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The effects of attitudes and beliefs about learning, about mathematics, and about self on achievement in a college remedial mathematics class.

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THE EFFECT OF ATTITUDES AND BELIEFS ABOUT LEARNING, ABOUT MATHEMATICS, AND ABOUT SELF ON ACHIEVEMENT IN A COLLEGE REMEDIAL MATHEMATICS CLASS

A Dissertation Presented

BY

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ABSTRACT

The Effects of Attitudes and Beliefs About Learning, About Mathematics, and About Self on Achievement in a College, Remedial Mathematics Class

May, 1986

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The study was designed to investigate the relationship between attitudes and performance in a college remedial mathematics course in which there was a strong emphasis on problem solving.

Three questions were posed:

(1) Do individual affective variables significantly affect performance? If not, will a constellation of affective variables produce greater significance?

(2) Will the variables have a differential influence on different subgroups, e.g., male-female and students of different ability?

(3) Will students' attitudes change from September to December?

Included in the study were two measures of ability--diagnostic tests of manipulative and conceptual skills; three measures of performance--final grade, a weighted exam average, and persistence; and eleven atttiudes--

confidence, predicted grade, anxiety, perceived usefulness of mathematics, attributions for success and failure, conceptions of intelligence, learning goals, beliefs about: the nature of mathematics, the role of the student and the teacher, and the role of memorization and understanding in learning mathematics.

Data were gathered from four sources: questionnaires in September and December, several essay questions, and interviews with sixteen students doing poorly in the course after the first exam.

The findings of the study were:

(1) Ability and predicted grade were the strongest predictors of performance in the course. Regression analsyses showed that several attitudes significantly added to the amount of variance explained in the exam average by the measures of ability. However, the beliefs variables were generally not significant.

(2) Ability was a much stronger predictor of performance for males than for females and attitudes were more significant for females than for males. Various analyses also showed a differential influence of attitudes on performance for students of different ability.

(3) All groups of students studied showed significantly higher confidence in December than in September. Levels of anxiety did not change. Furthermore, beliefs about the nature of mathematics did not change for any group, implying that these beliefs may be strongly resistant to change.

Finally, a new framework was proposed for future research, focusing on different types of students. Four types were discussed: helpless, denial, pressured, and naive.

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CHAPTER I

INTRODUCTION

All mathematics teachers, from first grade through college, have encountered, in virtually every class, varying numbers of students who do poorly. Some of these students seem to have done poorly because they have given up on themselves; others still try to do well, but their effort seems half-hearted as if they were almost expecting to fail or to do poorly; yet other students seem to try very hard but their effort simply does not translate to success in the course. Both teachers' experiences and reserchers' interviews and questionnaires have pointed to a number of attitudes and beliefs which may be damaging to students. Consider just a few examples of "poor" attitudes and beliefs: "some people just don't have mathematical minds; those who don't just can't learn math;" "if you can't see how to solve a problem within a minute, then you might as well give up;" "the key to mathematics lies in learning the right formulas and tricks;" "I don't worry about understanding what I'm doing as long as I can get the right answer;" and "one must produce a mathematical solution in a mathematics class." I believe that most high school and college mathematics teachers would agree that students' attitudes and beliefs about learning, about mathematics, and about self often have a significant impact on their ability to learn mathematics effectively. However, the researcher's task of discovering which attitudes and beliefs impact most strongly, and on which students, is an exceedingly difficult one.

Statement of the Problem

To date, research on the influence of affective variables on mathematics achievement has produced mixed and inconclusive results. In a review of studies on affective variables, Aiken (1976) noted that many studies have found significant but low positive correlations between attitude scores and mathematics achievement scores. Nine years later, Dick (1985) reported that "there has been little research convincing enough to indicate that attitudes are an important influence on mathematics achievement. . . If we are searching for predictors of mathematics achievement, then attitudes toward mathematics appear to be weak ones at best" (p. 3). However, researchers continue to explore this area for, as Kulm (1980) states, "the commonsense feeling that achievement ought to depend heavily on attitudes stimulates the search for a clear, simple relationship between these variables" (p. 366).

Several conclusions about atttiudes and beliefs are possible. One is that students' attitudes and beliefs do not affect performance as powerfully as had once been thought, that much or most of a person's success in mathematics is explained by the student's cognitive and metacognitive skills and ability or other factors.

Another conclusion is that there **are** significant connections between attitudes and achievement but they have not yet been demonstrated because of theoretical and methodological problems in the affective domain. Especially given the growing focus on problem solving in mathematics education, one cannot ignore students' attitudes and beliefs. At the very least, for **some** students poor attitudes and beliefs cannot help but undermine their ability to learn mathematics. In this respect, both Fennema and Behr (1980) and Kulm (1980) point to the study of relationships between math attitudes and achievement for different groups (e.g., males and females) as a rich area for further study.

Researchers in the area have also pointed to a number of theoretical and methodological problems which might account for the generally low correlations found between attitude and achievement. A central problem for researchers in the affective domain is that the nature of affect is not well understood in the psychological literature. Consequently, theoretical constructs in many areas of mathematics attitude research have not been clarified. Another problem is the lack of precision in the definition of the construct "attitude" in general and specific constructs such as anxiety and confidence in particular. Another related problem is that, regardless of the definition, measurement of attitudes is difficult.

A third possibility is that the relationships between attitudes and achievement may not be clear and simple, that is, that attitudes are directly related to achievement. There is a rich and growing literature concerning the differences in the relationships between atitudes and achievement for males and females (Fennema & Sherman, 1978; Licht & Dweck, 1983; Dick, 1985). There is also a large literature from the field of psychology which might enable us to better understand why certain students are less successful than others in mathematics, for exmaple, learned helplessness, defensive attributions, and the complex nature of anxiety.

Regarding how to proceed in the present, there is general consensus in the literature around several issues. For a number of researchers, theory development (both theoretical constructs for various attitudes and models concerning the relationship between attitudes and mathematics achievement) is a high priority (Fennema & Behr, 1980; Kulm, 1980; McLeod, Reyes, Fennema, and Surber, 1985). Since our understanding of the affective domain is still so incomplete, Kulm (1980), Reyes (1984), and McLeod (1985) agree that a variety of methodological approaches is necessary to deal with the various research issues in the affective domain.

Purpose of this Study

The present study is designed to address some of the issues raised above in the context of a remedial, college mathematics course in which there is strong emphasis on developing problem solving skills. Given Aiken's and Dick's reports of low correlations between affective variables and achievement, and given the consensus that the area of affective variables is presently so poorly understood, the present study has been designed as a comprehensive, descriptive study which will focus on the following four questions.

(1) Do individual affective variables significantly affect performance? If not, will a constellation of affective variables produce greater significance?

(2) What is the nature of the relationships among various affective variables?

(3) Do (certain) affective variables have more influence on certain subgroups (e.g., male-female, relatively high-low ability, etc.)?

(4) Will students' attitudes on any of the variables measured change

between the beginning and the end of the semester?

In addition to three affective variables well-studied in the mathematics education literature--confidence, anxiety, and perceived usefulness of mathematics--two other kinds of affective variables, which have shown promise in other studies, will be examined: attributions for success and failure in mathematics, and students' beliefs about the nature of intelligence, the nature of learning, and the nature of mathematics. Because of the nature of the course (problem solving) and the nature of the students (remedial), it was felt that a key to poor performance in the course might lie with poor beliefs about the nature of learning mathematics and the nature of mathematics.

The present study differs from previous studies in two main respects. First, it involves a large number of affective variables, some which have not been previously studied in a remedial college mathematics course. Second, the study employs both open- and closed-ended questions, both quantitative and qualitative data. Given that the affective domain in mathematics education is not well understood, given both Reyes' and McLeod's support for a variety of methodological approaches, and given the growing acceptance of studies which have both qualitative and quantitative components (see Rossman & Wilson, 1984; Schofield & Anderson, 1984), it was felt that a variety of data could very well turn up relationships previously overlooked. Most of the studies examining the relationship between the affective domain and achievement have been statistical studies. Thus, if correlations between affective variables and achievement are low, as the literature contends, the qualitative data (the open-ended questions, the essay questions, and the interviews) may provide clues for the causes of the low correlations and may lead to the formulation of better research questions.

Definition of Terms

At present there is no precise definition of the construct "attitude" in the mathematics education literature. In fact, Kulm (1980) notes that it is probably not possible to offer a definition of attitude toward mathematics that would be suitable for all situations. Though the lack of clear understanding regarding both the nature and the definition of attitude remains an issue which needs attention, there is growing convergence among the definitions offered in recent studies and reviews of studies. McLeod (1985) defines the affective domain in mathematics education as including "the feelings, emotions, and beliefs that have some relationship to student performance in problem-solving activities" (p. 267). Reyes (1984), in a review of the affective literature in mathematics education, states that "here affective refers to students' feelings about mathematics, aspects of the classroom, or about themselves as learners of mathematics. The definition is not intended to limit the affective domain to general feelings such as liking/disliking of mathematics, nor is it meant to exclude perceptions of the difficulty, usefulness, and appropriateness of mathematics as a school subject" (p. 558). Fennema (1979) simply says that "affective variables deal with feelings, attitudes and values" (p. 394). While not wishing to ignore the need for a more precise definition of attitude, that task is beyond the scope of this study. Each of the above definitions is consistent with the meaning which I wish to give to "affective" in this study, and the terms "affective variables," "attitudes," and "attitudes and beliefs" will be used interchangeably.

Theoretical Framework

The basic premise underlying research on affective variables in mathematics education is that one's attitudes (about self, about mathematics, and about learning) will affect both the quality and quantity of cognitive effort brought to bear in an achievement setting. For example, a student who feels confident of his/her ability to do mathematics will likely achieve at a higher level than a student who has little confidence. Similarly, one would expect that a student who sees mathematics as a bunch of formulas to be memorized and applied will approach the learning of mathematics differently from a student who sees mathematics as a set of logical, interrelated propositions which ultimately make sense. Attitudes can also interact. Thus, a student who feels a strong need to do well in a mathematics class but who also has a high level of anxiety may achieve at a lower level than another student who feels less need to do well but who also has less anxiety.

Virtually all theoretically based studies examining the nature of the relationship between affective variables and mathematics achievement are framed in the context of achievement motivation. Atkinson's (1964) classic expectancy-value formulation of achievement motivation states that one's motivation in a given situation is a function of the expectancy of success and the incentive value of success. For example, if one expects to be successful in a situation and one values success in that situation, one's achievement motivation is likely to be high. Conversely, if one's expectation that one can be successful is low and the value of succces is low, then that person's achievement motivation is also likely to be low. The present study is guided by two compatible models of achievement motivation. The first model (Eccles et al., 1983) has been framed in the context of mathematics education and strongly focuses on students' expectancies for success, the value of doing well in a mathematics course and on various factors which, in turn, influence those expectancies and values. The other model (Dweck & Elliott, 1983) has been framed in more general terms, that is, not specifically in the context of achievement in mathematics. Although it is also cast in expectancy-value terms, this model adds two new components--students' conceptions of intelligence and the learning goals which such conceptions tend to foster. These two components are seen as having a profound effect on the students' expectancies and values by leading students to conceptualize the entire achievement situation in strikingly different ways

Scope and Limitations of the Study

The focus of the present study (i.e., with college students in a remedial setting in which there is a strong focus on problem solving) warrants some caution regarding the generalizability of the findings. There is growing evidence in the research literature of a number of developmental changes in students' attitudes toward mathematics (see Eccles, Midgley, & Adler, 1984). At this point, enough studies have been conducted regarding the development of attitdes toward mathematics to caution against much generalizing results of studies from one age group and one context to another (see Nicholls, 1978; Harari & Covington, 1981). For example, one would expect some differences in certain attitudes between students in a high school algebra clas, a high school calculus class, and a college remedial mathematics class. Similarly, one would also expect some differences in certain attitudes between students in a traditionally taught course and a course with a strong emphasis on problem solving.

Another factor limiting the generalizability of the results is that the students in the course seem to represent a relatively diverse population. Some students have a history of poor performance in mathematics. Others did well in high school and were surprised by placement into this course. Others placed themselves into the course because they wanted a review of basic math before going on to take statistics or calculus. Additionally, although most of the students were 18 and 19 year-olds, there were quite a few "older" students. Qualitative analysis of the data indicated that these students may very well compose another significant subgroup. However, there were not enough older students to warrant a statistical analysis of their responses.

There were several limitations on the collection of data for the study. The September questionnaire had to be designed to be completed in less than thirty minutes. The December questionnaire could only take twenty minutes. The essay questions could not be completed in class, thus reducing the number of responses. Additionally, only a subset of the many potentially powerful attitudes which might influence performance could be considered. Thus, because of the constraints on data collection and because of the number of variables, the number of questions for each attitude was limited.

Importance of the Study

The study examines the impact of affective variables in a college remedial mathematics class in which there is strong focus on problem solving. Other research in the affective domain has been briefly discussed, so let us turn to the topics of problem solving and remedial mathematics in American education at the present time. The National Council of Teachers of Mathematics recently devoted an entire yearbook to the issue of problem solving (Krulik, 1980). In An Agenda for Action: Recommendations for School Mathematics of the 1980's (NCTM, 1980), the first recommendation was that problem solving be the focus of school mathematics in the 1980's. Despite the growing emphasis on problem solving, The Third National Mathematics Assessment (NAEP, 1983) noted that while students of all ages are fairly successful in solving routine, one-step verbal problems, their performance level on many multi-step verbal problems is "still below that which would generally be considered educationally acceptable" (p. 24). One need not talk with too many high school or college math students to discover a general feeling of either dislike or fear of word problems. Thus, research in the area of problems solving is a rich area for both cognitive and affective researchers.

Studies of problem solving do indeed dominate the recent mathematics research education literature (Lester, 1981). Cognitive-based research has focused on topics like misconceptions, differences between expert and novice problem solvers, and heuristics which might aid development of problem solving skills. On the other hand, affective-based research has focused on the influence of various attiudes, such as anxiety, confidence, and perceived usefulness of mathematics, on such achievement behaviors as choice of how much mathematics to study, persistence and performance in mathematics classes.

However, the overwhelming focus of the problem-solving literature has been on cognitive issues, and in general there has been little contact between those researchers from the cognitive and affective perspectives. However, that situation is beginning to change as cognitive researchers become more concerned with metacognitive aspects of problem solving, many of which have an affective component, and as affective researchers become more concerned with attributions and belief sytems, both of which have strong cognitive components. In a recent paper, Schoenfeld (1983), whose primary concern has been on cognition, urged more focus on "factors not purely cognitive." He states that ". . . it would appear that belief systems are a major driving force of students' behavior. Any framework that ignores them--regardless of how accurate it is in other contexts--can result in severe distortion and misinterpretation of the data" (p. 29).

Through the study of causal attributions, affective researchers are examining the reasons students give for explaining their successes and failures in mathematics (see Kloosterman, 1984 and Meyer & Fennema, 1985). Since causal attributions are part of a student's belief system, they are related to concerns about metacognitive behavior. For example, consider a student who attributes failure to do well in mathematics to lack of ability and attributes success to help from the teacher. That student's range of metacognitive choices (e.g., use of various heuristics) will likely be substantially restricted as a result of the nature of the attributions. Dweck and her associates (Dweck & Bempechat, 1981; Dweck & Elliott, 1983) have included students' conceptions of intelligence in the context of a general model of achievement motivation, arguing that the nature of a student's conception of intelligence influences the student's learning goals and ultimately affects performance. Thus, the present study, which includes both students' attributions and students' belief systems, bears directly on the area of growing overlap between cognitive and affective research on problem solving. It appears that we are heading to a point in which three interconnected skills will be seen as necessary for the development of successful problem solving: cognitive skills, metacognitive skills, and affective skills.

At the same time that problem solving has been given much more attention in American schools, the number of remedial mathematics classes offered in colleges has been rising sharply. In reviewing recent trends in remedial mathematics, Chang (1983) states that the population of students needing to remediate is "growing out of proportion" and referrred to the remedial problem as "epidemic." He cites a recent report which found that remedial mathematics enrollment at four year institutions of higher education increased 72% from 1975 to 1980 (Coleman & Selby, 1982). In another report cited by Chang, Myers (1983) determined that 25% of mathematics courses in all public four year colleges are remedial and 42% of all courses at the junior college level are remedial.

In my own survey of the remedial mathematics education literature, I found little attention to affective factors. Most of the focus seemed to be on improving methods of teaching and improving students' basic mathematical skills. Given the greater numbers of remedial students and a greater concern with improving instruction in remedial mathematics classes, this study will at the very least provide descriptive information about students' attitudes in such courses. Hopefully the results of the study will also increase our understanding of the nature of the relationship between attitudes and achievement in college remedial mathematics classes.

Overview of the Dissertation

In Chapter II theoretical and methodological difficulties in research on the affective domain will be discussed. Then, the general assumptions of achievement motivation will be reviewed, two achievement motivation models which guided the selection of variables for inclusion in the study will be elaborated, and the existing literature on each of the variables used in this study will be summarized. The design of the study, including a discussion of data gathering methods and construction of the instruments used, will be described in Chapter III. In Chapter IV the results of the analaysis of the data will be presented and discussed. Finally, Chapter V will examine several interpretations of the findings and suggestions for future research.

CHAPTER II

RELATED LITERATURE

The purpose of this chapter is to establish a conceptual base for the present study which seeks to add to our knowledge of the relationship between students' attitudes toward mathematics and performance in mathematics courses. In the first part of the chapter, we will discuss the difficulties which confront researchers in the affective domain and recommendations concerning areas and approaches for future research. In the second part of the chapter, we will look at the field of achievement motivation and examine two models which theorize the processes by which attitudes influence achievement. After discussing these models, we will examine the research on the specific attitudes which will be included in the study. Finally, a summary will be given of studies of differences in atttitudes between males and females with respect to the variables included in the study.

Difficulties Confronting Researchers

One of the problems in this area is that, for a variety of reasons, the results of past studies have limited value to present researchers. Reyes (1984) charges that too many studies have had no theoretical rationale and that many studies have not clearly specified what is meant by a particular variable. This detracts from efforts to compare results across studies. Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgely (1983) charge that "applied researchers have tended to proceed piecemeal, each researcher investigating a subset of the possible causes. What has emerged resembles the proverbial blind mens' description of the elephant: many conclusions but little understanding of the broader picture" (p. 137). McLeod, Reyes, Fennema, and Surber (1985) express concern that much of the research in this area has not recognized the complexity of affective factors, mathematics as learning, or the relationship between the two.

One of the reasons for the general critical tone of those reviewing research in this area is that a number of theoretical and methodological difficulties confront the investigator searching for relationships between attitudes and achievement-related behaviors such as performance. Let us now examine some of these difficulties. First, there is little agreement as to what "affect" means. In fact, in a recent review of affective variables and mathematical problem solving, McLeod (1985) noted that most theoretical models of problem-solving performance do not even include affective factors. He asserts that, at present, most researchers in problem solving seem content to steer quite clear of affective issues. Norman (1981) notes that most cognitive theorists would probably prefer if affective issues "just disappeared" (p. 268). McLeod offers some reasons for this lack of attention to affective issues. Much of the research in problem solving is being conducted using models of information processing, and such models do not lend themselves easily to inclusion of affective issues. Furthermore, present models of affect are quite primitive. McLeod cites Zajonc (1980) who believes that it is not yet time to construct an affective model because the affective components of even simple tasks (for example, recognition) are still not understood well enough.

A problem related to the lack of theory is that a large number of affective variables have been hypothesized to affect achievement, and, at present, there has not been enough conclusive reseach to allow us to significantly condense the number of potentially powerful affective variables. A partial list of the variables includes anxiety, confidence, perceived usefulness of mathematics, attributions for both failure and success, field independence, attitudes of parents and teachers, locus of control, beliefs about the nature of mathematics, learned helplessness, beliefs about the nature of intelligence, and degree of intrinsic motivation. Also, the relationships among these various affective variables and achievement are complex and at present not well understood. For example, Fennema (1982, cited in McLeod, 1985) concludes that, in the context of learning mathematics, her measures of confidence and anxiety were essentially the same.

Probably the most serious problem confronting the researcher is the difficulty of defining and measuring affective variables. In a discussion of research perspectives on problem solving, Silver and Thompson (1984) acknowledge that affective factors should play an important role in problem solving. They conclude that a major reason why we have little conclusive evidence about their influence on mathematics performance is that it is difficult to design instruments that can reliably measure these factors. Illustrating the difficulty of definition and measurement, Lester (1980) reports that the Mathematical Problem Solving Project decided that willingness, perseverance, and self-confidence were three of the most important influences on problem solving performance (Webb, Moses, & Kerr, 1977). "However, the MPSP was unable to develop an attitude instrument to measure adequately the extent to which these three factors changed over time, even though the staff and classroom teachers were confident that very definite changes had occurred" (p. 299). McLeod (1985) similarly concludes that the identification and measurement of affective variables is "difficult and frustrating" (p. 276).

A number of specific recommendations have been made to address the problems of definition and measurement. Fennema and Behr (1980) state that one of the problems is lack of precision in the definition of "attitude." They note that

> Mathematics is a complex discipline involving many kinds of related but diverse content and skills. To assume that a person feels the same toward different parts of mathematics is not reasonable. For example, computing the answer to 50 three-digit by three-digit multiplication problems could easily arouse feelings in a person entirely different from those aroused when solving a mathematical puzzle. (p. 333)

Kulm (1980) concurs with this and stresses that researchers should take care to specify the attitude which their instrument(s) purport to measure.

Another recommendation is that one should avoid combining disparate atttiudes. Kulm (1980) stresses that one should explicate a theoretical construct that provides justification for choosing a particular item or combining a set of items. For example, an attitude label such as "attitudes toward problem solving" which includes such items as "There are many ways to solve a problem" and "It makes me nervous to think about doing a math problem" is not likely to be useful. However, researchers should also avoid the opposite tendency of refining affective variables into a variety of narrow subdimensions, for such an approach is counter-productive. McLeod (1985) argues that in general, affective variables cannot be meaured very accurately and even if they could, such narrowly defined variables, taken individually, would be unlikely to have any major influence on performance. McLeod recommends defining constellations of variables and looking at their combined effect on performance.

