only have to finish 116. When I first came here I took 050 and failed it miserably. I kind of knew what it was going to be like but when it's really happening, I wasn't ready for it. So then I got in 050A and the best thing they did was teach me that there wasn't a 116A. That we can teach you the basic tools that you are going to need to go into these classes but you have to know these classes play hard ball. I think that's what it did for me the most. That's why I didn't stop going to 116 a month ago.

Myslef: Now that you know what 050 and 116 are like, if you had to do your college math classes over again, which 050 would you take?
Quint: The 050A, definitely.

Myslef: Do you think it would have been OK to go to 075 instead of 075A?
Quint: 075A is hard, it's harder than heck. In some aspects it's harder than 116. Math 116 is probability and it's really just application of formulas.
If you know the formulas like you know your own face, you can get by on the test.

Mysyelf: Do you still feel nervous in general about math at this point?
Quint: Yeah, I still feel nervous. I'm trying to do the course to the best of my mental ability. (Sp)

These comments show the students felt Math 050A/075A properly equipped them to deal with the next level of math. Even though there were several comments regarding the pace in Math 050A, only one of them mentioned this as a possible reason they were not doing well in the next math course. The other students interviewed felt Math 050A/075A adequately prepared them with the necessary mathematics and most importantly, showed them a different aspect of learning math.

**Individual Summaries**

Three students were selected with interesting yet diverse experiences in Math 050A and their following courses. Their data have been coordinated and a summary was constructed for each of the three; Quint, Ursula, and Francie.

**Quint:**

First, I have selected Quint because of his expressive and open personality. He was the only student in my sample to take Math 050 before enrolling in Math 050A. He did not pass the regular 050 course and was not looking forward to taking it again. He stated he was definitely more comfortable in Math 050A because it moves more at his pace. I asked him if he would like to take the regular 050 at his own pace or if he preferred a course such as Math 050A where you have to explain what you're doing. He said, "Well, if you want it to stick in your head, I would imagine Math 050A because it makes you learn it".
His score on the first MARS placed him in the middle of the class with a 293. His second MARS score increased by 19 points. However, he said he did not feel more anxious about math, that his anxiety was probably less now than at the beginning of the quarter.

Quint was enrolled in Class C for Math 050A and accidentally enrolled in Class D for Math 075A. He felt the two instructors had completely different teaching styles. He did not prefer one instructor over the other but he thought Math 075A with instructor D was definitely harder. Quint enjoyed being challenged in both of the classes and he believed the challenge is what kept the courses interesting. He states, "In a math class you're just kind of taught how to do it. It doesn't really require much thinking. It's just the picking up of OK, I do this here, but we learn there's more than one way to solve a math problem. In any context, you can take many directions".

Talking with Quint when he was enrolled in Math 075A and Math 104 lead me to believe he was comfortable in a math class now. I asked him what he felt changed from when he started in regular 050 and he did not do well until now, when he was passing in 116. The rules for success are the same in Math 050 and Math 116. He said, "The best thing they did was teach me there isn't a 116A. That we can teach you the basic tools that you are going to need to go into these classes, but you have to know these classes play hard ball. That's why I didn't stop going to 116 a month ago".

His anxiety seemed lower because he felt more comfortable in a mathematics environment. He does not seem to associate math with a negative atmosphere and I believe he used to. Quint seems to understand how to learn math now and consequently this has lowered his anxiety.
Ursula:

Next, Ursula was chosen because her reasons for course preferences seemed typical. She originally selected Math 050A with the suggestion of her advisor. Ursula wanted to try something different since she has had a hard time with math in the past.

Ursula enjoyed some aspects of Math 050A, such as the group work and other activities that were different from the standard lecture approach. However, she also referred to Math 050A as chaotic. Her reasoning follows, "Sometimes I wish things were more routine. I like an organized way of learning, like this is lesson 1 and we are learning about this. I wish we had a lesson and then group work inside of that lesson". From these types of comments, I was under the impression she wanted a familiar teaching style, but also wanted the class to have more variety and activities throughout. She felt secure with the lecture approach and the idea of something as different as Math 050A seemed unsettling to her. She mentioned several times how she liked things organized. Following are her reasons for why she selected this person as her favorite math teacher, "He was real organized. He took the quizzes from the homework, the test from the quizzes. You had something to refer to, you knew what you were learning". Even though she may have wanted to try a different type of teaching, I believe she missed the security of knowing how the course was going to be organized.

Her score on the first MARS was 213. This was the fifth lowest score so her anxiety was fairly low at the beginning of the quarter. Ursula believed it would have been higher though, if she was in the regular Math 050. She scored a 191 on the MARS 2 and was not surprised to hear her anxiety went down 22 points. Despite this, she elected not to take Math 075A because she thought Math 050A was moving too slow. She thought Math 075 would better prepare her for the next course. She also
commented on the fact that the instructors in Math 075 go by lesson plans and they use a book.