Concerning the problem of measuring attitudes, Kulm (1980) notes that the most popular method of measuring attitudes is by self-report scales. While he acknowledges that these scales are a valuable approach for assessing attitudes, he argues that they represent only one of several categories of attitude measurement approaches. He believes that alternative self-report approaches have the potential for furnishing more valid data on attitude than is possible with scales. For example, one alternative is to ask subjects to respond to open-ended questions such as "What makes mathematics easy (difficult) to learn?" and "Why are you taking this mathematics course?" He urges that the measurement of mathematics attitudes in the future should make use of many approaches and that "researchers should not believe that scales with proper names attached to them are the only acceptable way to measure attittudes" (p. 365).

Another approach for measuring attitudes, given by Kulm, involves changing the focus from obtaining quantitative measurements of attitudes at a particular time to directly observing individuals in their natural (as opposed to a laboratory) setting. One consequence of such an approach, he argues, is that a host of independent variables becomes important almost immediately. Fennema and Behr (1980) argue that such a clinical approach is particularly necessary as we consider the process dimension of problem solving.

Another change of focus recommended by Fennema and Behr is to explore not only interindividual differences but also intraindividual differences. This should be done because each person has the potential to respond in a variety of ways, and whatever response is made depends on a complex network of interrelated environmental and individual variables. In the context of attitudes toward learning mathematics, two specific questions are relevant. The first involves the stability of student's attitudes. In other words, how stable is a student's confidence, level of anxiety, beliefs about the nature of mathematics, etc.? Second, within a particular course, how much variation exists in a student's attitudes toward various topics (e.g., fractions, word problems, solving equations, etc.)?

Recommended Areas and Approaches for Research

Let us discuss several areas and approaches for research which have been recommended and which are relevant to the present study. Most researchers seem to agree that a high priority should be given to the development of theoretical models which illustrate the relationship between attitudes and achievement. Such models will allow studies to be conducted to determine causal relationships between attitudes and achievement and which can determine which variables directly and indirectly influence achievement. In order to develop better models, there is a need for better integration between constructs in the mathematics education literature and the psychology literature, for example, "confidence in learning mathematics" and "self-concept of ability" in achievement motivation theory, "perceived usefulnes of mathematics" and "task value" in achievement motivation theory, and attributions for success and failure in mathematics and attributions as used in the psychology literature.

Another related area needing research concerns how the various affective variables jointly affect motivation and achievement and how these variables relate to one another. Reyes (1984) ofers some specific research questions. Two which are related to this study are: "How are (affective variables) A, B, C, D, etc., related to each other?" and "How do A, B, C, and D as a group relate to mathematics achievement and participation?" (p. 573).

McLeod, Reyes, Fennema, and Surber (1985) note that research on affective variables has tended to focus on negative emotions like anxiety. Given the focus on the development of problem-solving skills in mathematics instruction, they urge more research on positive affective variables and how the development of these variables might improve problem solving abilities of students.

Finally, several researchers have asserted that a variety of methodological approaches is needed to address these issues. It has previously been noted that Kulm (1980) recommends studies using alternatives to self-report scales. McLeod (1985) reports that some studies have involved a wide range of observations of student performance with very little attention to theoretical considerations; yet other studies, based on specific theoretical positions, have gathered data related only to particular affective issues. However, he concludes that since our knowledge about the affective domain is presently so limited, there is a place for both data-driven and theory-driven approaches.

Models of Achievement Motivation

In light of the concerns raised by Reyes, Eccles, McLeod and others about the need for comprehensive studies based on theoretical models, a first priority in this review of the literature on the affective domain is to develop a model through which the results of the study can be viewed. Two models have been proposed which are especially relevant to the purposes of this study. Eccles et al. (1983) propose a comprehensive model of achievement motivation, framed in the context of mathematics education. Reyes (1984) considers this model to be the most detailed, comprehensive framework to date for viewing the complex interrelationships among factors affecting students' achievement behaviors. Although the model was tested for the effect of attiudes on choice of future mathematics courses, it also predicts effects of attitudes on performance. Dweck and Elliott (1983) have proposed another comprehensive model of achievement motivation, stated in general terms, which incorporates the dynamics of how students' beliefs influence performance. Both models were proposed and tested with pre-college students.

The two models will be discussed in turn, and then an integrated model which incorporates the two models will be proposed. However, before we discuss the two models, let us examine the general assumptions from achievement motivation theory which underlie both models. In the context of mathematics education, achievement motivation theorists seek to explain some or all of a number of behavior patterns such as the choice of how much mathematics to study, the development of problem solving skills, or persistence, performance, and improvement in a mathematics course.

Most achievement motivation theories are viewed in an expectancy-value framework in which a variety of expectancies and values are seen as directly influencing achievement behaviors in the particular task domain, which is basic mathematics in this study. Other factors are seen as affecting achievement through their influence on expectancy and/or value. Expectancies include factors such as the student's self-concept of ability in the domain, the student's perception of the difficulty of the task, and the student's confidence that, alone or with the help of others, s/he can master the task. Values include factors such as the intrinsic value, the usefulnes, the importance of mastering the task, the student's long- and short-range goals, and the cost (i.e., effort involved) in mastering the task. Factors which can influence the expectancy and value of success include previous experiences in the area, the student's attributions for previous success or failure, beliefs about the nature of the learning process and the nature of knowledge, test anxiety, the expectations and values of socializers (e.g., parents, teachers, and peers), and the student's sex and socioeconomic background. Although various models propose different factors and different dynamics, the important point is that these expectancies, values, and other factors are assumed to exist and to be important determinants of goal-directed behavior.

Another common assumption underlying most models is that it is not reality itself (i.e., past successes or failures) that most directly determines students' expectancies, values, and behavior, but rather the interpretation of that reality. Feather (1982) states that one's expectations, values, and motives may not always be well-defined, that they may be in error (for example, due to one's wishes and fears or because of insufficient information), and that one would expect them to vary in their details from person to person. Dweck and Elliott (1983) have added that "available information is likely to be processed in a selective, subjective, less than conscious fashion, that the resulting expectancies, values, and goal tendencies are likely to be impressionistic blends of cognition and affect, and that the resulting behavior is often likely to be a response to these poorly articulated states" (p. 652).

In terms of the dynamics of achievement motivation, it is assumed that, in practice, all components of the model (e.g., expectancies, values, goals, etc.) exist concurrently and are usually in some state of flux. Also, the learning process is seen as cyclical. Thus, performance during the course of the semester (grades on assignments, quizzes, and exams) can and do affect the student's expectancies and perceived value of success.

The Eccles et al. Model

The model, depicted in Figure 1, specifies the causal links among cultural factors, historical events, and students' expectancies, values, and achievement behaviors. The model was tested with students in grades five through twelve to see how these factors affect students' intentions to take more math. However, the model predicts the same general dynamics to be

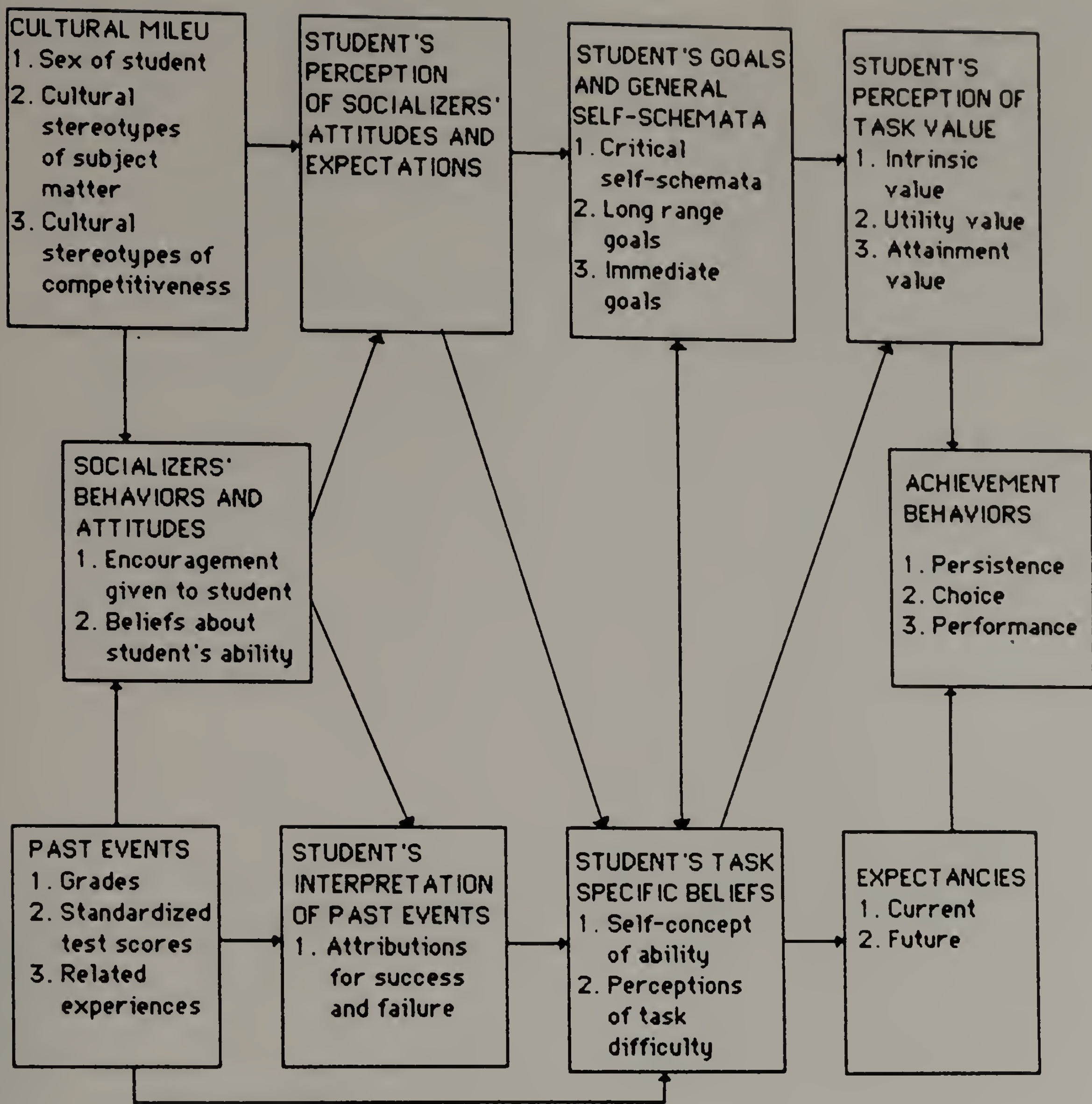

Figure 1. Model of achievement motivation (adapted from Eccles et al. 1983)

involved for other achievement-related behaviors such as persistence and performance. Essentially the model states that both the student's and the socializers' behaviors and attitudes are influenced by the cultural mileu and the student's past experiences in the particular task domain. These factors influence the student's goals, general self-schemata, and task specific beliefs which, in turn, determine the student's expectations for success and the student's perceptions of the value of success. These expectations and values then directly influence the student's achievement-related behaviors.

Various studies have demonstrated the importance of expectancies on achievement (Feather, 1966; Crandall, 1969; Covington & Omelich, 1979a). Developmental studies have indicated that the influence of expectancies on performance increases with age (Parson & Ruble, 1977; Fennema & Sherman, 1978). Eccles et al. propose that expectancies are influenced most directly by self-concept of ability and by students' estimates of task difficulty. Other factors (for example, past experiences and parents' and teachers' attitudes) are proposed to have an indirect effect on expectancies which is mediated through the students' interpretation of these past events.

Eccles et al. acknowledge that attributions have a causal role in achievement expectancies but urge caution. They believe it is possible that attributions play a critical role in the formation of students' self-concept of ability and perceptions of task difficulty when presented with novel tasks. However, they argue that once students have formed stable self-concepts of ability at any particular task, attributions may become epiphenomenonal rather than having a causal influence on subsequent expectancies and performance. In their study, Eccles et al. (1983) found that attributions related minimally to expectancies of performance in math class. However, in a previous study Parsons (1980) found that variations in the students' attributions for failure played a significant role in determining future expectancies. The results of this and other studies provide encouraging evidence that causal attributions do have an important role in predicting performance.

Looking now at how task value influences achievement and at factors which in turn influence task value, Eccles et al. suggest that the value of a task is a function of three major components: (1) attainment value of the task, i.e., importance of doing well, (2) intrinsic or interest value, i.e., inherent, immediate enjoyment one gets from performing a task, and (3) utility value of the task for future goals, e.g., usefulness of the present math class for one's chosen field of study in college.

In turn, Eccles et al. see task value as being influenced by three variables: (1) sex roles, e.g., viewing math as a male domain, (2) perceptions of the cost of success, e.g., the amount of effort needed to succeed, the loss of time that could be used on other activities, and the psychological cost of failing, and (3) previous affective experiences with similar tasks, e.g., humiliation in front of a class or public recognition for excellence.

In summary, Eccles et al. propose that task values are important mediators of achievement-related behavior which interact with expectancies to influence these behaviors. A number of factors which influence expectancies and task value were also discussed.

The Dweck and Elliott Model

One element missing from the Eccles et al. model which has received attention in other mathematics education research is students' beliefs, both about the nature of the learning process and about the nature of mathematics. Schoenfeld (1983) has discussed the influence of belief systems in determining the kinds of solutions that problem solvers may attempt. Silver (1982) talks about willingness to persist and perceived personal competence. Confrey (1980, 1982) has discussed the influence of students' conceptions about mathematics and the learning of mathematics on their ability to learn mathematics.

How students' beliefs fit into the framework of achievement motivation has been investigated by Dweck and her associates (Bandura & Dweck, 1981; Dweck & Elliott, 1983; Dweck & Bempechat, 1983) who have studied the influence on achievement of students' beliefs about the nature of intelligence and the consequent learning goals. Because the complete model of achievent motivation developed by Dweck and Elliott (1983) is quite involved and complex, discussion of the model will be confined to aspects which deal with students' conceptions of intelligence and learning goals.

Dweck and Elliott contend that students' conceptions of the nature of intelligence may strongly influence the goals which they seek and the persistence with which they pursue those goals. They propose that students hold, to differing degrees, two operating conceptions of intelligence which, in turn, lead to two different achievement goals. Table 1 (on the next page) outlines the two theories of intelligence and the consequent achievement goals and tendencies.

Students subscribing to an entity view of intelligence tend to see intelligence as a rather stable, global trait (e.g., you either have it or you don't). Such students tend to believe that they possess a specific, rather fixed amount of intelligence. Furthermore, they feel that this intelligence

Theories of Intelligence

	Incremental	Entity
Intelligence is:	A repertoire of skills that increases through effort.	A global, stable entity whose adequacy is judged through performance.
Effort is:	An investment that increases intelligence.	A risk that may reveal low intelligence.

Goals

	Learning Goal: Competence Increase	Performance Goal: Competence Judgment
1. Entering questions:	How can I do it? What will I learn?	Can I do it? Will I look smart?
2. Focus on:	Process	Outcome
3. Errors:	Natural, useful	Failure
4. Uncertainty:	Challenging	Threatening
5. Optimal task:	Maximizes learning (becoming smarter)	Maximizes looking smart
6. Seek:	Accurate information about ability	Flattering information
7. Standards:	Personal, long-term, flexible	Normative, immediate, rigid
8. Expectancy:	Emphasizes effort	Emphasizes present ability
9. Teacher:	Resource, guide	Judge, rewarder/punisher
10. Goal value:	"Intrinsic": value of skill, activity, progress	"Extrinsic": value of judgment

Table 1: Children's Theories of Intelligence and Achievement Goals (From Dweck & Elliott, 1983)

is displayed through performance and that performance is judged by them and by others to reflect the level of their intelligence. On the other hand, students subscribing to an incremetal view of intelligence tend to see intelligence as consisting of a repertoire of skills that can be increased through one's own actions. Though few students appear to subscribe entirely to one or the other conception, Dweck asserts that by late grade school one view tends to predominate.

According to the model, different theories of intelligence lead to different achievement goals. In this vein, achievement motivation can be viewed as involving goals relating to competence--increases in competence and judgments of competence. Some students are motivated predominantly by learning goals. Their focus is primarily on increasing their competence, seeking to master or understand new knowledge or skills. Other students are motivated more by performance goals. Such students tend to focus more on obtaining favorable judgments of their competence and on avoiding unfavorable judgments of their competence, i.e., obtaining a high grade or avoiding a low grade. In this light, it becomes less useful to consider people to be high or low in achievement motivation, but rather to speak of high or low expectancies and of high or low values attached to different goals. These different achievement goals (seeking competence vs. seeking competence judgments) lead students to structure the same achievement situations in very different ways. It is hypothesized that students motivated predominantly by performance goals are more vulnerable to maladaptive behaviors in the face of failure.

Some qualifications of the model are in order. Although, students favoring the incremental conception do realize that persons may differ in the rate at which they learn, they focus on the idea that anyone can become smarter by trying harder. While students favoring the entity conception also realize that practically anyone can increase his or her skills or knowledge, they tend to disbelieve that people can become smarter. It is also important to note that students may act in accordance with different conceptions of intelligence in different areas, e.g., math vs. social studies or physical vs. intellectual skills. In addition, environmental considerations may influence a student's conceptions. For example, an important exam may increase the salience of entity considerations. However, Dweck notes that she and her associates find striking individual differences regarding which view of intelligence students tend to endorse and use to guide their behavior (Bandura & Dweck, 1981).

Research to date in this area is very encouraging. Elliott and Dweck (1981) found no debilitation over a series of failure trials for children with learning goals regardless of whether they believed themselves to have high or low ability. However, children with performance goals who believed they had low ability showed marked deterioration of performance under the same conditions. Bandura and Dweck (1981) found significant differences in the behaviors and attitudes of students favoring entity and incremental conceptions of intelligence: the latter are more concerned with meeting challenges and increasing competence as opposed to obtaining positive judgments of competence and avoiding negative ones. Since most of the research has been done with younger children, an important question is whether similar results will follow with secondary and college students.

Affective Variables Included in the Present Study

In the present study it would be impossible to collect data on all the affective variables contained in just the two models discussed. This section will offer a rationale for the variables chosen for inclusion in the present study. Figure 2 represents those aspects of the two models which are seen as most influential on achievement and on which data were collected. The square boxes contain the components of the model and the hypothesized processes for how attitudes influence achievement. In the rounded boxes are the various factors on which data were gathered.

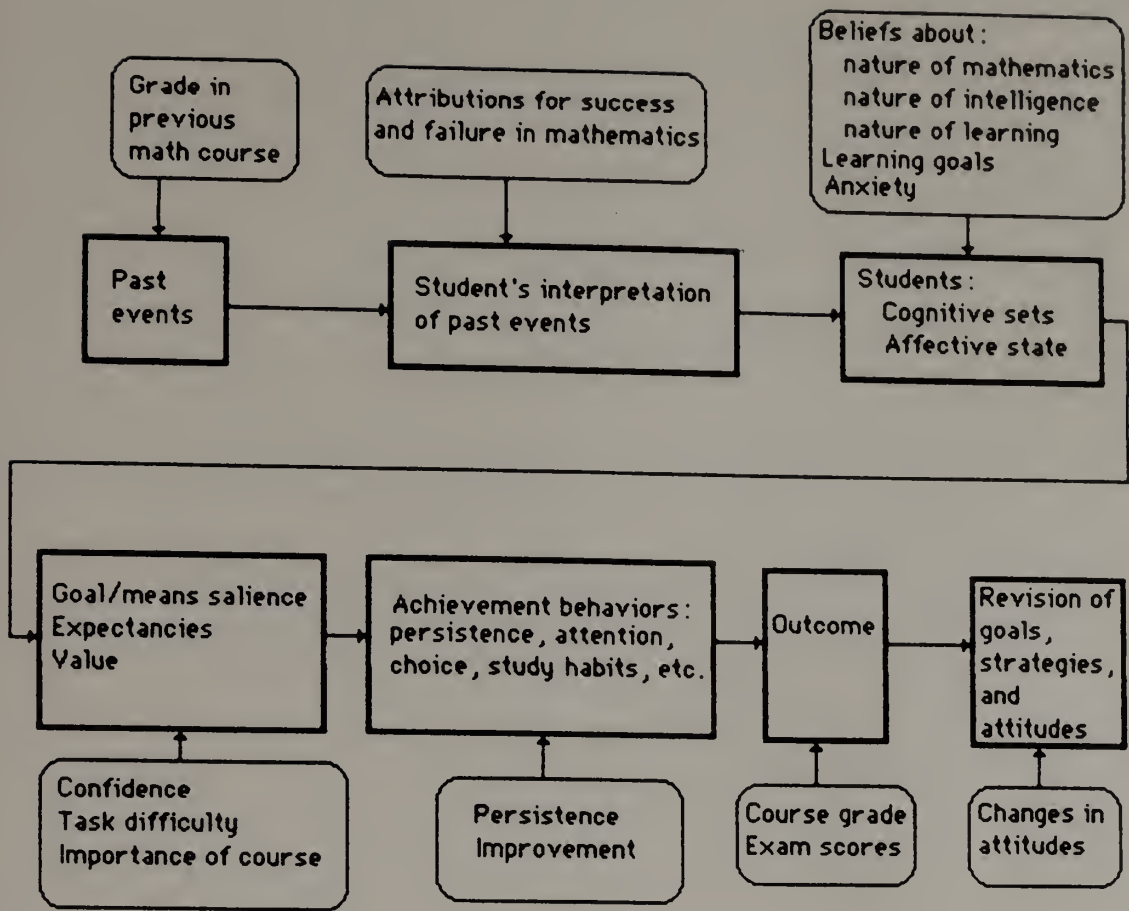

Figure 2: Model of achievement used in the study

Though the model in Figure 2 is more structurally connected to the Eccles et al. model, I have chosen the representational style used by Dweck and Elliott primarily because such a representation is easier to read. For example, since expectancy and values are seen as directly influencing achievement behavior, they have been included in the same box. This representational style also makes it easier to display those variables chosen for inclusion in the study.

Given the expectancy-value framework of both models, it was clear that measures of expectancy and value must be included. Given the fact that the students are in a remedial class, one would expect both larger variances in levels of anxiety and in significance of anxiety. Thus, a measure of anxiety was included. Since students' beliefs are one of the main purposes of this study, there are several measures of beliefs: beliefs about intelligence and related learning goals, beliefs about the nature of mathematics, and beliefs about learning mathematics. Finally, both models discussed above contained an attributional component. Other studies have noted success with modifying attributions, and there is a growing interest in mathematics education about causal attributions. Thus, measures of attributions for both success and failure were included.

These five areas--confidence, usefulness, anxiety, beliefs, and attributions--already push the limits of a single study, especially given the desire to include open-ended questions and to conduct interviews. Recalling the major purposes of the study, the goal here was not precision of measurement of individual variables or determining their precise influence on achievement but rather to better understand how these variables relate to one another and to determine if measures of various beliefs will significantly add to predictions of performance.

Certain elements in the two models previously discussed were omitted from inclusion in the study. Collection of data on some elements had to be considerably abbreviated, such as students' long- and short-term goals, the various values associated with learning mathematics (e.g., attainment value, utility value, and cost). Other variables were omitted because they were felt to be less influential with the population being studied than with younger students. For example, the Eccles et al. study found that the influnce of socializer's (i.e., parents, teachers, significant others) was significantly lower on older students than on younger students. This finding is consistent with findings from the developmental literature which indicate that older students generally have internalized many motivators which were previously seen as extrinsic (Connell and Ryan, 1984). Since the direct effect of socializers' attitudes and expectations on college students was felt to be small, that component of the Eccles et al. model was not included in this study.

The dynamics of the model are quite straightforward. Like the two models just discussed, the influence of past events is seen as mediated by the students' interpretation of those events. The students are seen as entering the mathematics course in the study with various cognitive sets (beliefs, theories, etc.) and affective states which influence the salience of different achievement goals and contribute to the expectancies and values attached to them. In turn, these goals, expectancies, and values influence various achievement behaviors such as persistence and performance in the course. Feedback on one's performance (assignments, quizzes, and exams) may or may not produce changes in the student's attitudes, strategies, and goals. Let us now look at the research on the specific variables included in the study.

Confidence

Confidence in learning mathematics is a particular component of self-concept of ability, defined as the assessment of one's own competency to perform specific tasks. In the general achievement motivation literature, numerous studies have shown a consistent, positive relationship between self-concept of ability and academic achievement (Covington and Beery, 1976; Nicholls, 1976; Covington & Omelich, 1979a, 1979b). In the context of learning mathematics, confidence has to do with how sure the student is of being able to learn new concepts and topics and how sure a student is of being able to do well in mathematics tests and courses. Numerous studies in the mathematics education literature have also demonstrated a consistent, significant, positive relationship between confidence and achievement (Crosswhite, 1972; Fennema & Sherman, 1976; Armstrong, 1980).

Perceived Usefulness of Mathematics

Another important variable is the student's perceived usefulness of mathematics which is a particular component of the construct called "task value" in the general achievement literature. Although most recent studies have examined perceived usefulness of mathematics with respect to how it affects students' choices to take future mathematics classes, as a component of task value it also affect how much effort students will expend in a particular mathematics class.

There are several aspects of this construct. For example, to what extent do students perceive learning math as an important activity? To what extent do they view a particular mathematics course as useful to them? Why do they view it as useful? A desire to do well in this course in order to finally master basic math concepts is much different than wanting to do well because "I have to take calculus next semester." Furthermore, a student tending to make defensive attributions for poor performance in mathematics is likely to state a low perceived usefulness of mathematics.

Anxiety

Although much progress has been made in theoretical constructions, in a recent review of the literature Reyes (1984) concluded that few programs have been effective in improving achievement while reducing anxiety. What do we know about anxiety and achievement? To begin with, we know that generally high achievement is related to low anxiety (Crosswhite, 1972; Aiken, 1976; Wine,1982). However, no studies have shown a clear cause and effect relationship (Reyes, 1984). Wine (1971) found that high-test-anxious students, compared to low-test-anxious students, tend to perform more poorly on cognitive tasks and to report more task-irrelevant thoughts (many of which are self-deprecating, such as, "I will never get this" and "I'm just no good at math"). In other words, high test-anxious students seem to be more concerned with how well they are doing while low-test-anxious students focus more of their attention on the task itself.

What we know about anxiety as a psychological construct has increased substantially in recent years. First, we must distinguish between facilitative and debilitative anxiety, for anxiety itself is not "bad." Second, Liebert and Morris (1967) distinguish between a cognitive and an emotionality component of anxiety. Worry, the cognitive component, is seen as cognitive concern about one's performance whereas the emotionality component is seen as arousal of the autonomic nervous system in evaluative situations. A consistent relationship has been found in studies between worry and performance while no consistent relationship has been found between emotionality and performance. Finally, we must distinguish between two types of anxiety, trait and state anxiety (Spielberger, 1972). State anxiety is time- and situation-specific and is activated when a student perceives a situation to be potentially harmful or threatening. Trait anxiety, on the other hand, is a relatively stable personality trait of being prone to anxiety. Richardson and Suinn (1972, cited in Reyes, 1984) have demonstrated that many people who suffer from math anxiety do not ordinarily exhibit such anxiety in other achievement situations.

Causal Attributions

Perhaps the most entertaining and persuasive introduction to the relevance of attribution theory was given by Ickes and Layden (1978, p. 27) when they cited a letter to "Dear Abby" which was printed under the headline, *She can't see beyond her nose.*

> Dear Abby:
>
> I am a 34-year-old woman who has divorced three husbands. (Not my fault. I always picked losers.)
>
> My problem is my nose. I had plastic surgery on it when I was 18, and the doctor botched the job, so at 21 I had it reshaped and then it was worse. I think it makes me look stuck up and keeps me from making friends.
>
> I went to a well-known plastic surgeon, and I offered to pay him in full in advance but he refused to take me as a patient! He said he

> didn't think any plastic surgeon could please me because I had "emotional and social problems" I should face up to instead of blaming everything on my nose. Then he insulted me further by suggesting that I use my money to see a psychiatrist!
>
> Abby, there is nothing wrong with my mind. It's my nose! Will you please recommend a good plastic surgeon? I can afford to go anywhere.
>
> *Determined in Hartford*

This letter brings to mind any number of students having trouble in math classes whose attributions for their failure (e.g., "the teacher doesn't like me," "the test was unfair") are likely to be as much a part of their failure as any cognitive deficits. In fact, some argue that as long as the attributions remain so maladaptive, a teacher's attempts to get the student to study more, to try harder, and to pay better attention are likely to be fruitless.

Attribution theory is not so much a unified theory as it is a collection of contributions that share several common aspects. According to the general attributional model, a student assesses whether s/he has failed or succeeded and has an emotional reaction, pleasure or displeasure. (It is important to note that the assessment often takes place below a level of immediate awareness.) These emotions, especially in the face of failure, prompt a search for the cause of the outcome along the three dimensions of locus, stability, and controllability. The locus dimension concerns whether an individual attributes the good or poor performance to internal or external factors. The stability dimension concerns whether the person believes the cause will change or not. The controllability dimension concerns whether or not a person believes s/he has control over the outcome.

Table 2 summarizes the three dimensions and gives examples of each kind of cause.

	Internal		External	
Controllability	Stable	Unstable	Stable	Unstable
Controllable	Typical effort exerted	Temporary effort exerted (for this particular task)	Some forms of teacher bias	Help from others
Uncontrollable	Ability	Mood	Task difficulty	Luck

Table 2: Possible Causes of Achievement Outcomes Acording to Locus, Stability, and Controllability (Adapted from Fiske & Taylor, 1984)

For example, a student attributing failure on a test to being tired (unstable factor) is more likely to do better on the next test than a student attributing failure to the teacher not liking him/her (stable factor). Similarly, a student attributing failure on a test to not going to the tutor for help (controllable factor) is also more likely to study harder the next time than a student attributing failure to low ability (uncontrollable factor).

Proponents of attribution theory argue that it is not success or failure per se but the causal attributions made for these outcomes that influence future expectancies and behavior. It is assumed that the manner in which one interprets outcomes guides the hope of subsequent success and thereby influences subsequent achievement-related behaviors (e.g., choice, magnitiude, persistence, etc.). Thus, the heart of attribution theory focuses on how causal attributions influence future expectations, emotions, and performance. In expectancy-value terms, the emphasis is on expectancy, with particular attention to changes in expectancy as a function of experiences of success and failure.

It is widely acknowledged (Reyes, 1984; Stipek & Weisz, 1981; Dweck & Elliott, 1983) that the attribution model has done much to increase our understanding of how students' success and failure affect their future achievement-related behaviors such as persistence, effort, and choice of challenging tasks. Factors seen as internal, unstable, and controllable (e.g., one's effort) are seen as most amenable to change. Attributions for failure to low ability are particularly paralyzing, because most students, especially by the time they arrive at college, view their mathematical ability as stable. Two studies by Dweck (1975) and Wilson and Linville (1982) have shown promising results of attribution retraining interventions.

Although the attribution model helps us to better understand students' behaviors and offers much promise for helping students to perform better in mathematics classes, it is important to note that a number of researchers have expressed concerns regarding the attribution model. There is speculation that the power of one's attributions for changing behavior may depend on when they occur. Eccles et al. (1983) argue that attributions may play a critical role in the formation of self-concept of ability, but when that self-concept has formed, attributions to ability may become epiphenomenal rather than playing a causal role in subsequent expectations and performance. If this is true, the implications of the attribution model for college remedial mathematics classes are seriously weakened, for by this time most students' self-concept of mathematical ability is fairly well formed, and it is hard to convince those who have done poorly in previous classes that the present math class is really different from others.

Attribution theory is also subject to the criticism that it contains a high degree of cognitive naiveté. Unlike scientific explanations, people's everyday explanations are full of inconsistencies; everyday explanations are often affected by motivational needs such as the desire to save face or look good. Furthermore, there is evidence that self-reports can be poorly related to future performance (Wilson & Linville, 1982).

A more basic question concerns the trust which many researchers put in cognition. Nisbett and Wilson (1977), among others, maintain that direct access to our own cognitive process is limited. To the extent that this is true, it may be problematic to give cognition such a central status in a theoretical model. In fact, we cannot be sure how much and what kind of causal work people really do. Fiske and Taylor (1984) note that there are a number of available models attempting to explain how indiviudals make attributions and how these affect behavior. They report that the tendency is shifting away from models which posit a quasi-scientific account of the causal inference process and a growing preference for those that emphasize causal inferences being drawn from a fairly rapid perusal of a few salient clues. It is simply very difficult to go through a lot of information to reach an inference, especially in a busy life. Fiske and Taylor note that there is some evidence that causal processing becomes more detailed and thoughtful as the issues themselves become more consequential.

Belief Systems

In the context of achievement motivation, we have seen the Dweck and

Elliott model propose how students' beliefs about the nature of intelligence and consequent learning goals can affect achievement. As previously mentioned, students' belief systems have received increasing attention in the problem solving literature as researchers have seen the need to look "beyond the purely cognitive" in explaining achievement. Let us now examine the types of beliefs which have been addressed.

In a recent paper, Schoenfeld (1983) describes how students' belief systems interact with other factors affecting the development of problem solving skills. He argues that there are three separate levels or types of analysis that may be necessary in order to obtain an accurate interpretation of students' problem solving performance: (1) an analysis of tactical knowledge, including facts, procedures, domain-specific knowledge, and "local" heuristics; (2) an analysis of "control" knowledge and behavior, including "strategic" or "executive" behavior and conscious metacognitive knowledge; and (3) an anlysis of consciously and unconsciously held belief systems, and the way that they "drive" problem solving behavior.

It is his discussion of this third level that is relevant to this study. Schoenfeld argues that "'purely cognitive behavior is extremely rare, and what is often taken for pure cognition is actually shaped--if not distorted--by a variety of factors" (p. 3). He maintains that any framework that ignores students' belief systems can result in severe distortion and misinterpetation of the data. Schoenfeld sees students' observed problem solving behavior as taking place within, and being shaped by, a broad social-cognitive and metacognitive matrix. That is, "the tangible cognitive actions that we observe are often the result of consciously or unconsciously held beliefs about (a) the task at hand, (b) the social environment within which the task takes place, and (c) the individual problem solver's perception of self and his or her relation to the task and the environment" (p. 3). This matrix, given in the form of a mathematical cross product, is shown in Figure 3.

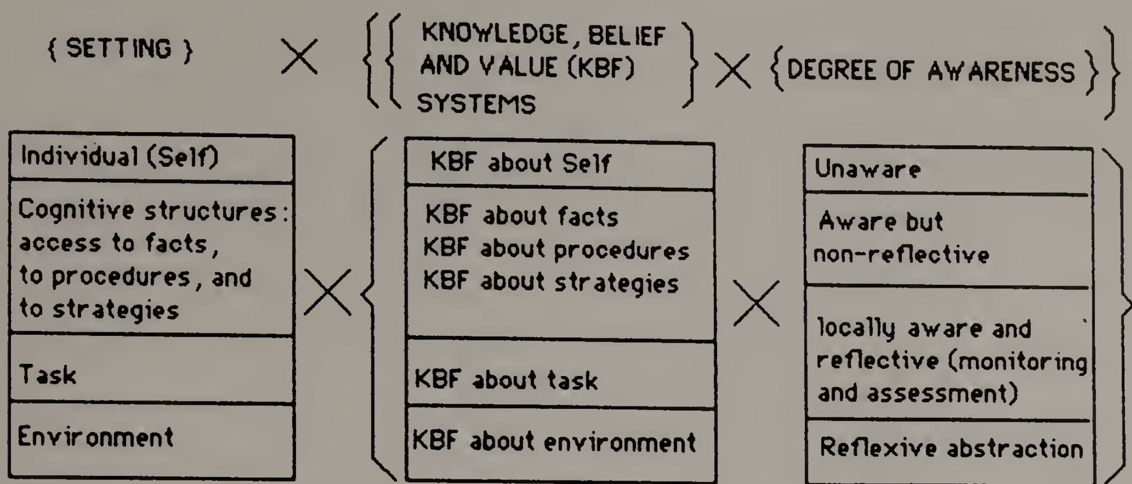

Figure 3: Matrix within which pure cognition resides (Schoenfeld, 1983).

Schoenfeld offers anecdotal evidence of the influence of belief systems on the learning of mathematics. Beliefs about the very nature of facts and procedures can determine students' performance. For example, he argues that a student who believes that mathematical knowledge must be remembered will be stymied when a particular object (for example, a procedure for constructing a line parallel to a given line) is forgotten, while another student, who believes that the procedure can be derived, will act rather differently. Another example comes from the effects of the environment, for example the belief that one must produce mathematics when one is solving problems in a math class. I recall a student of my own from a college remedial class. One day in class we had discused several different methods for solving a particular problem. Jeannette stayed after class and was obviously quite distressed, for not only did she feel that the method she had used was different from those discussed in the class, she was especially disturbed that her method was not "mathematical." In fact, she had carefully reasoned out the answer but without using any formulas or any "mathematics" beyond the four main arithmetic operations. Thus, she felt that she would receive no credit for her solution because it wasn't "mathematical."

Confrey (1980, 1982) sees students' conceptions of mathematics and mathematics learning as critical components in the student's construction of their understanding of mathematics. She states (Confrey, 1982) that "how one feels about the tasks (motivation) and what one believes to be the purpose of those tasks. . . must have an effect on the processes by which those tasks are undertaken" (p. 28). Examples of conceptions which impede the learning of mathematics include: the students' belief that the primary aim in math classes is to get answers, the "whole number mentality" in which the answer must be wrong if the answer is not in whole numbers, and the perception of mathematics as a fixed set of rules.

At this time, researchers have proposed several components of students' belief systems. The ones which will be included in this study are beliefs about the nature of intelligence and related learning goals, beliefs about the nature of mathematics, and beliefs about the nature of learning mathematics.

Sex-differences in Attitudes

The development of sex-differences in attitudes and achievement in mathematics has been well-documented by a number of researchers. (Sherman & Fennema, 1977; Fennema & Sherman, 1978; Dweck & Goetz, 1978; Licht & Dweck, 1983). However, few studies of sex-differences have been conducted with college age students, and studies with high school students have not produced conclusive results. The Eccles et al. (1983) comprehensive study with students in grades five through twelve concluded that few sex differences emerged. Dick's (1985) study with students in a college calculus class found no significant differences in attitudes between males and females. With these qualifications in mind, let us review the evidence on sex-differences with respect to the variables included in the study.

With respect to confidence in mathematics, females generally report lower confidence than males even when no differences in mathematics achievement are found (Fennema and Sherman, 1977, 1978). However, Frieze, McHugh, Fisher, and Valle (1978) conclude that while females' generalized expectances are lower than males, specific expectancies, like those of males', are largely determined by performance history. Thus, one would expect no significant sex-differences in expectancies for success in a specific math class. The Eccles et al. (1983) study supported this belief as females' expectations for performance in the current mathematics course were not different from those of males. However, they noted that when sex differences did emerge in measures of self-concept of math ability, females reported lower estimates of their ability than did males.

In her review of research on affective variables, Reyes(1984) reports that females tend to report higher levels of mathematics anxiety than males, but she noted that females also report higher level of other types of anxiety than males. It has not yet been determined whether differences in reported anxiety are because of true differences in anxiety or not.

Numerous studies have found significant differences in the career interest of males and females (Hilton & Berglund, 1974; Fennema & Sherman, 1977, 1978) The Eccles et al. (1983) study found that females reported math as less useful than males. Dick's (1985) study with calculus students found that differences in perceived usefulness of mathematics are not due to gender difference but to differences in academic plans. However, in the present study we are not interested in the students' perceptions of the usefulenss of a career in mathematics but rather in the use of basic mathematics.

With respect to attributions one finds a considerable amount of contradictory research findings. Reyes (1984) summarizes several studies which concluded that girls are more likely to see success as caused by effort and less likely to see success as caused by ability than are boys. In failure situations, girls are more likely than boys to attribute failure to lack of ability than to lack of effort. She notes that these differences are not large and that the data indicating the differences have often been collected in laboratory situations, and thus she cautions against generalizing to classroom situations until further studies are conducted. In reviewing the literature on sex-differences in attributions, Eccles et al. (1983) report that some studies reported that females attribute their failures more to lack of ability than do males, but other studies have either not found or have not reported sex differences. In their own study Eccles et al. (1983) found that when asked to recall a previous success and failure on a mathematics examination, males and females provided different attributions for their performances. Males attributed failure to ability less frequently than did females. In contrast, females attributed success more frequently to consistent effort than did males. In a study with high school students, Meyer and Fennema (1985) tentatively concluded that for males causal attributions might not be less important for males as predictors of future achievement, independent of prior achievement, than for females.

Summary

This chapter began with a review of the various difficulties confronting researchers in the affective domain investiating the relationship between attitudes and achievement in mathematics. These difficulties include the lack of a model of affect, the large number of variables hypothesized to affect achievement, and difficulties both in defining and measuring students' attitudes toward mathematics. A summary was given of recommendations in the research literature of areas and approaches for research. Two comprehensive models of achievement motivation were discussed, and research on the specific atttitudes included in the present study was reviewed. Finally, research on sex-differences in attitudes toward mathematics was summarized.

CHAPTER III

DESIGN AND METHODOLOGY

Introduction

This chapter presents a detailed description of the study. Since the design involves both quantitative and qualitative components, the rationale for using both methods is included. The construction of the instruments used in the study will be discussed. Finally, the methods by which the data were analyzed will be stated.

The construction of the study was guided by several issues. A primary purpose of the study was to address concerns raised in the research literature which indicated a need for studies to examine the influence of more than a small number of variables and a need to examine relationships among various affective variables. Additionally, no similar studies have been conducted with college remedial populations. Given the lack of previous related studies and given the acknowledgement of the lack of understanding about affective variables in general, the study is seen as a descriptive and exploratory investigation of the influence of affective variables on various achievement-related behaviors in a college, remedial mathematics course.

Four specific questions were addressed in the study:

(1) Do individual affective variables significantly affect performance? If not, will a constellation of affective variables produce greater significance?

(2) What is the nature of the relationships among the various

affective variables?

(3) Do (certain) affective variables have more influence on certain subgroups (e.g., male-female, relatively high-low ability, etc.)?

(4) Will students' attitudes on any of the variables measured change between the beginning and the end of the semester?

Combining Quantitative and Qualitative Methods

Because the purpose of the study is descriptive and exploratory (i.e., to better understand the influence of affective variables on mathematics achievement), it was felt that a combination of quantitative and qualitative methodologies would be most productive. Recently a growing number of scholars have argued not only that quantitative and qualitative approaches can be utilized jointly in educational research but that there are situations where they should be so utilized (Cook & Cook, 1977; Campbell, 1979; Spindler, 1982; and Schofield & Anderson, 1984). The reasoning behind this belief is that the two research strategies tend to have complementary strengths. Using both strategies in the same study allows the researcher to improve the accuracy of conclusions by relying on more than one type of data.

Rossman and Wilson (1984) state three functions of a mixed-design study: corroboration, elaboration, and initiatiion. Briefly, corroboration brings together data collected through more than one method to see if there is convergence in the findings. A mixed-design study may also be employed to use one type of data to elaborate the findings of the other, providing more richness and detail. A third function seeks to uncover variance in the areas where findings do not converge; in this methodoology, the mixed-design study can be used to initiate interpretations and conclusions, to suggest areas for further analysis, or to propose revisions of the entire research question. The present study is seen as basically a quantitative study in which the qualitative data will be used to elaborate the findings from the quantitative data and to provide clues for new interpretations and/or research questions.