After completing Math 075, Ursula admitted she liked it better than Math 050A. She liked the pace and the way it was structured because she was used to that. She also mentioned not spending as much time on the homework in Math 075. Her Math 050A homework could take hours some nights and that frustrated her. For these reasons, Math 075 was easier her. She said that she did not regret taking Math 050A but she also expressed it was not a significant course for her. She was apathetic toward the Math 050A experience.

Spending time on areas that were difficult for Ursula, such as word problems helped to reduce her anxiety. Also, the fact that she was comfortable with the level of material presented in Math 050A helped reduce her anxiety. Because the class did not follow the typical format, and Ursula was forced to learn in a new manner, I believe her anxiety held fairly steady overall. I feel her decrease in anxiety in Math 050A was attributed to the fact that she was able to learn using a different format, even though it was not her first choice of teaching style. Ursula contributes her decrease in anxiety to being comfortable with the material. Even though Math has not always been an easy subject for Ursula, I believe her experience in Math 050A has helped her realize she can succeed in classes that do not incorporate her ideal learning strategies. Hopefully this will transfer to her other college classes and life experiences.

Francie:

The last student I chose to summarize was Francie. She seemed to have matured from her Math 050A/075A experience and I wanted to evaluate this from her perspective. Her first statement to me was, "I hated math, it was hard. I like it now".
Her memories of math include listening to a lecture, struggling through all the homework, and then flunking all her tests. When I asked how she felt about coming to class now she stated how she did not mind coming, that she actually liked it.

Francie had the second highest score on the MARS 1 with a 348. She had the largest change in anxiety by decreasing 141 points. She did not hesitate in agreeing with this finding. She attributes this to thinking through the material for herself without having to worry about memorizing things. When I asked her if she thought her teachers in the past tried to explain the material she replied, "They tried to explain it to people who understood math. Like they would understand it". Another example of this class reducing anxiety involved her job. She is a hostess at a restaurant and one night the register was not working. When a customer gave her their money, she calculated their change in her head. She mentioned that she would have "freaked out" before and now she figures out the change before the register does. Francie stated that Math 050A is actually making her enjoy math.

These feelings carried on into Math 075A and Math 104. She was carrying a high A average in Math 104 and she credits this to the Math 050A/075A courses. She enjoys her Math 104 class but believes she would have been stressed with the course if she would not have felt comfortable before. Her feelings are, "Math 050A was like a comforting thing, it was a new approach to teaching that I had never seen before. I don't know many teachers that will actually try to make you understand. They just say do it this way, this is how you do it, no other way."

Francie agrees her anxiety had decreased and contributes it to the development of an interest in math. She believes, "When you're being told what to do and not given a choice of really thinking about it, being a robot, automatic, it's boring so you just sort of shut it off and don't concentrate". Francie seems to really understand why she
prefers one method of learning over a different method. She also was able to benefit from the Math 050A/075A series by using her knowledge of strategies and procedures for future courses.

In the next chapter, information gathered from the interviews and classroom observations is combined with the results of the quantitative analyses to answer the research questions posed in Chapter 1.
CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Introduction

This research examined the changes in mathematics anxiety when college students in a remedial mathematics course were taught using conceptual understanding teaching methods. Two classes participated in the research; twenty-three students completed the Mathematics Anxiety Ratings Scales while nine students were selected for interviews concerning their feelings and opinions on the course and its affect on mathematics anxiety.

Three research questions were investigated in this study. Both the qualitative and quantitative results will be combined to answer these questions:

1. Is there a change in first-year college students' mathematics anxiety when taught using conceptual teaching methods?
2. What are the students' overall perceptions of what contributes to or detracts from their anxiety towards mathematics?
3. What factors do students feel contributed to their change in mathematics anxiety?

The purpose of this chapter is to discuss answers to these research questions. First, a summary of the results from the study are presented. These results provide support for
using both the theoretical framework and the findings as a basis for the next section, the answers to the research questions. This chapter concludes with discussion and implications, recommendations, and directions for future research.

**Summary of Results**

Results from the two Mathematics Anxiety Rating Scales indicated a decrease in mathematics anxiety for the Math 050A students participating in this study. The average change in scores showed a decrease in mathematics anxiety of 42.31 points. The largest change in scores was a decrease of 141 points (out of a possible 490 points) while the smallest change was an increase of 2 points. When the changes in MARS scores were ranked from largest to smallest, the seven largest changes signified decreases in mathematics anxiety. The t-test for nonindependent samples showed the difference between the paired scores of the MARS to be almost three times as great as the difference that would be expected under a true null hypothesis. This was a significant difference at the .05 level. This indicated lower levels of mathematics anxiety toward the end of the quarter than was found at the beginning of the quarter. This difference could be attributed to the conceptual understanding teaching style or students feeling more comfortable in the classroom as the course progressed.