There are a number of potential problems to be considered in making the decision to combine research methodologies. Cook (1979) indicates that using both methods can be expensive and time-consuming for the researcher. He also expresses concern that the use of combined methods requires the researcher to be skillled in both fields. These concerns were not taken lightly by this researcher. However, because significant but low correlations have so consistently found between attitudes and achievement, a mixed-design study should enable us to better understand the low correlations, if they are also found in this study, and to provide clues for presently unseen ways in which attiudes influence achievement.

Collection of Data

For the present study, data on the following independent variables were collected from 145 students in six sections of Math 010 (basic mathematics) on the second day of classes in the fall semester of 1985: anxiety, perceived usefulness of mathematics, confidence in mathematics, students' predicted grade in the course, attributions for success and failure in mathematics, beliefs about intelligence and consequent learning goals, beliefs about the nature of mathematics, beliefs about the role of the student and the teacher, and beliefs about the role of memorization and understanding in learning mathematics. The dependent variables for the study included exam average, final grade, and persistence.

Data for the study came from four major sources: (1) a six page questionnaire administered on the second day of the semester (Appendix A); (2) five essay questions, given one week later, concerning attitudes towards mathematics (Appendix B); (3) interviews after the first exam with sixteen students doing poorly in the course (the interview guide is in Appendix C); and (4) a three page questionnaire administered at the end of the semester (Appendix D).

There was a high degree of standardization in the teaching of the six sections of the course. All six instructors were teaching assistants in the Cognitive Processes Research Group, which directs the remedial mathematics programs at the University of Massachusetts. The instructors underwent three weeks of training in the summer before the course and met weekly during the semester with a supervisor. A syllabus was published at the beginning of the semester so that all classes followed the same pace. All students took the same exams at the same time in the same location. Chapter quizzes were standardized in that, although few questions were identical (to reduce passing answers from one section to another), they were designed to be structurally as similar as possible. Individual instructors were free to give addditional quizzes and to make minor modifcations in the homework assignments.

Selection of Subjects

Permission was obtained to administer the questionnaire. Participation in the study was voluntary, and a consent form was constructed (Appendix E), and it was approved by the Human Subjects Review Committee. Students were told the purpose of the study and that their responses would be very helpful in allowing researchers to better understand how various attitudes can both help and hinder the learning process. I encouraged additional comments, both to individual questions and general comments at the end of the questionnaire, in cases where the students felt such comments might be useful to me.

Selection of subjects for the interviews was determined in the following manner. After students had received their results from the first exam, I went into each class and asked for volunteers who were not satisfied with their present performance. I wanted to avoid the more pejorative "doing poorly" or "scored below 60 on the mid-term." Also, because of the exploratory nature of the study , I did not want to limit too severely the population I would be interviewing.

Construction of the Instruments Used in the Study

Before designing the questionnaires and the interview format to be used in the actual study, I conducted several pilot studies. The first pilot study was conducted with 56 students in Math 010 (basic mathematics) and Math 011 (elementary algebra) classes, both taught through the Cognitive Processes Research Group. Afterwards, I interviewed five of the subjects from the pilot study, both to assess the reliability of the questions used in the questionnaire and to determine if additional questions would be needed. As a result of the analysis of the pilot study and the interviews, enough modifications were made in the questionnaire to warrant another pilot study. This pilot was conducted with 23 students in an introductory education class at the University. This was felt to be the most suitable alternative population since most of those students would be taking Math 113 (Mathematics for Elementary School Teachers) in the following semester.

Guidelines for Developing the Questionnaires

Before examining in detail the four istruments used to collect the data for the study, let us first review some basic guidelines recommended for designing questionnaires. To prepare for the task of designing the questionnaires, a number of sources were consulted, especially Sudman and Bradburn (1983), Borg and Gall (1983), and several reviews of research in the affective domain of mathematics education. Three aspects of questionnaire design will be discussed: suggestions relating to overall design, methodological problems which must be addressed, and suggestions of a technical nature.

Sudman and Bradburn (1983) strongly stressed the lengthy process involved in developing good questions. Citing a number of methodological problems involved in this process, they advised plagiarizing whenever possible, in other words, making use of questions which have been used in previous studies. This was done whenever possible. Decisions about which questions to borrow and justification for questions which were self-designed will be given in the discussion of each construct.

A second piece of advice from the literature was to make the questionnaire meaningful to the respondent. This advice was not followed in the pilot study which was originally constructed with closed-ended questions, most of which had been taken from published questionnaires. The results were disastrous, for many overtly hostile responses came from students who wrote at the end of the questionnaire that they resented having to answer "dumb" questions. Other students mentioned resentment at having to answer closed-ended, forced-choice questions in which the response which they would have given was not included among the choices to be selected. The second pilot questionnaire included more open-ended questions and used forced-choice questions only when they were felt to be absolutely necessary. Furthermore, before administering the questionnaire in September, the researcher explicitly told the students that their responses were valuable. The response to the September questionnaire was much better. Although students were explicitly told that completion of the thirty minute questionnaire and fifteen minute mathematics diagnostic test was voluntary, only five out of 180 students chose not to participate in the study. In most classes, several students stayed after class either to ask for more details of the study or to share more of their own attitudes about mathematics.

A fundamental methodological question concerns the nature of self-reports, for the questions in the study ask for students' self-reports of their attitudes. In mathematics research, the most widely used self-report procedure has been Likert's summed-rating approach in which subjects are asked to respond to items by choosing the extent of their agreement on a five- or seven-point scale. Numerical values assigned to each reponse are added, and a total score is computed which represents the attitude toward the construct or topic represented by those items. Kulm (1980) acknowledges that self-report scales are an extremely valuable tool for assessing attitude but offers several warnings of a methodological nature to researchers in mathematics education intending to use self-reports to measure atttiudes. His warnings are included in the following discussion.

While pretesting a questionnaire, one can use several techniques to minimize various ambiguities which can damage an item's usefulness in the study. Given the subjective nature of the questions and the inherent limitations of language, Sudman and Bradburn urge that great care should be taken to ensure that the respondents are interpreting the questions in the way intended by the researcher. They warn that attitude questions are highly susceptible to the wordings used, especially if the questions are not very salient to the respondents. This is done by asking at least some of the respondents to indicate what they understood the questions (and alternatives when multiple choices are used) to mean. If possible, one should also pretest questions in different formats so that effects of various alternative formats can be assessed (for example, explicitly stated alternatives or no stated alternatives, an included or excluded middle, and measuring attitude strength in a separate question or in a single question).

Another issue concerns the specificity of the questions. Sudman and Bradburn argue against globally stated questions. Their position is that attitudes do not exist in the abstract but are about or toward "something."

Fennema and Behr (1980) share this view. Their argument is that mathematics is a complex discipline involving many kinds of related but diverse content and skills. To asume that a person feels the same toward different parts of mathematics is not reasonable. In discussing the problems of research in the affective domain, Kulm (1980) further advises that researchers should measure attitudes as they relate to the specific classroom situation being studied rather than expecting a more general measure to mirror the effects of a specific treatment or enviromental setting. He further adds that the researcher should explain as clearly as possible the attitude that a given instrument purports to measure. This will be addressed in the introduction of each section detailing the questions used for each construct. One problem encountered in the study was that a number of the standardized questions considered for inclusion were of a general nature. Thus, a balance was sought between including, as much as possible, questions designed and tested by other researchers and using questions which were specific to the setting studied.

Another methodological problem is that certain questions cannot be asked directly. For example, to determine the students' learning goals one cannot simply ask, "Are you more concerned about increasing your mathematical ability or getting a good grade?" for very few students would admit to the latter. Devising questions to circumvent this problem is more of an art than a science. Related to this is the warning that the researcher should be aware of the well-documented self-serving bias (Fiske & Taylor, 1984), that is, the tendency of people to answer questions in a way that makes them look good. One cannot eliminate this effect from entering into the questionnaire, but one can take steps to minimize the possibility and to be aware when it happens.

A final methodological issue concerns the manner in which the self-report data is gathered. Most commonly used are closed-ended questions. Closed-ended questions are more difficult to construct than open-ended questions but easier to analyze and less subject to coder variance. On the other hand, open-ended questions often give the researcher insights into the reasons behind the subject's response. Borg and Gall (1983) conclude that the objective of the particular question determines the type of question to be used. They also report that available evidence suggests that both formats produce very similar information. Kulm (1980) argues for inclusion of open-ended questions on methodological grounds. He argues that such questions have the potential for furnishing more valid data on attitudes than is possible with scales, for example, "Why are you taking this mathematics course?" and "What makes mathematics easy (difficult) to learn?" In this study, open-ended questions were used for two purposes: to reduce the lack of meaningfulness or boredom which subjects reported in the pilot study and to ask questions which will elaborate the data from the closed-ended questions.

In addition to the obvious technical advice regarding the writing of items in a questionnaire (e.g., be specific and write the questions in understandable language), one other technical consideration is relevant to the study. Concerning multiple choice questions, the determination of the choice categories can be crucial. Borg and Gall (1983) state that the best method of determining the categories is to ask the question to a number of respondents, and then use their anwers to develop the categories. If a number of unexpected responses occur, they suggest including an "other" category along with space for explanations. Another potential problem with multiple choice questions concerns the order of placement. For questions in which some responses are more socially desirable than others, it was suggested to place the least desirable alternatives first.

The September Questionnaire

Following is a detailed, item by item, reporting of each item in the September questinnaire, for each construct. Coding of multiple choice items was done by asking four other researchers to code the questions. After discussing the coding decisions with the other researchers, final determination of the numerical value of each response was made either by averaging the numerical values given by each researcher or by taking consensus values when they emerged.

Each section will begin with a brief statement of what the questions are attempting to measure. Each question will then be considered, including the following information: its reference symbol (e.g., the first anxiety question is ANX1); its placement in the questionnaire (see Appendix A); the method of coding for computer analysis (if no coding is mentioned, the standard one to five coding was used); the source of the question, when appropriate; and the rationale for its inclusion. Each section will end with the formula by which each construct was computed from the individual questions.

Anxiety

The intent here was to assess the student's overall anxiety when doing mathematics and to assess the student's anxiety when doing word problems and when taking tests.

The questions:

ANX1 (Part I, *7). The intent of this question was to obtain an overall assessment of the strength of the student's anxiety and to identify some of the perceived causes. The students' repsonses were scaled from one to five depending both on the number of responses checked and whether they were perceived to be minor or major factors.

ANX2 (Part III, *4). This question was based on a question on the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976, p. 28). The question was modified by placing it in the context of working on word problems. Since there is a heavy emphasis on problem solving in the course, an assessment of the student's anxiety while working on word problems was desired.

ANX3 (Part III, *10). The test anxiety questions on other instruments focused on measuring the relative amount of anxiety felt by the student. This question asks the student to assess the extent to which test anxiety affects his/her performance on a test.

The anxiety measure was computed in the following manner:

$$ANX = (ANX1 + ANX2 + ANX3)/3$$

Confidence

This measure consists of two components: a measure of overall confidence in basic mathematics and the student's predicted grade for the course.

CON1 (Part III, *1). No standardized questions about confidence were asked in the context of a specific course.

CON2 (Part III, *5). This was taken from the Fennema-Sherman Mathematics Attitudes Scales, (Fennema & Sherman ,1976, p. 21).

CON3 (Part III, * 2). It was felt that a measure of confidence with respect to the specific content of this course was needed.

CON4 (Part I, *4). Though more time consuming to code, the rationale for the inclusion of this question is derived from Kulm's (1980) assertion that open-ended questions can often gather more accurate information than a scaled question.

CON5 (PART 1, *7). Students checking "I'm just not confident that I really know the material" were given a score of one.

The confidence measures were computed in the following manner:

CON = (CON1 + CON2 + CON3 +CON4)/4 - CON5/2

PRED = the student's predicted grade in the course.

Perceived Usefulness of Mathematics

The intent here was to get a measure of the value of this course to the student.

USE1 (Part III, *3). This question was taken from the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976, p. 27).

USE2 (Part III, *6). This question was taken from The Second National

Mathematics Assessment (NAEP,1981, p. 143).

USE3 (Part I, *5). Students whose responses indicated that they need to know this mathematics for future courses had one or two points added to their total usefulness score. Thus, a student could receive a manximum score of six on this measure.

The usefulness measure was computed in the following manner:

USE = (USE1 + USE2 + USE3)/3

Beliefs About Intelligence

Both of Dweck's measures (on beliefs about intelligence and learning goals) were adapted with personal recommendations from her on how to modify them for the purposes of this study. Since her measures had been obtained from personal interviews with elementary school students, it was agreed that a revision of the format was necessary.

All of Dweck's questions were asked in a global context, assessing the degree to which the student felt that one's overall intelligence could change over time, especially through one's effort. This caused some conflict. On the one hand, there was the desire to remain as close as possible to Dweck's format. On the other hand, as previously mentioned, Fennema and Behr (1980) and Kulm (1980) both strongly advise against globally stated items. It was decided to retain half of the questions in the general format developed by Dweck and to reframe half of the questions in the context of the students' beliefs that one could or could not become better at learning mathematics.

Questions on beliefs about intelligence in general: IE1, IE2, IE3 (Part

II, *1, *2, *3).

Questions on beliefs about intelligence, framed in the context of learning mathematics: IE4, IE5, IE6 (Part II, *4, *5, *6).

The beliefs about intelligence measure was computed in the following manner:

Beliefs in general: IEG = (IE1 + IE2 +IE3)/3

Beliefs in the context of mathematics: IEM = (IE4 + IE 5)/2

Learning Goals

The following questions were intended to measure the learning goals of the student. The students are seen either as focusing more on increasing their competence in mathematics or as focusing on performance, either getting a good grade or avoiding a low grade.

LG1 (Part II, *7). The responses were assigned the following values: 1,5,1,3. This question was adapted from Dweck's instrument. Responses one and three are seen as equivalent in terms of focus on performance as opposed to competence. The first response indicates a focus on avoiding doing poorly while the third response indicates a focus on doing well. The second response is seen as the most incremental-oriented response. The fourth reponse was given spontaneously in the pilot study often enough to warrant its inclusion in the dissertation. This response seems to indicate both a desire for feedback and a desire to know how well one is doing. A student choosing two responses will be given a score which is the average of the two responses.

LG2 (PART I, *1-3). Dweck used only the above question to determine the students' learning goals. While this is probably sufficient, used in a personal interview and with elementary school students, it was not felt sufficient for this study. Thus, the first three questions on the questionnaire were designed to increase the reliability of the construct in the present study. To assess the reliability of this coding, I coded the questions at the beginning of the semester and then recoded them one month later. The correlation coefficient for the two codings was .87.

The learning goals measure was computed in the following manner:

$LG = (LG1 + LG2)/2$

Beliefs About the Role of the Student and the Teacher

The following questions attempted to assess the students' beliefs about the roles of the teacher and the student with respect to the extent to which the students favor activeness or passivness on the part of the student and the teacher.

ACT1 (Part I, *6). The responses were coded in the following manner: 5,4,3,1. The rationale behind this coding was that since all the other measures are scaled from one to five, this one should be scaled similarly. The fourth response was deemed to be the most different and thus it was assigned a value much lower than the others.

ACT2 (Part I, * 8). The responses were coded in the following manner: 2,5,3,1. The second alternative is the only one in which the teacher does not tell the student part of the answer. Consequently, it is given a score of five instead of four to be consistent with the range of one to five used in the other questions. This scoring device was preferred to giving a fifth alternative.

ACT3 (Part III, * 14).

The beliefs about learning measure was computed in the following manner:

ACTIVE = (ACT1 + ACT2 + ACT3)/3

Beliefs About the Nature of Memorization and Understanding

The intent here was to measure the students' beliefs about the nature of memorization and understanding in learning mathematics. The impetus for such questions came from provocative responses in the pilot interviews. Attempts to develop scaled questions were unsucessful. Thus, two essay questions were designed to measure this construct.

MEM1 and MEM2 were questions one and two in the essay questions (Appendix B). They were coded on a scale from one to five. To obtain a measure of the reliability of my coding, I coded the responses of two classes at different times. The Pearson correlation coefficients of the two codings were 0.78 and 0.85.

This construct was computed in the following manner:

MEM = (MEM1 + MEM2)/2

Beliefs About the Nature of Mathematics

The following three questions, all taken from The Third National Mathematics Assessment (NAEP, 1983, p. 28), were designed to get a measure of the students' beliefs about the nature of mathematics which might influence the way in which they studied in the present course.

MATH1 (Part III, *7); MATH2 (Part III, *8); MATH3 (Part III, *9).

The beliefs about mathematics measure was computed in the following manner:

MATH = (MATH1 + MATH2 + MATH3)/3

Attributions

Questions about attributions were constructed, based upon Weiner's (1973) formulation of the nature of attributions. Since Reyes (1984) and others had reported that students' attributions following failure often differ from their attributions for success, two components of students' attributions were obtained: attributions for success and attributions for failure.

Attributions for failure were measured by question 18 in Part II of the questionnaire. Attributions for success were measured by question five in Part I of the questionnaire. The two attribution measures were computed in the following manner: attributions for uncontrollable factors minus attributions for controllable factors. A higher score indicates a higher degree of perceived lack of control over one's performance in learning mathematics.

Mathematics Ability

Two measures were obtained: a measure of the student's conceptual skills from the Math 010 diagnostic test (see Appendix F) and a measure of the student's manipulative mathematics skills, (see Appendix G).

Other Items

Two other items were included in the study: the lowest grade which the student would be satisfied with in Math 010 (Part III, *16); and the student's grade in the previous math class (Part III, * 17).

Performance Data

Three measures of performance were obtained: persistence in the course, a weighted exam average, and the student's final grade. The measure of persistence was calculated by recording the percent of assignments attempted by the student during the semester. The weighted exam average was designed to be used as a dependent variable which indicated how well a student had mastered the material in the course. Using only the score on the final exam was felt to be too unreliable a measure of their performance. However, a simple average of the three test scores was also seen as unsatisfactory, for the final exam should be more indicative of overall learning in the course than the two mid-terms. The exam average used in the study was computed in the following manner: EXAM = exam 1 + exam 2 + (2 * final exam). This was also the formula used by the instructors in the computation of the student's final grade.

The December Questionnaire

There were two major reasons for including an end of the semester questionnaire in the study. First, data on items asked in both questionnaires could be used to measure the change in attitudes between September and December. Second, since several of the attitude measures were developed for this study, refinements in certain items or constructs could be made and modified, and new questions could be asked.

Because of time constraints, the December questionnaire had to be designed to be completed in twenty minutes. The December questionnaire is given in Appendix D, and the interested reader can see the exact nature of the changes, deletions, and additions of questions. A brief summary of the questionnaire is given below.

The questions on anxiety, confidence, and beliefs about mathematics are identical to those asked in September. The questions on the usefulness of mathematics were not included in the December questionnaire, partly because their inclusion in the pilot study and the September questionnaire had not been found to add to the study and partly because of time constraints.

The other attitude measures were modified. The beliefs about intelligence measure was modified in three ways. First, questions concerning beliefs about intelligence in general were deleted since they did not prove as useful as the questions framed in the context of mathematics. Second, the format was changed to the same Likert format used for the other attitudes. The original format was found to be confusing to some students, and the new format was less time consuming. A third modification was that question number six in the September questionnaire was broken into two separate questions since many students stated that they agreeed with both alternatives. The learning goals construct was reduced to one question which was identical to one in the September questionnaire. Modifications were also made in the questions on students' beliefs about learning in order to further refine that measure.

Two changes were made in the attributions questions. First, the responses were standardized to be more in line with other studies. In this way, the responses of the students in this study could be more fairly compared with those from other studies. However, the attribution questions in the December questionnaire were framed in a non-forced-choice format. Connell (1981) argues that, when asked to make attributions for success and failure in a forced-choice format, most students will choose among the alternatives listed. However, he argues that, if asked in an non-forced-choice format, many students respond that they do not know why they do well or poorly. Thus, a response of "I'm not sure why" was added to both questions about attributions to see if students responding in this way would differ on performance or on other measures from those students indicating either controllable or uncontrollable factors.

Several other questions, two with open-ended components, were included in the December questionnaire: satisfaction with course (*1); overall rating of the course (*2); changes in attitudes and beliefs (*3); extent of liking or disliking of math (*4); and predicted grade in the course (*24).

The Essay Questions

As previously mentioned, the students were asked to respond to five essay questions during the second week of the semester. Because of time constraints, these were not completed in class but at home. To encourage a high response rate, homework credit was given for completion. However, to minimize the possibility of students giving more socially acceptable responses or trying to guess what the "better' or "more mature" response was, two precautions were taken. First, homework credit was given in the following manner: complete credit if the essays were completed and no credit if not completed; thus, the nature of the response had no bearing on the homework grade. Second, the students were explicitly told that their actual beliefs would be most useful to me in helping me to better understand how attitudes toward mathematics aid and hinder the learning process.

The development of the essay questions was stimulated by students' responses from interviews during the pilot study. The most striking instance is worth reporting. In the course of the interviews it seemed that several students were using the words "memorize" and "understand" interchangeably. I decided to probe into this. Following is a segment of one conversation.

> Researcher: Correct me if I'm misunderstanding you. You seem to be saying that one way of learning that works best for you is to go over and over the material until it becomes familiar. Now where does understanding come in?
>
> Student: I try to keep understanding out of it. Because if I don't understand something, if I take that factor [Ed. note: in other words, if I try to understand the concept and master the formula or technique] then I'm really gonna get confused. But if I just do it and say "O.K., this what I have to do, then I say fine."
>
> Researcher: So you don't try to understand it, you just try to be able to do it?
>
> Student: Right, because the last time when I tried to understand it, it just blew everything away. Like, "How did they get this? How did they get that?" But if I can just know how to do the technique and

> memorize it, then that just helps me with problems and I don't have to understand it as much.

As a result of this and other students' responses, more open-ended, longer-response questions were designed and piloted in the second pilot study, and five questions were chosen for this part of the data gathering process. Responses to these questions were used in both the qualitative and quantitative parts of the study.

Construction of the Interviews

There were two purposes for the November interviews. One was to gain more understanding of the dynamics and patterns of attitudes among students doing poorly in the course. The other purpose was to assess the quality of the questionnaire so that it could be further refined. Thus, students were asked to explain the reasons for many of their responses on the September questionnaire, and additional questions were also piloted with this group.

To develop the interview format and interviewing techniques, several sources were consulted, especially Patton (1980), Yin (1984), and Miles and Huberman (1984). Among the possible interview formats, I chose the general interview guide approach. Unlike the more formal standardized interview, this approach allowed me "to explore, probe, and ask questions that will elucidate and iluminate" (Patton, 1980, p. 200) the area of students' attitudes in a mathematics course. Unlike the informal conversational interview, certain questions were asked in the same or very similar ways to all students. Thus, comparisons could be made for students' responses to those questions.

Patton (1980) mentions two potential weaknesses of the approach used here: reduced generalizability and possibly overlooking certain topics. Since the purpose of the interviews was exploratory in nature, the first weaknesses is not damaging, and care was taken to ask certain questions in the same way to all students, so that conclusions about the responses to those questions could be cautiously generalized. The potential weakness of overlooking certain important topics was minimized since I had conducted pilot interviews during the previous semester.

The selection of the subjects has been previously mentioned on page 33. All interviews were audiotaped, and written permission was obtained from each subject. During the interviews I made brief notes. None of the subjects seemed distracted by either the tape recorder or by my note-taking.

Patton (1980) raises a concern about interview methodology which must be addressed here. He states a concern that open-ended questions are often not truly open-ended. Although I benefitted much from his cautions, there were times when I deliberately asked non-open-ended questions. For example, when one student spoke of failing a test, rather than ask, "How did you feel?" I asked, "That must have felt awful." In the course of the interviews I felt a growing rapport develop between most of the subjects and myself. I felt many subjects making more efforts at the end of the interviews than at the beginning to try to convey to me their beliefs and attitudes about learning mathematics. Although I am aware of the controversy surrounding such an interviewer stance, I am also guided by

Patton's statement that "distance does not guarantee objectivity; it merely guarantees distance" (p. 337).

Analysis of the Data

Since this is a comprehensive study, a number of analyses of the data were conducted. The report of the analyses has been grouped according to the four basic questions of the study. The statistical tests were conducted using the Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975; Hull & Nie, 1981).

Question 1: If individual affective variables are poor predictors of achievement, will a constellation of affective variables produce greater significance.

Pearson correlation coefficients between all the independent and dependent variables were found and compared.

Several multiple regression analyses were conducted. In the first analysis, the measures of ability were entered as a group, and then all the attitudes were entered as a group to determine the total percent of variance explained by the attitudes above that explained by ability. Regression analyses were also performed according to the theoretical model of achievement motivation. In this case, measures of ability were entered, then the three measures of expectancy and value (confidence, predicted grade, and usefulness of mathematics) were entered, and then the remaining attitudes were entered. Finally, a stepwise regression was performed to determine the most significant factors among the variables used.

Question 2: What is the nature of the relationships among various affective variables?

Two analyses were conducted for this question. First, the Pearson correlation coefficients of the attitudes were analyzed to determine correlations between individual attitudes (e.g., confidence and anxiety) and between groups of attitudes (e.g., attributions and the various beliefs about learning mathematics). Second, a factor analysis was conducted to see if different variables formed larger factors.

Question 3: Do (certain) affective variables have more influence on certain subgroups?

At the beginning of the study, it was known that one division of the subjects would be males and females. In the course of the study, especially from the investigation of the qualitative data, it was hypothesized that for both high and low ability students (as determined by combined scores on the two mathematics ability measures), attitudes seemed to be less influential than for students with medium ability. Thus, another division was made of high, medium, and low ability students.

For both of the subgoups, regression analyses were conducted to determine the influence of the various attitudes on achievement. In addition, correlation coefficients were examined to see if there were different patterns in the relationships among the variables. Finally, descriptive statistics were computed to compare the means of the various attitudes for the subgroups.

Question 4: Will students' attitudes change from September to December?

To answer this question, the September and December means of several attitude scores were compared to see if the differences were statistically significant. T-tests were performed to determine significance.

CHAPTER IV
FINDINGS

This chapter is divided into four sections which correspond to the four questions of the study. Findings from the qualitative data will be considered in the next chapter since discussion of those findings is of a more speculative nature. Tables which are central to the analyses have generally been included in the text. Supplementary tables and longer tables have been placed in Appendix H and are referred to in the text at appropriate places.

Question One

If it is true that individual affective variables are poor predictors of achievement, will a constellation of affective variables produce greater significance?

Introduction

Since there are many dependent and independent variables in the study, and since the nature of regression analysis is rather complex, an introductory section before the analyses of the data are reported may be helpful to the reader.

The independent variables in the study consist of one group of ability variables (which include a test of conceptual skills and a test of manipulative skills) and four groups of affective variables. The first group of affective variables are those representing the students' expectancies for success and the value of success. The second group of affective variables include students' attributions for success and failure. The third group of affective variables include the "beliefs" variables, and the final group consists of the students' reported anxiety. The dependent variables in the study include overall exam average, final grade, and persistence during the course.

Table 3
Variables in the study

Measures of ability	
(DIAGM)	diagnostic test of manipulative skills
(DIAGC)	diagnostic test of conceptual skills
Expectancies and value of success	
(PRED)	the student's predicted grade
(CON)	confidence in mathematics
(USE)	perceived usefulness of mathematics
Attributions	
(ATTS)	attributions for success
(ATTF)	attributions for failure
Beliefs variables	
(IEM)	conceptions of intelligence in the context of mathematics on a continuum from incremental to entity
(LG)	learning goals for the course: competence or performance
(ACTIVE)	beliefs about the the role of the student in the learning process on a continuum from passive to active
(MEM)	beliefs about the role of memorization and understanding in learning mathematics
(MATH)	beliefs about the nature of mathematics
Anxiety	
(ANX)	anxiety
Dependent variables	
(EXAM)	weighted average of the three exams
(GR)	final grade in the course
(PERS)	persistence, measured by percent of assignments handed in

Mention should be made of two variables for which there are large numbers of missing values. Many students did not perceive their peformance in a previous mathematics class to be poor and thus gave no attributions for failure. Regarding students' beliefs about the role of memorization and understanding in learning mathematics (MEM), the measure of this variable was obtained from coding the students' responses to the essay assignment given in the second week of the answer. Of the 145 students who completed the questionnaire and finished the course, 97 students completed those essays.

In regression analysis, a missing value for one variable results in the data for that student being excluded from the analysis. This becomes a factor in some of the regression analyses, since there are a large number of variables in the study (13 including the two tests of mathematical ability). In regression analysis, the multiple correlation coefficient and the regression weights will not be meaningful when the ratio of subjects to variables becomes small; a rough rule of thumb is to avoid ratios of less than ten to one. Thus, when subsets of the total population were analyzed (for example males and females), preliminary analyses were conducted to determine if certain variables could be eliminated from the analyses in order to maintain a reasonable ratio between subjects and variables. When this was done it will be noted. Additionally, when results of a surprising nature or magnitude were encountered, various tests of the data were conducted such as plotting the residuals and examining the beta values to assess the validity of the results. When such tests were done they will also be reported.

Concerning the two measures of performance in the course, (EXAM) and (GR), both the ability measures and the attitudinal measures were more highly correlated with students' exam averages than with their final grades. Although exam average is by no means a true indicator of how much a student has learned in a course (especially for students experiencing high levels of test anxiety), it is felt that it is a better indicator of a student's performance than the student's final grade. Whereas the range of the grades was from 0 to 4 and in increments of 0.5, the range of the exam average was from 7 to 95 and was composed of much smaller increments. Also, the final grade is determined by a number of factors: homework average, quiz average, exam average, and a more subjective class participation score. Thus, regression analyses with exam average as the dependent variable of performance will be discussed in the text. Several analyses with final grade as the dependent variable were run to determine if differential patterns for the influence of the attitudinal variables emerged, and none did. These analyses have been included in Appendix H and are referred to during the discussion of regression analyses with exam average.

Finally, since a number of regression analyses will be reported in this chapter, the reader will benefit from an explanation of the format of the regression tables (Pedhazur, 1982). In each table, the independent variables will be listed on the left. The first column of figures represents the total percent of variance in the dependent variable (e.g., exam average) explained by the independent variables, and is symbolized as "ADJRSQ" or the adjusted r square, since in a multiple regression analysis the computed r square value must be adjusted to take into account the number of variables entered in the analyses. The second column represents the change in the F value from the previous step, and the third column represents the significance of this change. The final two columns represent the degrees of freedom and the residual for each step.

Performance

To assess the influence of attitudes on performance, a series of analyses were performed on the data. First, Pearson correlations were computed. The Pearson correlations between the various independent variables and the three dependent variables are shown below in Table 4. Those showing significance below the .01 level are shown in bold face. One can see from the table that the single best predictors of performance in the

Table 4
Pearson correlations between independent and dependent variables

	DIAGC	DIAGM	PRED	CON	IEM	LG	ACTIVE	MEM	MATH	ATTS	ATTF	ANX	USE
EXAM	**.40**	**.56**	**.39**	.14	.15	.08	-.10	.04	.05	**-.24**	**-.25**	-.05	-.09
GRADE	**.25**	**.43**	**.30**	.02	.14	.09	-.08	-.03	.01	-.15	-.19	-.03	-.08
PERS	.05	.18	**.23**	.12	.02	-.02	-.05	-.11	.04	-.19	-.18	-.07	-.09

course are the two diagnostic tests and the students' predicted grade. Of the attitudinal variables, only the attributions for success and failure were significant. Only one variable, the students' predicted grade in the course, showed a significant correlation with the students' persistence in the course, though three other variables approached significance.

It was not expected that the Pearson coefficients for most of the attitudinal variables would be as high as the coefficients for ability or for confidence, but findings to be discussed shortly will show that the combined influence of attitudes on performance is significant and that attitudes seeem to exert a differential influence on different subgroups. However, the low Pearson correlations between individual predictor variables and both performance measures strongly support the contention raised in Chapter I that individual attitudes are weak predictors of peformance at best (Dick, 1985).

To assess the combined influence of the affective variables, several regression analyses were performed. Because of the missing values in ATTF and MEM, including both variables in the analysis would produce a regression analysis with 13 variables and only 56 subjects. Since a separate analysis showed that the attributions for failure added no significance after attributions for success were entered, the data in the next two regression tables include all the variables except ATTF. As shown in Table 5, it was found that the attitudes, entered as a group, added significantly to the variance explained by ability alone. The results of the same regression

Table 5
Results of multiple regression analysis indicating influence of ability and all attitudes on exam average

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
ABILITY	.3429	21.34	.000	2	76
ATTITUDES	.4933	3.26	.002	12	66

analysis performed with the final grade as the dependent variable are shown in Table 21.

In the next step of the analysis, the independent variables were added in accordance with the model of achievement motivation. According to that model, students' expectancies and values directly influence achievement while other affective variables influence achievement indirectly by their influence on the students' expectancies and values. The results of this analysis are shown in Table 6. (The same analysis with final grade as the dependent variable is shown in Table 22.) The table shows that after measures of students' ability and students' expectancies and values of success are partialed out, other attitudes explain a significant but small percent of the variance in the dependent variable.

Table 6
Results of multiple regression analysis indicating influence of ability, expectancies and value, and other attitudes on exam average

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
ABILITY	.3428	21.34	.000	2	76
EXPECTANCIES & VALUES	.4172	4.23	.008	5	73
OTHER ATTITUDES	.4933	2.57	.021	12	66

Because of the exploratory nature of this study, a stepwise regression analysis was also performed to determine which variables in this study were the most significant predictors of exam average. The results of that analysis, shown in the table below, indicate that the students' predicted grade and attributions for success add significantly to the regression equation after the influence of ability is considered. Two other variables, confidence and beliefs about memorization and understanding, contribute a smaller amount of predictive power to the regression equation.

Table 7
Stepwise multiple regression analysis indicating the most influential determinants of exam average

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
DIAGM	.3255	28.50	.000	1	56
PRED	.4172	9.81	.003	2	55
ATTS	.4766	7.24	.009	3	54
CON	.5138	5.12	.028	4	53
MEM	.5437	4.48	.039	5	52

Persistence

Persistence in the course was measured by the total percent of assignments turned in to the teacher. The measure was constructed in this manner, as contrasted to the student's homework average, to avoid biasing the measure in favor of students simply having more ability. For example, a more capable student could show much less persistence (i.e., hand in fewer assignments) than a struggling but persisting student and yet have a higher homework average.

From the table of correlation coefficients in Table 4 we see that none of the independent variables, alone, were strong predictors of persistence in the course. Only the test of mathematics skills, predicted grade, and both attributions for success were significant at or below the .01 level.

A preliminary regression analysis showed that the measures of students' ability did not explain a significant amount of the variance in persistence. Thus, since we are interested here in determining the influence of attitudes on persistence, a stepwise regression was performed using all of the attitudinal variables. The results are given in Table 8. The results show that only two variables explain a significant amount of the variance in the students' persistence in the course--one of the measures of confidence (predicted grade) and the students' conception of the role of memorization and understanding in the learning process. However, taken together, these two variables explain only 15 percent of the total variance in the amount of persistence. Thus, other factors, not included in this study, determine most of the students' persistence.

Table 8
Stepwise multiple regression analysis indicating the most influential determinants of persistence

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
PRED	.0682	5.25	.026	1	57
MEM	.1530	6.68	.012	2	56

<u>Summary</u>

In summary, the measures of students' ability were the strongest predictors of performance in the course, which is to be expected. Of the attitudes, only two measures significantly increased the amount of variance explained in the students' performance--the students' predicted grade and students' attributions for success. That the attributions were significant predictors of performance lends support to the increasing attention being given to attributions in mathematics education research (Meyer & Fennema, 1985; Kloosterman, 1985).

That the beliefs measures fared so poorly is surprising, for it had been thought that especially in a remedial course with much emphasis on problem solving, the students' beliefs would contribute significantly to success or failure in the course. However, the students' conceptions of intelligence showed only a modest Pearson correlation with performance and the students' beliefs about the role of memorization also contributed modestly to the regression equation.

Several conclusions are possible and will be more thoroughly discused in the next chapter. First, it is likely that one source of the low correlations lies in the fact that most of the beliefs measures contained only a few items, and thus the measures may not be accurately measuring these constructs. Additionally, this was the first attempt to measure some of these attitudes, and it generally takes some time to refine both the definition and measurement of a new construct. Another possible cause of the low correlations is that, for post-secondary students and/or for students in a remedial course, their beliefs about mathematics or about how one learns mathematics may simply not be signifiantly related to performance. A third possible cause is that beliefs have a differential influence on different kinds of students. This possibility will be further investigated in the third section of this chapter.

It is also noteworthy that the usefulness of mathematics measure (seen as a component of task value in the achievement motivation model) was such a poor predictor of performance in the course. This may reflect a reality that the usefulness of mathematics to students in this course is not as significant a determinant of performance as the students' expectations and confidence of success. It may also reflect inadequate measurement of this construct. Eccles et al. (1983) noted in their study that less systematic research has been done on task value (of which usefulness is a component) than on expectancies (of which confidence is a component).

Question Two

What is the nature of the relationships among the various affective variables?

Descriptive statistics

We will consider this question in stages. First, we will examine the descriptive statistics for the affective variables. Following this will be a discussion of various correlations between both individual variables and groups of variables. Because of the large number of variables in the study, only correlations of theoretical interest will be discussed, and the interested reader may refer to Table 23 for a complete list of correlation coefficients among all the variables. Finally, an exploratory factor analysis among the independent variables will be discussed.

First, let us examine the descriptive statistics for the affective variables, shown in Table 9 on the next page. The mean predicted grade of

Table 9
Descriptive statistics for the attitudinal variables

	Range	Mean	Standard deviation
Predicted grade	0 to 4	2.92	0.60
Confidence	1 to 5	2.71	0.98
Usefulness	1 to 6	3.88	1.14
Anxiety	1 to 5	3.15	0.80
Conceptions of intelligence in general	1 to 5	3.87	0.79
Conceptions of intelligence in mathematics	1 to 5	3.40	0.94
Learning goals	1 to 5	3.08	0.97
Beliefs about activeness	1 to 5	3.44	0.77
Beliefs about memorization	1 to 5	3.11	0.66
Beliefs about mathematics	1 to 5	3.48	0.60
Attributions for success	-2 to 4	0.73	1.50
Attributions for failure	-4 to 7	2.77	2.51

2.92 (over two-thirds of the students predicted a grade of B or higher) seems to indicate that students are generally optimistic about their ability to do well in the course.

The students' scores on the perceived usefulness of mathematics construct were not normally distributed, with scores from 2.5 to 5.0 receiving relatively equal numbers of responses. One interpretation of this is that some students see this as their last mathematics course while others plan to take future mathematics courses (e.g., precalculus, calculus, and/or statistics).

The relatively low level of reported anxiety was surprising and may relate to the basic content of the course and the students' relatively optimistic predicted grade for the course.

The means of most of the beliefs measures hovered around the middle value of three, indicating that most students were inclined toward neither extreme. Plots of the distributions of the beliefs variables showed relatively normal distributions. Two graphs (conceptions of intelligence and learning goals) showed bimodal distributions. Since these two constructs are closely related theoretically, this pattern of similarity is to be expected.

Concerning the attributions for success and failure, recall that a higher score on these measures indicates attributions toward uncontrollable (as opposed to controllable) factors. The data indicate that students' attributions for failure, compared with attributions for success, lean more heavily toward uncontrollable factors, even when taking into consideration the differences in the ranges. The general attribution literature (Fiske & Taylor, 1984) has noted this tendency in other areas also, that is, the tendency to take credit for our successes but not for our failures.

The difference between the means of the conceptions of intelligence in general and in mathematics were statistically significant ($t = 5.85$, $p < .001$, df 139). This is interpreted as saying that students' general conceptions of intelligence appear to be more incremental (as opposed to entity) than their conceptions of mathematical intelligence (see Chapter II, p. 27, for a discussion of these terms). It was the expectation of this finding that caused me to ask some of the conceptions of intelligence questions in the context of learning mathematics. Recalling the concerns raised by Kulm (1980) and Fennema and Behr (1980) about asking global questions concerning students' attitudes about learning mathematics, it was hypothesized that the conceptions of intelligence questions should be framed in the context of conceptions of mathematical intelligence.

The data from the two measures of conceptions of intelligence is at once encouraging and discouraging. Several developmental studies have noted that as students become older, their conceptions of the relationship between ability, effort, and achievement change. Harari and Covington (1981) found that younger students seem to view ability as fluid, malleable, and highly dependent on effort. Framed in Dweck's terms, they favor incremental, as opposed to entity, conceptions of intelligence. Harari and Covington found that, by college, ability is seen as a more stable factor and perceived academic outcomes are felt to be primarily a function of ability. For example, "Well, if someone is not smart, they can only do so well" (p. 26). That the students' responses in this study strongly lean toward more incremental conceptions of intelligence (mean score of 3.88 on a one to five scale) is encouraging. On the other hand, that their conceptions of intelligence in mathematics are significantly lower than their conceptions of intelligence in general is discouraging. Such data imply that students' see less possibility of changing their ability to learn mathematics.

Relationships Among Attitudinal Variables

Although many studies have investigated the relationship between individual attitudinal variables and achievement, the relationships among the various attitudinal variables has received little attention and was a research question posed as worthy of study by Reyes (1984). Data on eleven attitudinal variables was obtained in this study, and such a large correlation matrix does not easily lend itself to discussion. The interested reader can refer to Table 23 in the Appendix for the entire table.

For some variables, one would not necessarily predict a high correlation. For example, there is no reason to expect that students expressing predominantly incremental conceptions of intelligence will indicate a higher perceived usefulness of mathematics than students expressing predominantly entity conceptions of intelligence. Thus, we will break the cumbersome eleven-by-eleven matrix in Table 23 into theoretically related bits.

Let us first consider a group of five variables which can be loosely grouped under "beliefs about learning mathematics." While each of the variables was designed to measure a different belief, from a pedagogical perspective one would hope that these beliefs would be moderately related as opposed to highly related or not related at all. Extremely high correlations would indicate that the measures are not usefully different. Extremely low correlations would indicate either that the constructs had either been poorly defined or measured or that the students' beliefs are not related very well, a conclusion which would have serious pedagogical implications. Table 10 shows a matrix representing the values of the ten possible correlation coeffients between the beliefs variables. For the most part the relationships are as one would expect. For example, the higher relationship between IEM and MEM would be expected. This indicates that students expressing incremental conceptions of intelligence favor understanding the material over simply memorizing, and more significantly, that students favoring entity conceptions of intelligence favor memorizing over understanding. Consider also the relationship between MEM and MATH. Once again we would expect a higher relationship between these two variables because one of the MATH items asked the students to state their extent of agreement or disagreement with the statement, "Learning mathematics is mostly memorizing.

Table 10
Correlation coefficients of the "beliefs" variables

	IEM	LG	ACTIVE	MEM
LG	.22			
ACTIVE	.18	.31		
MEM	.36	.32	.31	
MATH	.12	.28	.19	.31

Two variables which, according to Dweck and Elliott's (1983) model, should be highly related are conceptions of intelligence and learning goals. However, the correlation coefficent between these two variables is only .22 (statistically significant at the .01 level), much lower than expected. Since Dweck's studies were with younger students, one explanation for the low correlation is that with older students these two constructs are not as highly related. Another explanation is that the constructs were not accurately measured. This is quite possible since each measure was obtained from only two responses, because at least one question for each variable had to be discarded.

Another series of relationships which are of interest concern the relationships between confidence and the other attitudes. Achievement motivation theory suggests that other attitudes influence performance through their influence on students' expectancies and value of success. As reported earlier, the students' predicted grade in the course was highly related to performance. The table below shows the correlation coefficients between all the attitudes and the students' predicted grade. Correlations which are significant below the .01 level are in bold face.