Qualitative measures were required to expand on the reasons for the differences in scores.

Results from the interviews and classroom observations indicated the decrease in mathematics anxiety was due to the level of understanding that was expected in Math 050A/075A. When enough time was spent on the material to reach a level of understanding and comfort, some of the students felt they were actually learning math
for the first time. They had been able to successfully complete math courses in the past but their understanding of most of the concepts was missing, thereby leaving them frustrated with not knowing why many of the algorithms worked. By taking the time to discuss different teaching methods and several approaches to problems, the students began to feel comfortable thinking on their own and finding their own unique way to solve a problem. However, the students did not feel this level of comfort was reinforced when they were enrolled in classes taught using traditional methods. Student interviews revealed most of the students were happy that they took the Math 050A/075A sequence because of the exposure to different ways of learning math that were more satisfying from what they had seen in the past.

**Answers to Research Questions**

The three research questions that guided the study will be answered using the data gathered and analyzed throughout this study:

1. *Is there a change in first-year college students' mathematics anxiety when taught using conceptual teaching methods?*

Yes, a decrease in mathematics anxiety was shown as a result of the analysis of the MARS. Eight of the thirteen students that completed both MARS had a decrease in their scores. The average of the scores that decreased was 75.75 points (out of a possible 490) while the average of the scores that increased was 11.2 points. This lead to a net average of a decrease of 42.31 points. These results show that there was a change in their mathematics anxiety during this course. These results differ from a study conducted by Norwood (1994). She found mathematics anxiety scores were virtually unchanged when the conceptual understanding approach was used, and the
scores decreased when the traditional lecture approach was used. Interviews were not conducted in the Norwood (1994) study to explain any of the changes in mathematics anxiety.

The two students whom I interviewed that had an increase in their MARS scores believed their anxiety actually decreased from the result of this course. Even though the MARS is a valid and reliable instrument for measuring mathematics anxiety, it is more difficult to capture a numerical change for certain constructs of mathematics anxiety through quantitative measures. In this study, small changes in the MARS scores were not significant enough to warrant a change in anxiety and therefore not sufficient to interpret if the change was due solely to the nontraditional teaching methods that were used. The reasons for the changes in the students’ mathematics anxiety was not able to be detected by the MARS results alone, so this is when I turned to and relied on the qualitative data.

2. **What are students’ overall perceptions of what contributes to or detracts from their anxiety towards mathematics?**

Through student interviews, perceptions of what contributes to mathematics anxiety became more clear. When the interview participants began discussing their mathematical histories, varying degrees of anxiety emerged. Many of the students recalled stories from elementary school where they were the only one left standing at the board, or they felt as if they let down their group because they could not figure out the problem. They did not hesitate to place the blame on themselves and to reveal a lack of confidence in their mathematical ability. Most of them in this situation mentioned how nervous and anxious they felt when they were put on the spot in the classroom and commented on how confused they were most of the time. Very few students at the
remedial level in college can recall feeling comfortable when doing board work or presentations of any kind during a math class.

In a similar light, many of the students remarked on feeling a sense of worthlessness when it appeared their teachers did not want to take the time to help them figure out their misunderstandings. When the teachers would use lecturing as their sole instructional method, or just write on the board and expect the students to be able to figure it out, they would interpret this as the teachers not trying to help them understand. Several of the students believed the teachers who did not care if you understood the material made them feel more anxious toward mathematics. Their goal was to get through the book and they would explain mathematics to the people who understand it. In other words, they explained the material the way they would have understood it themselves. Through these processes the students lost their sense of value in mathematics and their sense of valuing themselves being able to do mathematics, possibly leading to their feelings of anxiety in future courses.

Another factor that contributed to the students' anxiety in math surfaced when several of them expressed fear in forgetting how to solve a problem, forgetting the algorithm that was needed to solve the problem. One student mentioned trying to come up with different methods but her teachers always wanted to see her step-by-step procedures. Anxiety was developing because of her fear of not being able to remember that one procedure that was required for a given situation. These results were consistent with those reported in other studies; the "explain-practice-memorize" teaching paradigm separates facts from reason and is the real cause of mathematics anxiety since memorization is promoted instead of understanding and reasoning (Arriola, 1994; Greenwood, 1984; Lazarus, 1974; Stage & Kloosterman, 1991; Williams, 1988). As was also stated in the theoretical framework for this study, "But if
at any stage he makes a mistake, he will be lost; and he will stay lost if he is not able to 
retrace his steps and get back on the right path" (Skemp, 1976, p. 25). The student 
interviews show these students wanted to know more than how to reach their 
destination, they wanted to learn and understand all the different ways to get to their 
destination. As Skemp (1976) believed, a person with a mental image of the town is 
able to produce a number of plans from which he can guide his steps. "And if he does 
take a wrong turn, he will still know where he is, and thereby be able to correct his 
mistake without getting lost" (Skemp, 1976, p. 25).

Students' perceptions of what detracts from mathematics anxiety was harder to 
uncover. However, some of the detractions focused on past teachers and favorite 
mathematical activities. A teacher who went at a reasonable pace and tried to help you 
understand the content was an asset; someone who was able to take the time to really 
make sure you understood, not a teacher who was satisfied when you could redo the 
same type of problem they had just completed. Comments focused on the positive 
aspects of the teachers who would take the extra step to explain the material clearly 
 enough to be certain everybody knew and understood the concepts. As reported by the 
student interviews, this task was easier to accomplish when more than one method was 
demonstrated to solve a problem. If some students were still confused after a concept 
was explained, the teacher would stress understanding by trying to explain another 
technique to reach more of the students. This effort did not go unnoticed by the 
students.

Activities that were enjoyable for the majority of students seemed to incorporate 
non-standard tasks in the traditional classroom. Through observations and interviews, 
the favorite activities appeared to be the ones where the students were involved. When 
they left their seats and performed an activity, such as a pendulum swinging from
various heights with different weights attached or other measuring activities, the
students became involved in the learning experience and were no longer a spectator.
These types of activities did not seem like typical mathematical experiences and the
students preferred learning using several different instructional methods. Since Math
050A was a remedial class, most of the students assumed the same type of material
would be presented in the standard format. Any variation from that format seemed to
attract their attention; typically this would seem to contribute to their anxiety but in this
course it seemed to detract from it.

Classroom observations revealed the students in the Math 050A courses did not
appear nervous when doing presentations, group activities, or other situations that
demanded one person supply the answer, the infamous "put on the spot" situation.
When this was brought to their attention, they simply smiled and agreed they were not
nervous in Math 050A, not quite being able to single out the reason for this change.

3. What factors do students feel contributed to their change in mathematics
anxiety?

Respect toward the students seemed to be an important underlying concept that
reduced anxiety for these students. A few specifically mentioned this, but the idea was
lingering throughout many of our conversations. By requiring the students to think for
themselves, I believe they felt a sense of responsibility for their learning and started to
develop a belief in their ability to do mathematics. Comments were made indicating the
quarter started out with the instructors having confidence in the students; expecting and
demanding that they be able to figure out mathematical situations for themselves. These
data show that validation of one's ability to do mathematics may lead to more comfort
and less anxiety. One student specifically said her anxiety decreased by having to think
for herself instead of depending on memorization. Another said she felt good about

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doing math. The students also emphasized how the instructors took the time to ensure the material was understood by helping them make connections to their existing knowledge. This was consistent with the beliefs of Peterson, Fennema and Carpenter (1989), who express the importance of instruction facilitating connections. This may be where the problem of pace came in for some of the students. When you take the time to instruct the material to this degree, some of the students are going to feel those extra steps are not necessary, thereby slowing the class down. However, all of the students who made the comments regarding pace were hesitant in stating that the class was moving too slow; they seemed to be unsure if pace was the problem or maybe the level of the math. Each student needs to move at their own rate and it seems they recognized that sometimes the pace was too slow for them and that at other times they were the attentive audience when concepts were being expanded upon for a third time.

Some of the students attributed their decrease in anxiety to being able to learn and understand several ways to solve one problem. They were able to see connections between different mathematical representations and finally understand the underlying principles because they attacked the problem from various angles as suggested by NCTM (1989) and Skemp (1971). The students appreciated that they did not have to follow a set way to do a problem. They could create their own methods and there were choices available when solving problems. They felt it was effective to do it their own way sometimes. Some of the other students liked the group work because they talked about different opinions and saw better ways that might be quicker or easier to understand. Other comments focused on the lack of the sense of panic on exams because they knew there was a choice of methods that could result in the correct answer.
Not only are the various choices to solve a problem helpful, but so are the various methods of presentation by the instructor. Traditional lecture format can work fine for many of the students, but a variety of instructional methods prevents boredom and reaches a more diverse group of students. As the results from this study show, students prefer different ways of learning for personal reasons. One student remarked how she was a visual learner while another student described herself as a hands-on learner. They both stressed how comforting it was to see the different instructional methods incorporated. This shows the importance and necessity of various instructional strategies to reach all types of students. If educators use a variety of instructional strategies, they will be better able to match more students with their preference for learning mathematics. They can then develop the confidence and ability to adapt to other ways of learning.