Table11
Pearson correlations between other attitudes and predicted grade

	ATTS	ATTF	IEM	LG	ACTIVE	MEM	MATH	ANX	USE
PRED	**-.29**	-.16	**.30**	.12	.10	.20	.16	-.19	.05

One can see that two affective variables are significantly related to the students' predicted grade: attributions for success and conceptions of intelligence. It is noteworthy that, among the attitudinal variables other than the two measures of confidence, these two variables also showed the strongest individual correlations with exam average. Thus, their influence on performance in the course may very well be due to their influence on the students' confidence. Stated in another way, the data suggest an experimental study which would examine whether positive changes in students' attribution patterns and conceptions of intelligence would result in increased achievement. Success with attribution training interventions with both younger and college students has been reported in the literature

(Dweck, 1975; Wilson & Linville, 1982).

It is also noteworthy that Fennema (1982) had expressed concern that anxiety and confidence in mathematics are not distinct attitudes. At least in this study, it would appear that, although highly related, they are distinct because the measures of confidence were much more related to performance than was the measure of anxiety.

Factor Analysis

An exploratory factor analysis was conducted with the attitudinal variables to see if there might be larger factors involved. Several factor analyses were conducted using the SPSS program. The analysis was conducted using a modification of the principal factoring without iteration method (PA2); at present, this is the most widely accepted factoring method. The computed factors were rotated using the equimax rotation principle, which is a compromise between the quartermax rotation (which centers on simplifying the rows of a factor matrix) and the varirmax rotation (which centers on simplifying the columns of a factor matrix). The results of the analysis are reported in Table 12 on the next page.

Since the students' predicted grade and confidence in mathematics both load most heavily on the first factor, one could tentatively label this factor a measure of confidence. The five beliefs variables all load most heavily on the second factor, though several of them also have large loadings on other factors. The attributions for failure factor loads most heavily on the third factor while the loadings of attributions for success are split between the first and third factors, indicating that attributions

Table 12
Factor analysis of attitudinal variables

	FACTOR 1	FACTOR 2	FACTOR 3
PRED	.58	.14	-.18
CON	.89	-.02	-.15
ATTS	-.29	.06	.18
ATTF	-.11	-.06	.72
IEM	.30	.35	-.13
LG	-.02	.60	-.11
MEM	.15	.57	-.32
ACTIVE	.23	.49	.06
MATH	.04	.40	-.21

for success may be more related to confidence. Though one must be careful of making definitive statements from factor analysis, the results of the factor analysis conducted in this study support the contention that the measures of confidence, beliefs, and attributions are indeed measuring different attitudes, and the contention that the various beliefs measures are likely subcomponents of a larger construct--beliefs about learning mathematics.

Variance in Students' Responses

As was seen previously, individual correlations between independent and dependent variables showed that, of the attitudes in the study, only the attributions for success and failure showed significant correlations with exam average. In examining the data, it was noticed that there was a great deal of variance in the responses given by quite a few students. For example, on the one hand, a student would agree with the statement that

"You can tell how smart you'll be in the future by how smart you are now." Yet, the same student would also strongly agree with the statement that "If someone isn't very good in math in high school, they can be much better in math when they're older." Similarly, a student would respond that s/he would never "rather have someone show me how to do a difficult math problem than to try to work it out myself." However, the same student, on question eight on part II of the September questionnaire (which asks what you would want to happen when you get stuck in class) would check the response "the teacher sits down and shows you how to do the rest of the problem. Then you go on to the next problem."

The lack of intraindividual consistency in students' attitudes has been commented on by other mathematics researchers (see Lesh, 1982; Fennema & Behr, 1980) and will be further discussed in the next chapter. From a quantitative point of view, a measure of variance was computed to determine the relationship between such variance in responses and performance in the course, the hypothesis being that students whose responses showed high variance would do less well because a high variance would be indicative of a student with poorly formulated or unstable attitudes.

A measure of the lack of consistency in responses was computed in the following manner. The student's variance in responses to the six conceptions of intelligence questions was computed. Then the student's variance in responses to the seven questions about learning goals and beliefs about the activeness of learning was computed. The two variances were summed to give a total variance score (VART). That the measure of variance is so highly inversely related to the students' exam averages ($r = .24$, $p < .002$) supports the hypothesis that unstable or undeveloped attitudes are more reflective of the unsuccessful as opposed to the successful student.

Summary

The evidence in this section is, for the most part, consistent with what was expected. The students' reported levels of confidence were moderate and perceived usefulness of basic mathematics were higher, though the level of anxiety was less than expected. The means of the beliefs variables were neither extremely high nor extremely low.. The attribution scores indicated a tendency toward attributions for success and failure to uncontrollable factors, which was expected in a remedial population.

The moderate correlations between the various beliefs variables and their similar loadings on the factor analysis indicate that it may be useful to develop a larger construct of beliefs about learning mathematics within which there are a number of subconstructs. However, the generally low correlations between the beliefs variables and the measures of confidence is not encouraging. The achievement motivation model developed by Eccles et al. (1983) proposes that one's expectation and value of success in a course directly influence performance and that other attitudes influence performance indirectly through their influence on expectancies and values. Again, one has to consider the reliability of the attitudes, since most were computed from only a few items. Another possibility is that these attitudes, on the whole, are not as influential as had once been thought or that their influence is not uniform on all students. This latter possibility will be discussed in the next section.

Finally, another factor which might be operating was considered, that the variance in the students' responses might be as important as their actual responses. The VART measure was strongly related to performance and a number of students were found to respond to some items in ways that contradicted their responses to other items. Thus, in this course, it seems possible that many students' beliefs about learning mathemtaics may be very poorly developed and that this factor itself may be a significant influence on performance.

Question Three

Do (certain) affective variables have more influence on certain subgroups (e.g., male-female, relatively high-low ability, etc.)?

Differences Between Males and Females

In Chapter 2, it was noted that enough differences in attitudes toward mathematics between males and females had been found in previous studies to warrant examination for differences in the present study. In this section, the data for females and males will be analyzed in a number of ways. We will compare the means of the variables in the study between the two groups. To assess possible differences in the relationship between the variables and performance, we will examine Pearson correlations between attitudes and performance and also the results of regression analyses. Finally, we will look for differences in the relationships among the attitudinal variables.

Examination of the mean scores of females and males on the attitudes (Table 24 in Appendix H) reveals a significant difference in only one attitude, confidence in learning mathematics ($t= 2.54$, $p = .012$, $df = 140$). This is noteworthy, for the means of the predicted grade were virtually identical. This corresponds to the findings of Eccles et al. (1983) who found that, in general, males report more confidence in mathematics but that in the context of a specific course they found no difference between confidence in males and females.

However, there were significant differences between males and females when the data were examined in other ways. Table 13 below shows Pearson coefficients between the variables in the study and students' exam average. Those showing a significance level less than .01 are shown in bold face. In the case of the males, the combined diagnostic test scores and both measures of confidence were significant predictors of exam average while,

Table 13
Pearson correlations between independent variables and exam average for females and males

	DIAG	CON	PRED	ATTS	ATTF	IEM	LG	MEM	MATH	ANX	USE
FEMALES (N=82)	**.49**	.07	.25	**-.32**	-.25	.15	.08	.10	-.07	-.13	-.10
MALES (N=63)	**.68**	**.30**	**.56**	-.15	-.24	.11	.05	-.05	.22	.06	-.07

for females, the combined diagnostic test scores and attributions for success were significant predictors of exam average.

Significance tests were performed on the differences between the females' and males' correlation coefficients by performing a test for significance between the differences of two independent correlation coefficients using the Fischer r to Z transformation in Hayes (1981, p. 465). Only the differences in the the correlation coefficients for the diagnostic test scores and the predicted grade were statistically significant for the numbers of students involved in the study. Similarly, although most of the correlation coefficients between attitudes and exam average were higher for the females than for males, none of the differences between these correlations were statistically significant.

To assess differences between females and males regarding the combined influence of ability and attitudes on performance, several regression analyses were performed. Before presenting those results, a few comments are in order. For the purposes of conducting regression analyses, the number of females (81) and males (63) in the study is already low relative to the number of variables in the study (13). Thus, the large number of mising cases for two variables, ATTF and MEM, precludes their inclusion in the regression analyses. Preliminary analyses determined that the diagnostic test for conceptual skills adds no significance to the regression equation beyond that determined by the test of manipulative skills, and so it was also excluded. Since the Pearson correlations of two other attitudes, USE and ACTIVE, have not approached significance in general or for males or females, these two variables were also excluded. The additional exclusion of these two variables produces a regression equation with 67 females, 56 males, and 8 variables.

As was done previously, a first regression analysis was conducted to determine the combined influence on performance of all the attitudinal variables. Since some variables included in those previous analyses have not been included in the present analysis, the table below reports the results for all students as well as for females and for males.

Table 14
Results of regression analysis indicating the influence of ability and all attitudes on the exam average of females and males

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
ALL STUDENTS					
ABILITY	.2897	50.75	.000	1	121
ATTITUDES	.3677	3.13	.005	8	114
FEMALES					
ABILITY	.1239	10.33	.002	1	65
ATTITUDES	.2829	3.06	.008	8	58
MALES					
ABILITY	.4986	55.69	.000	1	54
ATTITUDES	.4843	0.79	.602	8	47

The results are striking, for they show that by far the most powerful predictor of exam average for males is their ability and that attitudes do not add any predictive power. For the females, on the other hand, ability has much less predictive power, and the attitudes add significantly to the total percent of variance in the exam average. The magnitude of the differences between males and females was surprising enough to warrant examination of the regression data to discern if other factors, not in the study, might be operating in a systematic manner. However, scatterplots of the residuals in the regression equation were distributed randomly.

In the next regression analysis, the variables were entered in accordance with the model of achievement motivation. The results of this analysis are shown in Table 15. Again, we find that ability has far more predictive power for males than for females. The data also show that both

Table 15
Results of regression analysis indicating the influence of ability, expectancies, and other attitudes on the exam average of females and males

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
ALL					
ABILITY	.2632	43.86	.000	1	119
EXPECTANCIES	.3079	4.85	.009	3	117
OTHER ATTITUDES	.3454	2.34	.046	8	112
FEMALES					
ABILITY	.1239	10.33	.002	1	65
EXPECTANCIES	.1742	2.98	.058	3	63
OTHER ATTITUDES	.2829	2.91	.021	8	58
MALES					
ABILITY	.4750	47.04	.000	1	52
EXPECTANCIES	.5121	1.90	.160	3	50
OTHER ATTITUDES	.4414	0.26	.933	8	45

expectancies and other attitudes add significance to the regression equation for females while neither do for the males.

Finally, a stepwise regression was performed (with all variables excluding attributions for failure and beliefs about memorization, for which there were many missing cases) to determine the most significant variables in each case.

Table 16
Stepwise regression analysis indicating the strongest predictors of exam average for females and males

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
FEMALES					
DIAG(M)	.1089	8.94	.004	1	64
ATTS	.1980	8.11	.006	2	63
MALES					
DIAG(M)	.4986	54.70	.000	1	53
PRED	.5278	4.28	.044	2	52

In the case of the females, their attributions for success are significant and in the case of the males, their predicted grade (a measure of confidence) is marginally significant. It has been noted before that increasing attention is being given to patterns of attribution in mathematics education and that some studies have reported differences in attributional patterns between males and females. The evidence from this study supports the increased focus on differences in patterns of attributions.

Another place where differences between males' and females' attitudes emerged was in the correlations among the various independent variables. In the case of the females, for the most part, variables which were expected to be related were indeed related. However, with the males, the relationships among the attitudinal variables were consistently weaker. For example, consider the "beliefs" variables discussed earlier. Table 17 shows the Pearson correlations among these variables for females and for males. Because of the unequal sizes of the two groups, comparing the significance of the correlations would not be fair. However, as can be seen from the table, many of the differences between the males' and females' correlations are large, and in every case the correlation coefficient is higher for females than for males. Even with the small numbers of students involved, three of the differences were found to be statistically significant using the Fischer Z transform test which was used in the previous section. They are shown in bold face.

Table 17
Pearson correlations among the beliefs attitudes
for females and males

FEMALES (N=82)					MALES (N=63)				
	IEM	LG	ACTIVE	MEM		IEM	LG	ACTIVE	MEM
LG	**.37**				LG	**-.04**			
ACTIVE	**.32**	**.46**			ACTIVE	**.01**	**.09**		
MEM	.47	.34	.40		MEM	.18	.31	.10	
MATH	.16	.33	.28	.37	MATH	.05	.19	.06	.18

Since, among the attitudinal variables, the students' predicted grade for the course was the variable most strongly associated with exam average, Pearson correlations between predicted grade and the other attitudinal variables were also examined for males and females. From Table 18 we see that the correlations between attitudes and predicted grade are greater for females than for males in almost every case. However, only the differences in the correlations between attributions for success and exam average were found to be statistically significant.

Table 18
Correlations between other attiudes and predicted grade for females and males

	ATTF	ATTS	IEM	LG	ACTIVE	MEM	MATH	ANX	USE
FEMALE	-.26	-.42	.38	.17	.16	.23	.18	-.26	.02
MALE	-.04	-.16	.23	.07	.02	.14	.15	-.10	.09

Summary

Examination of regression analyses and Pearson correlations support the findings in the literature of differences in the dynamics of achievement between females and males. Although, for both males and females, measures of ability and predicted grade are still the strongest individual predictors of performance in the course, these measures have substantially greater predictive power for males than for females. Additionally, the attitudinal variables, as a group, explain a significant percent of the variance in performance for females while they do not for males.

Differences in relationships among the attitudinal variables also emerged. The attitudinal variables were consistently more highly related to each other in the case of females than in the case of males. The data in this section support the contention by McLeod, Reyes, Fennema, and Surber (1985) that more sophisticated analyses of data need to be conducted, for the differences were not found in the means of the attitudes measured but in regression equations and relationships among variables.

Differences Between Students of Different Ability

Another place where attitudes seem to have a differential influence on performance is with students of different mathematical ability, as measured in the two diagnostic tests. This discovery was prompted by my surprise that the MEM construct was so poorly related to performance in the course (the correlation coeffficient between MEM and exam average was only .043). In my experience as a high school math teacher and in my two semesters as an instructor in the Math 010 course, I had felt that a number of students' progress in learning mathematics was obstructed by poor attitudes, especially in this area. Thus, the relationship between MEM and performance seems not to be a linear one but rather more complex.

Searching to better understand the relationship, I read through the students' responses to the two essay questions searching for patterns in the relationship between their responses and performance in the course. A breakthrough in the analysis came when I separated the responses into two categories--poor attitudes and good attitudes. What emerged was the discovery that in the poor attitudes category were a surprisingly large number of students doing well in the course and in the good attitudes category were a surprisingly large number of students doing poorly in the course. Below are some examples of students' responses to the two questions which illustrate this finding. The responses to the two questions will be discussed in turn.

Consider the first question (the first question in Appendix B). Below are the responses of two students who did well in the course and the responses of two students who did poorly in the course. The student's final grade in the course is in parentheses after each quotation.

"I find it easier to learn the formula which at first, usually does not make sense. After learning (memorizing) I do a number of problems using the formula so it does make sense. I think it's easier for me to know the general format and not to waste time trying to understand it. I need to know the basics and work on my own pace from there." (B)

"The strategy I use in solving those kinds of problems is to memorize the formulas or technique at first even if it doesn't make sense until the formula sinks in. Maybe this is the reason I'm not very good in math. I don't think I have the patience to try and see if the formula makes sense. I believe that it probably will make sense after awhile." (A)

"I am used to trying to understand the concept or technique until it makes sense. I can't memorize the formula first and then try the problem if it doesn't make sense to me." (CD)

"I find it best to keep trying to understand the concept or technique until it makes sense. I don't prefer to do problems until they sink in because I'd get more confused and lose the whole concept of the original formula. I'd rather understand it and take the problem from there." (D)

Let us now look at several responses to the second essay question (number two in Appendix B).

"Yes, if a student gets an answer without really knowing how, he shouldn't have to explain himself." (B)

"I feel that if a student repeatedly achieves the correct answer then he is obviously understanding the material. And if he is comprehending the work and getting the right answer there really isn't any need for explanation." (A)

"In a way both do have merit, but I do favor the teacher's point of view because I've been in the position where I can do some of the problems because I understand the basic concept. Then as soon as a hard problem comes along if I'm missing one piece to the answer I fail at the problem So I think it's better to make sure that the student can explain in full the technique." (D)

"I think it's a good idea for teachers to ask students to show them how they got their answers. Because if a student gets a right answer but the wrong technique, this could cause a lot of problems. They may have just been lucky with that right answer." (F)

From the examination of these responses and other data came the hypothesis that attitudes may exert a differential influence on students of different ability. To assess this hypothesis, the students were grouped, according to their combined scores on the two diagnostic tests, into three levels--low, medium, and high ability. Given the relatively small numbers of students in each group, the following data can only be seen as exploratory. In the table below, the Pearson correlations are shown; those significant below the .01 level are shown in bold face. The table shows some striking differences which, if replicated, will do much to explain the generally low correlations found between attitudes and performance.

Table 19
Pearson correlations between independent variables and performance for students of different levels of ability

	DIAGM	DIAGC	CON	PRED	ATTS	ATTF	IEM	LG	MATH	ANX	USE
LOW ABILITY (N=48)	**.43**	.12	-.13	.30	-.27	**-.44**	.16	.22	.19	.30	-.11
MEDIUM ABILITY (N=61)	**.32**	-.16	.13	**.41**	**-.34**	-.04	.17	.09	-.04	**-.36**	-.03
HIGH ABILITY (N=36)	.28	.22	.20	.32	-.13	-.37	.19	.00	.21	-.20	-.04

From the table, we see that the two measures of mathematical ability have substantially different predictive power depending on the group. The test of manipulative skills is significantly correlated to performance for low and medium ability students, but the test of conceptual skills seems to better differentiate among students of the highest level of ability.

For students in the low ability group, Pearson correlations for both the test of manipulative skills and the students' attributions for failure were significant below the .01 level. Three other attiudes approached signficance: attributions for sucess, predicted grade, and anxiety. For the students of medium ability, four variables were significant below the .01 level, predicted grade, anxiety, attributions for success, and the diagnostic test of manipulative skills. For students in the high ability group, none of the variables were significant below the .01 level, though the predicted grade and the diagnostic test of conceptual skills approached significance.

Because of the generally low numbers in each group and the unequal numbers of each group, a fairer comparison would be to examine the size of the correlation coefficients. Such a comparison shows the same general pattern. For low and medium ability students four variables have correlation coefficients above .30 while this is true for only one variable for higher ability students.

Perhaps the most surprising correlation is with respect to anxiety. For students of medium and high ability, anxiety is inversely related to performance--that is, higher anxiety is associated with lower performance and lower anxiety with higher performance. However, for the students of lowest ability, anxiety showed a strong **positive** correlation with performance. Recalling the discussion of anxiety in Chapter II, one might speculate that for many students of low ability, anxiety might have more of a facilitative rather than a debilitative effect.

A stepwise regression analysis, shown in Table 20 on the next page, was performed on the three ability levels. Though the numbers involved are too small to make any conclusive statements, the data show differential patterns of influence of various factors on performance in the course. For low ability students, one of the diagnostic tests explained a significant amount of the variance in peformance. For medium ability students, predicted grade and anxiety added significace. For high ability students no variables added significance.

Table 20
Stepwise regression analysis indicating the strongest predictors of exam average for different ability levels

	ADJ R SQ	F CH	SIG	DF	RESIDUAL
LOW ABILITY					
DIAG(M)	.1176	5.53	.025	1	34
MEDIUM ABILITY					
PRED	.1544	11.04	.002	1	54
ANX	.2239	5.84	.019	2	53
HIGH ABILITY					
(no variables reached significance)					

Summary

The findings reported in this section lend support to the hypothesis that better understanding of the influence of attitudes on performance in mathematics may come from analyzing the influence of attitudes on specific kinds of students rather than on the general population. For example, it might be true that students of higher ability with high confidence will do well regardless of their attitudes or, in the context of this study, in spite of poor attitudes. Similarly, it might be true that students of lower ability with low confidence may do poorly in the course even if their attitudes are excellent.

Question Four

Will students' attitudes on any of the variables measured change between September and December?

Identical or nearly identical questions were asked on five different attitudes in the September and December questionnaires. Table 25 shows the mean September and December scores of those attitudes for five different populations--all students, females, males, high ability, and low ability students. High and low ability students were determined by taking a median split on the combined scores of the two diagnostic tests. T-tests of the means were conducted to determine significance. For each case, the t value and level of significance is reported. Included also in the table are the Pearson correlation coefficients between the September and December attitudes. All were significant below the .001 level except the learning goals which was significant at the .01 level.

From the table we can see that all groups reported significantly higher confidence in December. Also, whereas the males reported higher levels of confidence than females in September, by the end of the semester the means of the confidence measure for both sexes were nearly identical.

Overall, there was a significant increase in students' learning goals (i.e., more focus on increasing competence than on grades). However, this difference was significant only for females and higher ability students. Scores on the conceptions of intelligence measures showed a significant increase only for the lower ability students, which is encouraging, for higher scores represent beliefs that one's ability to master mathematics can change. Surprisingly, even though the two measures (i.e., IEM and LG) are theoretically related, the high ability students showed a significant increase in learning goals but not in conceptions of intelligence, while the low ability students showed a significant increase in conceptions of intelligence but not in learning goals. Whether this implies that, for college remedial populations, these measures are not closely related or that other factors are involved will be discussed in the next chapter.

Importantly, scores on the students' reported anxiety did not increase, which is likely to be even more significant since the December questionnaire was administered on the next to the last week of the semester and before the final exam.

Scores on the students' beliefs about the nature of mathematics (MATH) did not change significantly. This was surprising, for the two questions asked were "Learning mathematics is mostly memorizing" and "mathematics is made up of unrelated topics." Apparently, the course may have influenced the students' confidence in their ability to learn mathematics and affected some of the students' conceptions of intelligence and related learning goals but not so much their attitudes about the nature of mathematics itself.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a summary of the study, offers several interpretations of the findings, and concludes with recommendations for future research

It was stated in the first chapter that the relationship between attitudes and performance in mathematics classes has been the focus of considerable research for some time. However, to date, there has not been research convincing enough to indicate that attitudes are an important influence on mathematics achievement. Nevertheless, researchers continue to explore this area because of the commonsense feeling that achievement should depend heavily on attitudes.