Having the students express and explain their ideas by written communication was another learning strategy. Research has shown communication in the form of discussion and writing enhances student thinking (Mumme & Shepherd, 1990). Articulating mathematical thought was a difficult experience for most of the students but was important for understanding to occur. Ursula was honest in saying, "I think my anxiety decreased because you were able to explain what to do. I was glad we had to do that because I was forced to understand, but I hated it while I was doing it." The many forms of communication that were used in this course seemed to lower mathematics anxiety because it gave the students a chance to voice their own thinking. Even when the writing assignments were difficult and frustrating, it did not appear to have increased their anxiety because the students were able to express their concerns and confusion while they were explaining their reasoning.
Typically students do not like change in their classroom situations. Change in any life style brings on bouts of anxiety; such as a new job, moving to a new home or a new baby. But when the students were asked about why they enrolled in Math 050A, most of them were eager to try something new. Instead of staying with what was familiar, and not being successful, they were drawn to a difference that could hopefully lead to more understanding. Undoubtedly some students were also hoping for an easier path to complete their mathematics requirement, but I did not get the impression they found it. The questioning techniques were a source of frustration for a large number of the students with whom I spoke. They were not used to working so hard for an answer from the instructor and it took some of them the entire quarter to become accustomed to this, many of them never did care for this style of teaching. Most of the students were quick to admit that they were ready to learn math a different way and were happy they enrolled in Math 050A as was summarized in the following comment from Debra, "I don't hate math. I hated the way it's been taught to me in the past."

An issue that did not appear to be a factor that contributed to the students' anxiety dealt with the type of instructor needed for the conceptual understanding course to run smoothly. I wanted to know if the students thought a particular type of person was needed to teach these courses, or if they thought anyone who believed in the conceptual understanding method could do a good job. I felt some of the students seemed to develop a sense of comfort with their instructor and I wanted to see how they viewed some of their past teachers running a classroom using this style. Some of the students thought the teacher would play a major part in the success of this course while many of the others stressed the importance of the instructional style, not the teacher who was delivering the material.
Discussion and Implications

What implications do the findings described above have for mathematics teaching and learning? Although the quantitative data was limited, it is clear that mathematics anxiety was reduced for this population, as shown in the other forms of data collected. After conducting the interviews, it was also clear that the instructional methodology played a key role in that reduction. A few of the students mentioned how they enjoyed being able to think for themselves instead of being told how to do the problems. This was encouraged by the use of questioning techniques in the classroom. The students became frustrated with this approach at first because they did not understand the purpose behind this method. Once they became used to the ideas of finding their own methods to solve problems, asking one another questions to seek out a solution, and asking the instructor questions without receiving immediate answers, many noticed that learning was taking place. I believe most mathematical learning does not take place in the classroom when students are taught using traditional methods. When students listen and take notes, they are simply following along and trying to keep up. In that type of environment, the majority of learning takes place outside of the classroom when they are doing their homework. However, when teaching with the goal of conceptual understanding, questioning while teaching is a common and necessary task to make students question why they are doing certain procedures, why these procedures work, and similar types of questions. It can become very frustrating to be asked to think for yourself in the classroom when you have become accustomed to waiting to try to understand the homework on your own time.

Patience was another word I heard when I asked the students what they had gained from Math 050A. They learned to take their time and think about several
available solution routes, and to take their time with homework and exams. One student, Imie, discussed how she is more relaxed during exams and she takes the time to look through it a second time. Janet commented on how upset she would become when she could not figure out homework problems quickly. She was accustomed to being able to look at an example problem in the textbook and follow the same procedure. She stated, "I'm used to doing everything really quick and picking things up really quick. And if I don't get it, it's like, I don't even care." This excerpt shows the reason patience is important in a mathematics class. This is the type of feeling students should change before they can feel comfortable and capable while learning mathematics. Janet’s comment summed up many students' opinions on how a mathematics class should be conducted when she mentioned "picking things up really quick." Students learn mathematics when they discover and uncover theories and spend time learning the skills, not when others simply tell them how to do it. It is necessary for math students to read and understand some material on their own. This is a foreign idea to those students who have always been told how to do the problems. A new level of mathematical maturity is attained when you can read and decipher new material for yourself. Her comments are important when designing a mathematics course so students can learn and understand the material, and see why the old methods seemed easier but not better for long term learning.

Students in this study seemed to have learned strategies that helped them to learn mathematics. They have given thought to studying and learning mathematics, and in doing so realized what works best for them to ease their anxiety. When the students enrolled in the subsequent courses that used the traditional lecture approach, this knowledge was sufficient for helping students cope in environments that are not oriented to conceptual understanding. Most students in these courses appeared to have
less anxiety from having taken Math 050A and/or Math 075A first. Those who were interviewed mentioned certain aspects of the Math 050A course that helped maintain lower levels of anxiety in their future courses; such as studying techniques, an appreciation for a new approach to learning mathematics, and a realization that success in future courses relies on some memorization. This implies that lower mathematics anxiety can continue into future courses when the anxiety was lowered by techniques that helped the students understand.

A number of the students mentioned worries about entering the traditional style courses, yet when they made this transition they realized important ideas were imbedded in the conceptual learning philosophy of the Math 050A course. One of the students mentioned the focus on memorization in their subsequent math courses. He did not feel he was learning the material and mentioned that to do good on things he had to actually learn them and memorization did not help him understand the content. Another student, Debra, realized that Math 104 and above are just about memorizing formulas and passing the test. She felt Math 050A was more about learning the material and how to pass the test. I was wondering if this was reality or the students' interpretation but then I realized that it did not really matter. Regardless of how it actually happened, these were the feelings left lingering with these students. Overall, the qualitative data collected after the students completed the course that was geared toward conceptual learning indicated the students were prepared for their next mathematics course. This was a difficult construct to measure because of the assessment measures used in the traditional style courses. Retention of material at this level is often a problem with success in more advanced mathematics courses. Once the advantages to this method of learning are realized, I believe the students will agree that mathematics is easier to retain when taught by way of understanding.
Gay and Thomas (1993) believe students can be very successful with the traditional approach to learning and perform well on typical assessment measures, thereby allowing the teachers to believe their students are understanding mathematics. These students are typically being assessed on superficial rote learning techniques with specific steps and procedures memorized. Quint expresses these beliefs when he states, “In some aspects Math 075A is harder than 116. Math 116 is probability and it’s really just application of formulas. If you know the formulas like you know your own face, you can get by on the test.” This shows achievement scores in a mathematics course are not an appropriate measure of the student’s level of understanding. If conceptual understanding is the goal of the course, then assessment measures should be designed in alignment with the course.

**Recommendations**

This research suggests that learning when using conceptual understanding teaching methods reduces mathematics anxiety in college remedial mathematics students. The theoretical framework for this study is supported by the idea that learning mathematics for understanding helps alleviate anxiety. If students do not have the necessary understanding needed to solve a problem, when they forget what they are doing, they usually freeze and can go no further on the problem. Without the conceptual understanding to fall back on, these students are lost and can no longer reach their destination. Skemp's (1976) analogy does a good job of describing how some of these frustrated students feel. The recommendations in this section are presented as possible ways to alleviate the frustration of mathematics anxiety and help develop confidence in the students' ability to learn and understand mathematics.
Many educators believe it is boring to teach a remedial type class because of all the drill and routine problems that must be involved to master the material. They do not find this level to be interesting or challenging to teach because they typically do not try to challenge the students. The results from this study show the students would prefer not to learn using rote calculations; they also find this boring. When fraction and decimal operations were being reviewed on a regular basis, the routine boredom typically associated with these operations was not present. This is a useful alternative to consider when implementing a review of the basic concepts in the curriculum for remedial classes. By doing so more time is allotted for higher level mathematics.

"Teachers of remedial college courses need to help students learn rules, but they also need to make sure learning is the result of conceptual development" (Stage & Kloosterman, 1991, p. 34). Educators of remedial classes need to realize that students appreciate challenging material with an emphasis on the underlying concepts, and the rote calculations hidden within these.

A second recommendation focuses on the amount of material presented in a mathematics course. Instead of trying to cover every concept in the book, it is my opinion educators focus on the most important concepts needed for this level and teach those well. If educators would take the time to develop depth in the students' knowledge base, help students make connections with other concepts, and show various representations, students may actually retain and understand what they have learned better than when they cover many topics lightly. Teachers can then weave in additional new topics and are able to review basic facts within the context of the major course requirements.

Textbooks that incorporate conceptual understanding teaching methods are few. Math 050A was taught without a textbook and students were given handouts to insert in
a binder, or notebook, that was divided into several sections by the instructors. Throughout the quarter the notebook was compiled of class activities, writing assignments, homework, and class notes. New mathematics textbooks must be written so this material can be supported and reinforced by the problems and topics in the textbook. Until this happens, teachers need to be willing to supplement or eliminate their textbooks when they feel they do not meet the needs of the students.

Special attention should be directed toward helping instructors and teaching assistants with materials and the implementation of the conceptual understanding philosophy. Instructors need time to learn and understand the importance of adjusting the entire course; the presentation of activities, learning within groups, and assessment methods. Changing assessment is such an important step because students will not value the change in presentation of topics if they are not required to respond and think in the same fashion during assessment procedures. Studies similar to this one have previously been conducted, but the entire course was not structured for conceptual understanding, instead traditional style assessment measures were used throughout their course. Instructors could benefit from contact with other instructors to share ideas on the new teaching methods.