Several possibilities about the relationship between attitudes and beliefs were offered in Chapter I. First, it is possibie that students' attitudes and beliefs simply do not affect performance as powerfully as had once been thought, that much or most of a person's success in mathematics is explained by the student's cognitive and metacognitive skills and ability and other factors not directly related to attitudes.

Another possibility is that there **are** significant connections between attitudes and achievement, but they have not yet been demonstrated because of theoretical and methodological problems in the affective domain. From a theoretical perspective, there is little agreement as to what "affect" means, and theory development in the area (both theoretical constructs for various attitudes and models concerning the relationship between attitudes and achievement) is seen as a high priority (McLeod, Reyes, Fennema, & Surber, 1985; Reyes, 1984). Many researchers have also pointed out various difficulties in defining and measuring attitudes, and several recommendations have been made to address these problems (Fennema & Behr, 1980; Kulm, 1980; Reyes, 1984).

A third possibility is that the relationship between attitudes and achievement may not be clear and simple, that attitudes may exert a differential influence on different types of students.

Purpose of the Present Study

The present study was designed to address the issues raised above, in the context of a college remedial mathematics course in which there is a strong focus on problem solving, by focusing on four questions:

(1) If it is true that individual affective variables are poor predictors of achievement, will a constellation of affective variables produce greater significance?

(2) What is the nature of the relationships among various affective variables?

(3) Do (certain) affective variables have more influence on certain subgroups (e.g., male-female, relatively high-low ability, etc.)?

(4) Will students' attitudes change between the beginning and the end of the course?

Description of the Study

A comprehensive study was conducted during the fall semester of

1985 in which data on a number of attitudes was gathered from 145 students in six sections of a basic mathematics course at the University of Massachusetts at Amherst in which a strong focus was placed on problem solving.

Data were gathered from four sources:

(1) a six page questionnaire was administered on the second day of the semester. From this questionnaire data were collected on eleven attitudes in five attitude groups. The attitudes were:

level of anxiety,

perceived usefulness of mathematics,

two measures of confidence:

--confidence in ability to learn mathematics,

--the student's predicted grade in the class,

students' attributions for success and failure in learning mathematics,

and four measures of students' beliefs about learning mathematics:

--beliefs about the nature of mathematical intelligence,

--students' goals in the course--competence or performance,

--beliefs about the nature of mathematics,

--students' beliefs about the role of the student and teacher on a continuum from passive to active;

(2) several essay questions were given as an assignment during the second week of the course. These questions were designed to measure students' beliefs about the role of memorization and understanding in the learning process;

(3) sixteen students doing poorly in the course were interviewed after the

first exam;

(4) and a three page questionnaire administered at the end of the semester.

To assess the students' mathematical ability, two diagnostic tests were administered, a test of the students' conceptual skills in mathematics and a test of manipulative mathematical skills.

The primary measure of performance used in the study was a weighted average of the students' scores on the three exams in the course. Also investigated was the influence of ability and attitudes on the students' final grade and on persistence.

Findings

Before interpreting the results of the study, let us reexamine the basic findings of the study according to the four questions which were posed in Chapter I.

(1) As expected, ability was the strongest predictor of performance in the course. Of the affective variables, two individual variables were significant predictors of performance: the students' predicted grade for the course, and the students' attributions for success in mathematics. As a group, the attitudinal variables significantly added to the amount of variance in exam average explained by ability alone. The five beliefs variables (beliefs about intelligence, learning goals, beliefs about the nature of mathematics, beliefs about the role of student and teacher, and beliefs about the role of memorization and understanding) both singly and as a group were not significant. The other two affective variables, anxiety and perceived usefulness of mathematics were also poor predictors of

performance.

(2) For the most part, the relationships among the affective variables were either moderate or low. Measures of confidence showed a strong negative relationship to anxiety. The beliefs variables were moderately related to each other, and there was support for the grouping of individual beliefs variables under a larger construct called "beliefs about learning mathematics."

(3) Examination of Pearson correlation coefficients between attitudes and performance and results of the regression analyses point to significantly different dynamics for the influence of both ability and attitudes on performance for two different subpopulations: males and females, and students of different levels of ability.

(4) The September and December means of five different affective variables were compared for several groups--all students, males, females, high ability, and low ability. All groups reported significantly higher levels of confidence in December, and no groups reported significant differences in levels of anxiety. Although overall, the means of the two beliefs measures adapted from the work of Dweck and her associates (conceptions of intelligence and learning goals) increased, the increase was only significant in a few cases. Finally, students' beliefs about the nature of mathematics did not significantly change for any group. In fact, the means of four of the groups actually decreased slightly. This will be discussed later in the chapter.

Three Interpretations of the Findings

Discussion of the interpretations of the findings of the study will begin with an exploration of the possible causes of the generally low correlations between attitudes and performance in the course, especially with respect to the five beliefs variables. Both methodological and theoretical issues will be discussed. Next, two alternative approaches for better understanding the relationship betwen attitudes and performance will be developed. The first approach will focus on the surprisingly high differences in the influence of ability and attitudes on performance found between males and females and between students of different ability. The second approach will focus on an alternative conceptualization of the research question. At this point, the three possible explanations for the low predictive power of attitudes mentioned in Chapter I (p. 2) will be discussed in light of the findings and interpretations of this study. Finally, recommendations for future studies will be offered.

1. Possible Causes of the Weak Relationship Between the Beliefs Attitudes and Performance

Problems of Definition and Measurement

That the five beliefs variables were such weak predictors of performance in the course was one of the major findings of the study and was surprising, given the nature of the students (remedial) and the focus of the course (problem solving). Thus, we will spend some time examining the possible causes of these low correlations. First, let us focus on two difficulties facing researchers in the affective domain which were discussed in Chapter II: problems in defining and measuring attitudes. We will examine first the definitions of the beliefs variables and then the measurement of these variables.

Both the conceptions of intelligence and the learning goals measures were adapted from the work of Dweck and her associates. Students' conceptions of intelligence were defined as lying on a continuum from entity to incremental. In the learning goals measure, students were seen as either focused on increasing competence or focused on performance (i.e., grades). The next two constructs were designed to measure aspects of students' beliefs about the processes involved in learning mathematics. In the first measure, students' beliefs about the role of memorization and understanding were perceived to lie on a continuum. At one end of the continuum are students who tend to equate memorization and getting the answer with learning. At the other end of the continuum are students who see mastering the technique or getting the answer as only the first step toward understanding. The second measure concerns students' beliefs about the roles of the student and teacher in the learning process. At one end of the continuum are students who tend to believe that the teacher's role is "to teach." Such students tend to believe that when the student is having difficulty with a concept or a problem, it is the teacher's responsibility to lead the student out of his/her difficulty and to show the student how to do the problem. A student at the other end of the continuum believes that learning requires a very active role on the part of the student and that the role of the teacher is more to assist and to guide rather than to "pour in" the knowledge. The final belief variable addressed the students' beliefs about the nature of mathematics. This measure used three questions from The Third National Mathematics Assessment (NAEP, 1983), for example, "Mathematics is made up of unrelated topics."

Reviewing the manner in which the beliefs variables were defined, it does not appear that poor definition is a main cause of the low correlations between the beliefs variables and performance. The first two beliefs variables were adapted from an established source. The focus of the next two beliefs variables was clear, and a continuum of student responses was stated. The final variable was less clearly defined, but standardized questions from an established source were used. Additionally, certain pitfalls which were pointed out in the literature, such as combining disparate items or asking global questions, were avoided.

However, a number of difficulties were encountered in measuring the beliefs variables, and we will examine the measurement of the these five constructs in turn.

The two measures used by Dweck and her associates (conceptions of intelligence and learning goals) were designed by Dweck for use with younger students, and data were obtained from personal interviews. To adapt her measures for use in this study, I met personally with Dweck and, with her approval, made modifications for use with older students and for use in a questionnaire format. However, the low Pearson coefficient between the two measures ($r = .22$) indicates that either they were not measured accurately or that they are not as highly related with older students in a remedial setting as they are with younger students. A case can be made for both possiblities.

Concerning problems of measurement, although modifications were made as a result of the pilot study, a number of students (both in the pilot study and in the actual study) voiced or wrote objections to the conceptions of intelligence questions. Some students felt that the questions were too simplistic and felt that both alternatives were true for some persons. Other students argued that the questions were asking for their definitions of the nature of intelligence and that their responses to scaled questions did not accurately reflect their own beliefs about the nature of intelligence. I am persuaded by both of these objections and, were I again to do a similar study, I would redesign this measure, probably using at least some open-ended questions.

Similar problems were encountered in attempting to measure students' learning goals. Consider question seven on Part II of the questionnaire (see Appendix A). In the design stage of the questionnaire, only the first three alternatives were given. However, enough respondents volunteered that their actual response would have been something like "problems hard enough to show what level I am at" that it was felt that this alternative had to be added. However, it was realized that this alternative could be checked by both types of students, those focused on increasing competence and those focused on performance For example, the desire for feedback on their performance could prompt both types of students to check the fourth alternative, but for different reasons. Thus, this response was coded as a three (on a scale of one to five). To reduce the ambiguity which would arise if a student marked only this alternative, students were encouraged to mark more than one item. Thus, a student marking both this item and the competence item was differentiated from the student marking both this item and one of the performance items.

Although Dweck's learning goals construct consisted only of this one item, which might be satisfactory for younger students interviewed personally, it was felt that more questions on this construct were needed in this study. A number of other questions attempting to measure students' learning goals were designed and tested. However, all of the scaled items, both in the pilot tests and the actual study, were found to be flawed. Interviews with students revealed that some students interpreted the questions in ways other than that intended by the researcher. . Also, students who were determined in the interviews to have different learning goals, often gave the same response. Thus, the other measure of learning goals in the study came from a subjective coding of students' responses to the first three questions on the questionnaire. Such open-ended questions had been encouraged by Kulm (1980) on the ground that in some cases they have the potential for furnishing more valid data on attitudes than is possible with scales. Because of the difficulty with scaled questions, this alternative was tried, and the Pearson correlation coefficient of 0.87 between codings at different times was encouraging.

I believe that improvements in measuring these two constructs should increase the Pearson correlation coefficient between them. However, there is evidence that the two constructs may be less closely related in older students than in younger students. Developmental studies (Harari & Covington, 1981) have indicated that younger students' conceptions of ability are more fluent and malleable than those of older students, and the conceptions of intelligence construct in this study is closely related to students' conceptions of the nature of ability. Harari and Covington believe that by the time students enter college, their conceptions of ability are fairly stable. It makes sense that their conceptions of the nature of intelligence would probably be stable by this time also.

However, the students' learning goals are likely to vary for reasons not necessarily connected to their conceptions of intelligence. In arguing against a unitary theory of achievement motivation, Nicholls (1984a) has noted that students may have different reasons for wanting to increase their competence. While it is likely that entity-focused students may be more anxious about their grade in the course than incrementally-focused students, it also seems likely that many entity-focused students might still state increasing their competence as their primary learning goal in the course.

The third beliefs construct, beliefs about the role of memorization and understanding, was measured by two open-ended questions (see Appendix B) which were then coded on a scale of one to five. As reported earlier, the Pearson coefficients between two codings of these questions were .78 and .85. Thus, it seems that, in most cases, a stable assessment can be made of the student's beliefs in this area. Additionally, the responses to these questions were very revealing and contributed significantly to my understanding of the relationship between the beliefs variables and performance. Examples of some of the responses were offered in Chapter IV on page 104. Thus, though only a rough measure of this attitude was obtained in this study, it is felt that further refinement of the construct and better measurement could prove productive.

The fourth beliefs measure, beliefs about the role of the student and the teacher in the learning process, was the least satisfactory of the beliefs measures. At this point, it seems that both the definition and measurement of this construct need to be reexamined. One possible direction comes from observations during the interviews with students doing poorly in the course. Many of the students had indicated the more socially desirable responses to the questions in this construct, that is, for a more active role on the part of the student. Yet, during the course of the interviews, many students indicated a desire for a "safe" learning environment, for example one in which the teacher clearly explains new concepts and techniques, proceeds step-by-step from simple to more difficult problems, does not give problems on the exams which are not isomorphic to problems on assignments, etc. Underlying these statements may be a deep-seated fear of failure that may relate to failure or poor performance in previous math courses and to a low self-concept of mathematical ability. In other words, while many of these students seemed to believe in the necessity of their active role in learning, many also wanted the more traditional teacher who "tells" and "shows."

Therefore, it might be better to separate this construct into two subcomponents. One component would assess the student's beliefs about the necessity of the student's active role in the learning process. The other component would assess the degree to which the student wants a "show and tell" teacher as opposed to a "guide." The second component would probably be more closely related to performance, while a large discrepancy between the two components might point to a lack of confidence on the part of the student in his/her ability to master the material.

Finally, let us consider the beliefs about the nature of mathematics measure. Although it was previously stated that this measure was not as well-defined as the others, it produced some interesting results, mainly that the students' scores on this measure did not increase from September to December. In other words, these beliefs may be highly resistant to change. Thus, it may be profitable to further develop this construct and add more questions to determine if students' beliefs about the nature of mathematics are unaffected by a problem solving course, and which specific beliefs are or are not affected.

In summary, it appears that while, for the most part, the beliefs measures were reasonably well-defined, refinement of the measurement of these attitudes is most called for, both in the area of designing better and more questions. I believe that such attempts would produce higher correlations between these variables and performance. However, there is also strong evidence, both from analysis of the open-ended questions and from the interviews, that even if these constructs were precisely defined and accurately measured, beliefs alone do not have a linear relationship with performance. As cited in Chapter IV (p. 104), there were a number of instances of students with excellent beliefs who did poorly in the course and a number of instances of students with poor beliefs who did well in the course. In the following pages, I will offer several possible causes which might explain why beliefs alone do not significantly affect performance.

Support From Developmental Theory and Research

In this section, we will examine conclusions from developmental research which suggest that older students are more extrinsically motivated, more focused on assessments of ability, and have poorer attitudes toward mathematics than younger students. These conclusions will then be applied to findings from this study.

One potential cause of the weak relationship betwen attitudes and performance comes from the developmental literature on students' attitudes toward mathematics. A number of studies have noted a marked shift from intrinsic to extrinsic motivation as age increases. In a study with students from grades three through nine, Harter (1981) found that students' scores on three motivational subscales showed a marked shift from intrinsic to extrinsic motivation. Harter suggests that, over the grade levels sampled, the students' intrinsic motivation to learn either wanes or is stifled. She notes that this shift may also reflect the tendency for students to adapt to the demands of school which reinforces a relatively extrinsic orientation. In explicating a developmental theory of extrinsic motivation, Connell and Ryan (1984) attempt to address the development of extrinsic motivation and the interaction of intrinsic and extrinsic motivation. They argue that while intrinsic motivation is clearly present in the exploratory activities of infants and in the play of young children, it is not so clearly present in classroom environments. They argue that, to the extent that most classroom learning is done to achieve extrinsic goals, extrinsic motivation initiates, maintains, and regulates virtually all goal-directed activities in schools.

Eccles, Midgley, and Adler (1984) found that the decline in achievement motivation varies across domain and subject area. In a cross-sectional longitudinal study with students from grade six to twelve, Brush (1980) found a drop in attitudes toward math but not English. Eccles et al. (1983) found a decline in attitudes toward math. In that study, it was concluded that older children had lower expectations for both their current and future math performance, rated both their math ability and math performance lower, saw both their present and future math courses as more difficult, and rated the utility of advanced math courses lower than did the younger children.

In reviewing the developmental literature on achievement motivation, Eccles, Midgley, and Adler (1984) conclude that children's achievement orientation declines with age and that this decline is especially marked when children enter first grade and again when children enter middle or junior high school. They suggest that systematic changes in the school environment might underlie the age-related decline in children's achievement-related attitudes. They conclude that the changes in the school environment over time should produce an increased focus on ability assessments, increased salience of a stable conception of ability, and increased anxiety over one's relative ability and performance levels. Furthermore, each of these consequences, in turn, should produce a decline in academic motivation "*especially in students who are not highly able or who do not perceive themselves as highly able*" (p. 307) (my italics). Stipek (1984) similarly concludes that as students progress through school, they become increasingly concerned about achievement outcomes and the reinforcement (e.g., high grades) associated with high performance and are less concerned about instrinsic satisfaction in achieving greater competence.

These conclusions are consistent with several findings in this study: (1) of the attitudes measured, the students' predicted grade (i.e., self-concept of ability) was the best predictor of performance, (2) of the beliefs variables, the conceptions of intelligence (the one most closely associated with conceptions of ability) was the strongest predictor of performance, and (3) beliefs about mathematics did not change significantly from September to December. Unfortunately, two other beliefs measures, beliefs about the role of the student and teacher and about the role of memorization and understanding, were not measured in September and December, for I would predict that these two also did not change significantly.

With declining achievement motivation and increased extrinsic motivation, it may be more productive to focus on the students' confidence than on their beliefs about learning mathematics. If Harari and Covington (1981) and Nicholls (1976, 1978) are correct in asserting that older students are more focused on gaining assessments of their ability and competence, then we would expect more change in these attitudes than in the more process-oriented attitudes such as beliefs about the nature of mathematics, the relationship between understanding and memorization, and the role of the student and teacher. Support for this possibility comes from students' responses to a question on the December questionnaire, "Have your attitudes and beliefs about learning or about mathematics changed as a result of this course? Explain briefly." Most of the positive responses to this question related to students' increased confidence in their ability to do mathematics. Few students spoke of the more process-oriented attitudes. Thus, these attitudes may be more deeply entrenched and more resistant to change. In other words, if a student has tended to rely on memorizing formulas or techniques, that student may be likely to adhere to this approach. Similarly, if a student has tended to rely on help from others, that pattern may be likely to persist.

However, there are pedagogical implications of the resistance to change of the process-oriented attitiudes. Giving shape to this discussion is Holt's (1964) distinction between what he calls *producer* and *thinker* strategies:

> We used the word *producer* to describe the student who was only interested in getting the right answers, and who made more or less uncritical use of rules and formulae to get them; we called the student *thinker* who tried to think about the meaning, the reality, of whatever it was he was working on (p. 24).

Later Holt states that schools should

> teach their courses and assign their tasks so that students who really thought about the meaning of the subject would have the best chance of succeeding, while those who tried to do the tasks by illegitimate means, without thinking or understanding, would be foiled. But the reverse seems to be the case. Schools give every encouragement to *producers*, the kids whose idea is to get "right answers" by any and all means. In a system that runs on "right answers," they can hardly help it. And these schools are often very discouraging places for *thinkers* (p. 49).

Holt offers anecdotal evidence of "successful" students who can give the answer and even "explain" the answer without understanding what they are doing or saying.

One of the goals of the remedial mathematics program is, in Holt's words, to encourage thinker-strategies. However, to borrow from Nicholls (1976) who once titled a paper "Effort is virtuous, but ability is better," in the context of learning mathematics, we might say that many students believe that "understanding is nice, but grades are more important." An implicit assumption in most studies examining factors related to performance is that better performance is also better understanding. However, it is likely that attitudes and strategies which lead to better performance may not be the same as, and may often conflict with, those attitudes and strategies which lead to better understanding. In assessing the effectiveness of these remedial mathematics courses, Lochhead (1977) writes

> It seems that what we have been trying to teach is in a sense irrelevant to the students' ability to get high grades. In fact the few negative reactions we have had from students are from those cynical but insightful people who see what we teach as unnecessary to their own academic survival (p. 5).

From my experience as an instructor in the course and from my interpretation of the data collected in this study, I think that many students have concluded that their beliefs about learning are largely irrelevant to performance (i.e., grades) and so they focus on factors which they perceive to be directly related to improving their performance. This is not to deny that many students are not able to balance the producer- and thinker-strategies. However, I think such students are the exception to the rule. More common, I think, are students who have concluded, long before they entered this course, that thinker-strategies are not relevant to performance and other students who have concluded that thinker-strategies actually impede performance. Recall the student who said, "the last time I tried to understand it, it just blew everything away" (p. 68) and the student who commented, "It's easier. . . not to waste time trying to understand" (p. 104). To the extent that this is true and what can be done about it bears investigation.

A Network of Factors

Another possible cause of the poor relationship between the beliefs variables and performance is that they are only part of a larger network of factors which influence achievement and, considered separately, are not strong predictors of performance. A number of comprehensive models of achievement (see Maehr, 1984; Covington & Beery, 1976; Nicholls, 1984b; and Harter & Connell, 1984) have been proposed to explain the development and/or the dynamics of achievement motivation in classroom settings. Two models were discussed in Chapter II (Eccles et al., 1983; and Dweck & Elliott, 1983). There is still much disagreement concerning the most powerful factors involved and whether a unitary state of achievement motivation even exists, for there is much evidence that students' states of achievement motivation can vary in quality or type as well as in strength.

Some of the many factors which have been hypothesized to influence academic achievement in general and in mathematics in particular include: cognitive and metacognitive skills; attitudes toward mathematics; acceptance of and trust in the teacher and the curriculum; emotional factors--fear of failure, liking and disliking of mathematics; and other skills associated with performance--knowing how to study for a test or how to take a test and knowing how to budget time for a number of different subjects. In this larger network of factors affecting performance, beliefs about learning mathematics alone may not significantly affect performance, but may influence performance through their influence on the student's confidence, or they may interact with other factors to influence the performance of certain kinds of students. Dweck and her associates (Dweck & Elliott, 1983; Licht & Dweck, 1983) have focused on certain beliefs which make some students more vulnerable than others in the face of failure.

Two other possible contributors to the low relationship between the beliefs variables and performance in mathematics are suggested below.