**Directions for Future Research**

It is the nature of qualitative research to have questions arise as the design evolves and emerges. Since many aspects of the situation are probed and are under investigation, many questions are raised for future investigations. This was also the case with this study. One of the possibilities for future studies is to conduct a study similar to the present research using a modified population where a comparison group
is included. This was not possible for this study because the Math 050A students were not randomly placed in the course. When looking at mathematics anxiety, it would then be easier to determine if the change was due to the type of instruction or another factor. By conducting an experiment, achievement could be an additional variable to help determine which group has a better understanding of the content. This would need to be done carefully as to not favor one group or the other by the assessment measures used. It would not be appropriate to compare the two groups using an exam of the traditional format. A study qualitative in nature would be recommended for a true comparison.

Students who successfully completed the Math 050A/075A sequence should be followed through subsequent terms to see if anxiety level, understanding, and achievement in future courses differs from the Math 050/075 traditional students. Particular attention should be directed toward the reasons for any differences. Once again, interviews and observations would be necessary. A longitudinal study could provide a more complete picture of the impact of conceptual understanding on students' anxiety and their knowledge of mathematical connections in future courses.

It would be beneficial to lengthen the exposure of students to this particular style of instruction. They have been taught for many years using traditional methods and it is difficult to change their attitudes towards mathematics and have an impact on their mathematics anxiety within one or two quarters. Again, it would be helpful to conduct a longitudinal study with one group following the conceptual understanding teaching methods and one following the more traditional style. When they have reached the same level of mathematics, in-depth interviews could provide valuable insights into their level of anxiety and how they view and value mathematics. After studies of these
types are conducted, results need to be evaluated and teaching strategies will have to be adjusted to better meet the needs of the students.

**Researcher Reflection**

After completing this study, there are several areas of interest that I would like to expand upon. First, when I began this study I envisioned the data following one of two routes. If the MARS scores showed an increase in mathematics anxiety, I anticipated the interviews would relay that the students were nervous about what to expect in this new type of course and wanted the familiarity and security associated with the traditional teaching style. When this was not the case, and the MARS showed a decrease in anxiety, I was not sure what the reasons would be. The degree to which the students in this study preferred the conceptual understanding teaching methods did surprise me. The ones who were happy they took this course gave reasons that I would not anticipate hearing from students who typically enroll in remedial mathematics. I have taught remedial mathematics, Math 050 in particular, for many years and I was amazed at how confident and comfortable these students appeared to be in Math 050A.

I taught using the conceptual understanding teaching methods at a different college and was happy with the results, but I did not interview the students regarding their anxiety and comfort level in the classroom. I was trying to measure the success of the course by achievement alone and I believe I have learned that some students will not ever be good mathematics students. This does not mean that non-A students cannot enjoy the course and feel they are learning the material to the best of their ability, even if that ability is a grade of C.
When mathematics educators think about how they have taught remedial mathematics in the past, I feel most of them would think they went at a slow enough pace so everyone in the class could understand. But when educators slow the pace down, attendance begins to dwindle and the class becomes boring for us to teach and for the students to attend. One can judge that Math 050A was not a slower version of Math 050 by the fact that attendance was much better than one would find in Math 050 and the interest level appeared much higher. When students are challenged, I believe more often than not they rise to that occasion. When more was expected from students on the Math 050A exams, I found they even surprised themselves with their ability to explain and communicate what they had learned in the course. A quote from an unknown source summarizes how I feel with regard to students being able to communicate their knowledge of mathematics, "What you cannot explain to others, you do not understand yourself."
APPENDIX A

MATHEMATICS ANXIETY RATING SCALE (MARS)
MATHMATICS ANXIETY RATING SCALE (MARS)

The items in the questionnaire refer to things and experiences that may cause tension or apprehension. For each item, place a check (X) in the circle under the column that describes how much you would be made anxious by it. Work quickly, but be sure to think about each item.

<table>
<thead>
<tr>
<th>Item</th>
<th>Not at all</th>
<th>A little</th>
<th>A fair amount</th>
<th>Much</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Deciding how much change you should get back from buying several items.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>2. Having someone watch you as you add up a column of numbers.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>3. Having someone watch you as you divide a five digit number by a two digit number.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>4. Being asked to add up 976 + 777 in your head.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>5. Dividing a five digit number by a two digit number in private with pencil and paper.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>6. Figuring out a simple percentage, like the sales tax on something you buy.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>7. Listening to a salesman show you how you would save money by buying a higher priced product because it reduces long term expenses.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>8. Listening to a person explain how your share of expenses on a trip was figured out (including meals, transportation, housing, etc.).</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

The full 98 item MARS is copyrighted by R. M. Suinn and not to be duplicated in any way. Orders may be obtained from: Dr. Richard M. Suinn, 808 Cheyenne Dr., Ft. Collins, CO, 80525
<table>
<thead>
<tr>
<th>53. Taking an examination (quiz) in a math course.</th>
<th>Not at all</th>
<th>A little</th>
<th>A fair amount</th>
<th>Much</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>54. Taking an examination (final) in a math course.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>55. Hearing two of your friends talking about the best way to figure out the actual cost of a product.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>56. Having someone ask you to recheck the numbers in a simple calculation, such as division or addition.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>57. Being asked by a friend to answer the question: &quot;How long will it take to get to the state capital if I drive at 30 miles per hour?&quot;</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>58. Studying for a driver's license test and memorizing the figures involved, such as the distances it takes to stop a car going at differing speeds.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>59. Hearing friends quote the odds on a game as they make bets.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>60. Playing cards where numbers are involved, like poker or blackjack.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>61. Having a friend try to teach you how to do a math problem and finding that you cannot understand what is being said.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>62. Making a schedule for your daily routine, setting aside times for classes, study time, meals, recreation, etc.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>63. Juggling class times around at registration to determine the best schedule.</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>
APPENDIX B

Letter to Students
Dear __________ ,

Thank you for participating in my study involving Math 050A students. I have evaluated your Mathematics Anxiety Rating Scale (MARS) and will share the results with you after you take the second MARS, which will be distributed in class on Monday November 4th. The results from both MARS are needed for a comparison of your scores.

Some of the Math 050A students will be selected for 30-45 minute interviews scheduled between November 12th and November 20th. The interviews will be scheduled at your convenience if you are selected. These same students will be interviewed a second time during finals week. These second interviews will last only 10-15 minutes and will be conducted via the telephone.

As I stated on the first day of classes, I will share my data analysis with you at the end of the quarter, and a final analysis will be published in my dissertation. As promised in the consent form you signed, all data collected by me will remain confidential and you may select a pseudonym for reference or I will choose one for you. I will not use any students' names in my research.

Thank you for your help,

Sandy Schroeder
APPENDIX C

Participant Consent Form
PARTICIPANT CONSENT FORM

The purpose of this study is to investigate the change in mathematics anxiety when conceptual understanding teaching methods are used. All data collected by me, Sandy Schroeder, will be kept confidential and any data disseminated by me will use the chosen pseudonym or code. I will share my analysis of the data with you at the end of the quarter.

The data collected will consist of: (1) the Mathematics Anxiety Rating Scale; (2) audio taped interviews from eight students; (3) notes from the observations of the two 050A sections; and (4) documents which are collected by the instructors and made available to me.

The information collected from the data will be used: (1) to explain the change in mathematics anxiety based on method of instruction for my dissertation; (2) in professional writing and reporting at professional conferences; and (3) to answer current questions and generate new questions for further research.

Signed: ___________________________ Date: __________________

I, ____________________________, consent to participate in the Mathematics 050A research study. The purpose of the study, the procedures to be followed, and the expected duration of my participation have been explained to me. I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Further, I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me. I acknowledge that I have read and fully understand the consent form.

Signed: ___________________________ Date: __________________
EXAMPLE: Dr. Simmons is teaching a Psychology 101 course. Eighty students attend his section. Dr. Simmons reported that 60% of the class passed the first midterm with an A. How many of his students received an A on the first midterm?

Solution: 48 students received an A on the first midterm.

Extension: What is 1% of 80? What is 13% of 80? Explain.
Activity E: READING A MATHEMATICS TEXT

STUDENT RESEARCH PROJECT

Project Team Members: 

Target completion date: ___/___/___

During the first half of this century mathematics textbooks contained little more than enumerated exercises. Today, however, textbooks can (and should) be read.

Your team will select a topic from a list provided by the instructor. Each topic will be new - not a concept previously discussed in class. Team members will consult mathematics texts for explanations and examples of problems within this topic. Please make a xerox copy of the section(s) from the textbook(s) your team selected. Author(s) and textbook title(s) should also be provided.

Your team will use this information to become experts in this particular area of mathematics. You will prepare a brief (10-minute) lesson to share with the class that will include: examples; definitions; explanations; and at least 2 homework problems.
1. Sarah has been challenged to add the integers from 1 to 10 without using a calculator. She devises the following method:

\[
\begin{align*}
1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 \\
10 + 9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1 \\
11 + \ldots
\end{align*}
\]

Explain Sarah’s method.

2. Perform the indicated operations.
   a. \(6 - 2(3 - 1) + 4\cdot 2\)
   b. \(1 + 2[3 - 4(5)]\)
REFERENCES