Instability and Inconsistency of Beliefs

The extent to which students' beliefs fluctuate from day to day and/or from topic to topic (for example, "I like decimals but I hate fractions") has not been studied. Lesh (1982) noted the lack of intraindividual consistency in the performance of many students in his study. Fennema and Behr (1980) have cited the lack of intraindividual consistency as a topic worthy of investigation, but they cited no studies in this area, and no subsequent studies were found. However, as reported earlier (p. 92), a measure of the students' lack of conistency in responses to certain groups of questions in the study was computed and the Pearson correlation coefficient of -.24 between this measure and performance (significant below the .002 level) is encouraging.

Another related cause is that, in forced choice situations, the students might choose among the stated alternatives, but in actuality their beliefs may be poorly developed or unformulated, at least at a conscious level. In the December questionnaire, a non-forced-choice format was adopted for the two questions on students' attributions for success and failure (Appendix D). In both questions on attributions, one of the possible choices was "I'm not sure why." In each case, over one-third of the students gave this response a strength factor of three or higher (on a strength scale of one to five). Interestingly, the Pearon coefficient between the strength of students' responses to these two items and performance in the course was higher than for some of the other formulations of attributions from other mathematics education studies (Meyer and Fennema, 1985; Kloosterman, 1985). Thus, it may not simply be a case of what the student's attributions are but also how well-developed they are.

The Nature of the Student

A final possible contributor to the low relationship between beliefs and performance may have to do with the nature of the population, that is, remedial. If the beliefs of the entire population of college freshmen were measured, we might find the responses of the students in the remedial course to the beliefs questions to be more clustered in the lower end of the spectrum. Though this alone would not totally explain the low correlations, it would certainly reduce the correlations between beliefs and performance.

Summary

It is possible that better measurement of the beliefs variables will produce higher correlations between these variables and performance. However, there are a number of other possible causes for the low correlation between beliefs about learning mathematics and performance: developmental changes in students' attitudes toward mathematics, a large network of factors which influence performance of which beliefs are only one part, instability and inconsistency of beliefs in many students, and the nature of the student in this course, that is, remedial.

While it may be more productive, from the perspective of predicting performance, to focus on the influence of beliefs on the students' confidence, there are pedagogical implications of the low relationship between beliefs and performance. Especially given the evidence of declining achievement motivation and increased extrinsic motivation as students progress through school, the majority of students, in Holt's words, may be focusing more on producer-strategies than on thinker-strategies in this course.

2. Differential Influence of Ability and Attitudes on Certain Populations

One possibility, which was developed in the last chapter, is that while beliefs in general may be poor predictors of performance, they may be more influential for certain subgroups. Evidence supporting this possibility was presented in Chapter IV with respect to males and females and with respect to students of different ability.

In the case of males, ability was a much stronger predictor of performance than it was for females. Both regression analyses and Pearson coefficients between attitudes and performance suggest that attitudes in general have more influence on females' than males' performance and that different specific attitudes may be more influential--attributions for females and confidence for males. However, the lack of consistent findings in this area (Eccles et al., 1983) does not allow any strong conclusions to be made at this point.

Similarly, differential patterns of influence of ability and attitudes on performance were found in students of different ability. While none of the Pearson coefficients between attitudes and performance were significant for high ability students, three were significant at the .01 level for medium ability students. For the low ability students, one attitude was significant at the .01 level and three more were significant at the .05 level. Given better measurement and a larger sample, it seems likely that more of the attitudes would approach significance.

Examination of the data from the study, especially students' responses to the open-ended questions, suggest some possible explanations for the differential influence of attitudes on performance of students of different levels of ability. It seems that, regardless of their attitudes, the higher ability students generally have the mathematical ability and skills to sufficiently master the material to do well on the exams. On the other hand, it seems that for low ability students, even excellent attitudes are not sufficient to overcome the lack of mathematical ability. There is another explanation, which is not incompatible with the one given above. It is possible that many of the lower abilty students have found that, in general, they **have** to try to understand the material. On the other hand, many of the higher ability students may have confidence that, even if they do not understand the concept or technique at first, if they persevere, the concept or technique will eventually "sink in." These possibilities would contribute to the poor linear relationship between beliefs and performance in the course when all students are considered together.

3. Different Types of Vulnerable Students

A second alternative explanation for the low correlations, in general, between beliefs about learning mathematics and performance comes from changing the focus of the question. Instead of focusing on the specific attitudes, we might instead focus on the individual student. In the case of the sixteen students interviewed in November who were doing poorly in the course, examination of their attitude scores showed a range on every attitude almost as great as the range for all 145 students. Their predicted grade for the course ranged from a CD to an AB (the class range was from D to A). Their scores on the conceptions of intelligence measure ranged from 1.5 to 4.5 (the class range was 1 to 5). Their levels of anxiety ranged from 1.3 to 4.7 (the class range was from 1.3 to 5.0). Such data points away from a simple, clear relationship or at least a linear relationship between attitudes and performance.

The change in perspective in attempting to understand what dynamics might be operating came from the psychology literature. A key concept in this change in perspective came from the work of Dweck and her associates (Dweck & Elliott, 1983; Dweck & Bempechat, 1982). An essential assumption made by Dweck in her studies with helpless students, and again in her studies examining the effect of different conceptions of intelligence on achievement, is that certain beliefs make some students more vulnerable than other students in the face of poor performance. For example, consider two students who are struggling in mathematics, one of whom favors an entity conception of intelligence while the other favors an incremental conception of intelligence. Dweck asserts that the former student is more vulnerable than the latter, because the former student's conception of intelligence interferes with the motivation to continue to persevere whereas the latter student's conception of intelligence positively reinforces the motivation to persevere.

With this idea of vulnerability in mind, I looked through the sixteen interviews, writing beside each student's name words or phrases which seemed to capture what was standing in the way of his/her doing better. Although the original list contained over 20 descriptive terms, the following four types capture most of the dynamics which seem to be operating in the students.

The helpless student essentially has little or no confidence that his/her effort alone will be sufficient to learn the material. Such a student often gives up after only minimal effort. Helpless students often make statements like the following: "I'm just no good in math," "I'm dumb in math," "My mind just goes blank," and "The only way I'll pass the class is by getting lots of help." There is a rich literature in psychology on learned helplessness (see Seligman, 1975; Diener & Dweck, 1978) and a growing literature in mathematics education on helplessness (see Kloosterman, 1984; Meyer & Fennema, 1985).

The most succinct description of the second type of student is denial. There seem to be two basic types of denial in students. Some students insist that they really know the material but just make "lots of little mistakes." For example, one of the students in the interviews said he thought his grade at the time of the interview was "either a low C or a CD." When asked what his strengths were as a math student, he replied that he really knew the basics. In fact, he had received a 25% on the first exam and had not passed any of the five chapter quizzes. Another pattern of denial is referred to in the psychology literature as "defensive attributions." Following are several examples of defensive attributions for. poor performance: "I didn't feel good on the day of the test," "I can't learn from this teacher (this book, this system, etc.)," and "I didn't have enough time to do the test (to do the assignment)." As with helplessness, there is a rich psychological literature pertaining to denial (see Jones & Berglas, 1978).

At the heart of both helplesness and denial is the desire to preserve one's self-esteem (Beery, 1975; Covington & Beery, 1976). The helpless student truly feels stupid, at least in mathematics. The act of giving up, the helpless posture, can be seen as "cutting one's losses." Since the student feels that perseverance will not "pay off" anyway, by not seriously engaging with the material, the helpless student at least reduces the frequency and intensity of times of feeling so stupid. The denying student, on the other hand, refuses to acknowledge his/her lack of mathematics skills. Should such a student do poorly in the course, the student has a number of explanations for the low grade which protects his/her self-esteem.

A third type of student may be called pressured. This includes the classic "math anxious" student but goes deeper into the causes of anxiety, which often have to do with either having to get a good grade in the course or needing to master the material in the course for some specific reason. The pressured student is likely to make statements like the following: "I have to get at least a B in this class," "I've got to learn this stuff because I have to take statistics (or calculus) next semester," and "I've got to have a high GPA for graduate school." Pressured students are often answer- and grade- oriented, and they tend to focus on producer-strategies at the expense of thinker-strategies. The analogy to a horse with blinders comes to mind. Just as that horse cannot see the surrounding environment, the pressured student misses many cues in the mathematical environment (e.g., similarities from one problem to another and heuristics which can be applied to many types of problems) because s/he is so preoccupied with getting the answer, applying the algorithm, or getting the desired grade.

The fourth type of student I have called naive. This student is often someone who never really had to work hard in high school and has undeveloped study habits. Such a student has given little thought to how one learns, little thought to what mathematics is all about. To such students, learning is often synonymous with memorizing. Being able to get the answer is equivalent to understanding. When asked about the nature of mathematics, such a student is likely to make statements such as: "Mathematics is a bunch of facts and formulas," "Math is something you either understand or you don't" and "If you can't find the answer right away, you might as well give up."

Although the present study was not designed with these types of students in mind, an attempt was made to operationalize these four types based on the variables in the study so that some preliminary data might be obtained. Keeping with the underlying concept of vulnerability, it was decided to consider only students whose combined score on the two mathematics diagnostic tests was below the mean score for all students. It was also decided to operationalize each type so that none of the categories contained over 15 students. Otherwise, there would likely be significant overlap between each category which would reduce the distinction between categories.

Helpless students were defined as those whose scores on both measures of confidence were low. The heart of the denial process is an unwarranted (public) confidence in one's ability. A measure of this unwarranted confidence was constructed by subtracting the combined diagnostic test score from the difference between the student's predicted grade in this course and reported grade in the student's previous class. The pressured type was defined as a student who reported both high levels of anxiety and high levels of usefulness of mathematics. The naive type was defined as someone with low scores on the beliefs about memorization and understanding and the beliefs about the nature of mathematics measures.

Table 26 shows the mean scores of the dependent and independent variables for all students in the course and for each of the four types. The variables used to define each type are in parentheses above each type. Descriptive statistics tell only part of what might be happening (recall the case of the males and females where the means of the attitudes were not very different). However, the table shows some interesting patterns.

The helpless students show the highest degree of attributions to uncontrollable factors as would be expected. They also show significantly lower scores on all of the beliefs measures. The lower score on the conceptions of intelligence measure indicates more focus on entity than incremental conceptions of intelligence. Similarly, the lower score on the learning goals measure may indicate a greater focus on avoiding a poor grade than on becoming more competent in mathematics.

The denial students do not differ from the whole population on their patterns of attributions, perceived usefulness of mathematics, or anxiety. However, on some of the beliefs measures their responses actually indicate better beliefs. Also, not coincidentally I think, this group had the highest proportion of males.

For the pressured students, the most significant items were their predicted grade in the course and their confidence in their ability to learn mathematics. In general, the means for these two scores were very close. However, the pressured students' predicted grade was much higher than their confidence in their ability to learn mathematics. This might indicate that, because they see mastery of the material in the course as necessary, they feel a strong need to do well in the course but they do not have much confidence that they will do well.

The naive students reported both lower levels of confidence (except for the denial group) and lower levels of anxiety than the other types. Although they were defined only by scores on two of the beliefs measures, their scores on the other beliefs measures were also low.

As stated above, this framework on different types is still being developed. Future research should deepen our understanding of each type, how such attitudes undermine the student's ability to learn mathematics effectively, and the teacher interventions and strategies which might be most productive. Although most of a teacher's attention should necessarily be in the direction of increasing the student's cognitive and metacognitive skills, focus on these types can enable teachers also to address the psychological-motivational factors which impede such students' abilities to learn mathematics effectively.

A Reexamination of the Three Possibilities Posed in Chapter I

Looking now at the three possibilities posed in Chapter I for explaining the relatively weak influence of attitudes on performance in mathematics classes, I will argue for the third possibility, that the relationships between attitudes and performance are not clear and simple. I believe that the first possibility, that attitudes are weak predictors of performance, is true only in the narrow sense of asking if individual attitudes are powerful predictors when considering the whole population of students. Framed in that context, it does seem that attitudes are indeed weak predictors of performance. However, the next step should not be to conclude that attitudes are irrelevant to the learning of mathematics but rather to ask why the attitudes do not correlate better with performance and to attempt to determine which attitudes are most influential for which (kinds of) students.

The second possibility posed in Chapter I is that there are simple, clear relationships between attitudes and performance, but they have not yet been demonstrated. To the extent that this is true, the present study found a clear relationship between two variables and performance: ability and the student's predicted grade. That ability is a strong predictor of performance was already known. That the student's predicted grade was a much stronger predictor of performance, for all groups, than the more commonly used questions which have been used to measure confidence, is helpful in that it allows us to gain more information while at the same time asking fewer questions.

It is quite possible that the right combination of or the right attitude groups have not yet been formulated or measured precisely enough, and that such a development will produce stronger correlations between attitudes and performance. However, I believe that the virtually exclusive focus on discovering clear, simple relationships between attitudes and performance is harmful, for such a focus may lead researchers and teachers to oversimplify the complex dynamics of the learning environment and it neglects other potentially useful types of inquiry. I would argue that very few attitudes, other than perhaps confidence, measured by the student's predicted grade, have a direct, linear relationship with performance. As mentioned earlier (p. 134), the sixteen students interviewed in November who were doing poorly in the course showed practically as much variance in every atttiude as was found in the class as a whole.

Consider also just one example in which the same attitude in one person can positively influence performance while in another person it can negatively influence performance. A close friend of mine recently remarked that the reason he did so well in math and science in school is that he refused to memorize formulas and concepts but rather insisted on understanding them. When I related this story to another close friend, she laughed and said that she had taken the same posture in school, refusing to memorize and insisting on understanding. However, in her case the results were disastrous. Whether she did not possess the 'mathematical cast of mind' as Krutetskii (1976) puts it or whether she had poor teachers, in her case she did not succeed in understanding the concepts, and her refusal to memorize without understanding resulted in a permanent retreat from the study of mathematics and science.

I believe that progress can be made in increasing our understanding of the relationship between attitudes and performance by focusing on these relationships with various subpopulations. Much progress has been made in the past ten years in our understanding of sex differences in the development of attitudes toward mathematics and their consequences on achievement-related behaviors such as performance and choice of how much mathematics to study. From this study, it appears that in a college remedial mathematics course, there are significant differences in the influence of both ability and attitudes on performance between males and females. Another set of productive subpopulations to study seems to be students of different ability. Evidence from this study suggests a differential influence of attitudes on performance for students of different ability.

Finally, I have presented a new framework for investigating the question of the influence of attitudes on performance--by changing the focus from specific attitudes to different types of students. There is substantial research in the psychology literature which can deepen our understanding of these types, and further research in this area could produce effective teacher strategies and interventions for use with each of the four types discussed.

Suggested Future Research

Although there has been considerable research in the affective domain in mathematics with elementary and secondary students, very few studies have been done with college students and with remedial populations. I offer five areas of research which could increase our understanding of the influence of attitudes on performance in college remedial mathematics courses.

(1) Eccles, Midgley, and Adler (1984) have noted marked changes in achievement-related attitudes in students between kindergarten and first grade and again between elementary and junior high school. They suggest that systematic changes in the school environment might underlie the age-related decline in students' achievement-related attitudes. Given the significant change in both the school and social environment between high school and college, it would be interesting to see what changes in attitudes toward mathematics emerge in students between high school and college, especially in the increasing number of students having to take remedial mathematics in college. In light of the weak influence of attitudes on performance found in this study, it would be interesting to determine the

nature of the influence of attitudes on performance for high school students, especially those in remedial math classses.

(2) Causal studies which accurately measure the most important attitudes could increase our understanding of how attitudes directly and indirectly influence performance in college remedial math classes. With better measurement of the beliefs variables we could determine whether they influence performance through their influence on students' expectancies and value of success, or whether, for students in general, they are basically irrelevant to performance.

(3) More studies are needed to determine whether the marked difference in the influence of ability and performance between males and females found in this study holds up. Also, are certain attitudes differentially significant for the two groups as was found in this study, where predicted grade was more significant for males but attributions for success were more significant for females?

(4) Support was offered for the findings in this study of the differential influence of various attitudes on the performance of students of different levels of ability. If future studies confirm and add to these findings, a next step would be intervention studies. Such studies could then offer teachers strategies for working with students of different levels of ability.

(5) Concerning the four types of vulnerable students described earlier, more theoretical work is needed both to deepen our understanding of the dynamics operating in these students (for example, studies on helplessness, attributions for success and failure, defensive attributions, and anxiety)

and to determine if there are additional types which might be usefully articulated, for example, the 'don't care' student, the 'I've always hated math' student, and the seemingly hopeless student (i.e., poor attitudes and extremely low skills). Case studies could do much to enable us to better understand how the dynamics involved for each type interfere with the student's ability to effectively learn mathematics, and to understand ways in which students can overcome these obstacles. Intervention studies could determine the effectiveness of various remediation strategies--for example, attribution retraining, and increased self-awareness of the psychological, motivational, and attitudinal causes of the students' poor performance. The implications for classroom teaching are potentially powerful.

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APPENDIX A
SEPTEMBER QUESTIONNAIRE

PART I

1. Briefly explain why you are taking this course.

2. Which of the following best describes how you feel about taking this course.

_____ to get the best grade you can.
_____ you don't really want to take the course but need to for one reason or another.
_____ to become better at math (to master basic mathematics).
_____ you want to learn but you're somewhat scared that you may do poorly (D or F) because you've had troubles with math before.
_____ other (specify):

3. How important is it that you do <u>well</u> in this course?

4. Briefly explain how <u>confident</u> you are of your ability to do well in this course?

5. Many factors can affect how well or how poorly you do in a math class.
I have listed several factors below. Please put a 1 beside those factors which, by themselves, can make or break you in a math class. Put a 2 beside factors which are not as powerful but which are still influential. Leave blank those factors which are not influential for you.

_____ How difficult the material was
_____ How much mathematical ability you have
_____ How hard you worked in the class
_____ How good the teacher was
_____ Good or bad luck on tests and quizzes
_____ Help from others (teacher, tutor, friend)
_____ other factors? (specify):

6. Let's say you are working on a homework problem at home or in your dormitory and you can't do it. Which of the following most closely resembles you:

_____ it bugs you that you can't do it so you keep trying.
_____ it bugs you and you find someone who can show you how to do the problem.
_____ the next day you ask someone in class or the teacher how to do it.
_____ you don't worry about it as long as you could do most of the problems.
_____ other (specify):

7. If you tend to get nervous and anxious on math tests, which of the reasons below apply? Write a 1 beside a major reason, a 2 beside a minor reason. If a reason doesn't apply, leave it blank.

_____ I need a high GPA for graduate school, a scholarship, or other reasons.
_____ I'm just not confident that I really know the material.
_____ Sometimes I just go blank on math tests.
_____ I get nervous on all tests, even in other subjects.
_____ Many times test don't accurately reflect how much you know.
_____ My parents will be upset if I don't get good grades.
_____ I have to learn math because I will need it later on.
_____ Other (specify):

8. Suppose you were working on some word problems in class (for example: Johnate one-third of a pie and then Sue ate one-half of what was left. How much of the pie remains?) Let's say you got stuck on one of the problems and asked the teacher for help. Rank the following teacher actions from 1 (most preferable) to 4 (least preferable).

_____ The teacher sits down and shows you how to do the rest of the problem.Then the teacher makes up a similar problem for you to do and then show him/her.
_____ The teacher asks you to tell him/her where you are stuck and asks you questions or gives you hints, but makes you do the thinking to get unstuck.
_____ The teacher explains the part where you got stuck and then leaves you to try to finish the problem by yourself.
_____ The teacher sits down and shows you how to do the rest of the problem. Then you go on to the next problem.

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Part II

Directions: In each of the pairs of statements below, circle the number that most closely represents your viewpoint. A score of 1 means that you completely agree with the statement on the left while a score of 5 means that you completely agree with the statement on the right. A score of 3 means that you think that both statementsare equally true. Use the space below each question to explain any of your responses, if necessary.

1. You can learn new things, but how intelligent you are stays pretty much the same

When you learn new things, you increase how intelligent you are.

1 2 3 4 5

2. You can't really tell how smart you'll be when you get older.

You can tell how smart you'll be in the future by how smart you are now.

1 2 3 4 5

3. If you aren't as intelligent as you want to be, there isn't much you can do about it.

Much effort can increase one's intelligence considerably.

1 2 3 4 5

4. You can change how intelligent you are in mathematics.

You can do things to get better grades in mathematics, but you really can't become more intelligent in mathematics.

1 2 3 4 5

5. Some people just don't have mathematical minds.

Some people may have more abilitythan others, but anyone in collegecan master basic mathematics and algebra.

|—————————————————————|
1 2 3 4 5

6. If someone isn't very good in math in high school, they probably won't be very good in math when they get older

If someone isn't very good in math in high school, they can be much better in math when they're older.

|—————————————————————|
1 2 3 4 5

7. Suppose you have been studying a topic for a few days and the instructor comes in and says, "Today you will spend the whole period working on problems and you can choose what kind of problems you will work on." Which kind of problems wouldyou prefer?

If more than one kind strongly appeals to you, list a first and second choice. Otherwise, list only your first choice.

______ problems that aren't too hard so you won't get a lot wrong.
______ problems that you would learn something from, even if they were so hard that you might have difficulties at first.
______ problems that are fairly easy so that you will get a lot done.
______ problems that are hard enought to show what level you are at.
______ other (specify):

Part III

In questions 1 through 11 please indicate your respone to the statement by marking whether you: strongly disagree (SD), disagree (D), are neutral (N), agree (A), strongly agree (SA). If you feel that any of the questions does not accurately represent what you feel, please explain yourself briefly in the space below the question or at the bottom of the page.

1. I feel confident that I will do well in this course. SD D N A SA

2. I know basic mathematics (e.g. fractions, decimals, percents, equations) pretty well. SD D N A SA

3. I'll need a firm mastery of mathematics for my future work. SD D N A SA

4. Working on word problems usually makes me feel extremely uncomfortable and nervous. SD D N A SA

5. For some reason even though I study, math seems unusually hard for me. SD D N A SA

6. The career(s) that I am interested in require that I take additional courses in math beyond this one. SD D N A SA

7. Learning mathematics is mostly memorizing. SD D N A SA

8. Mathematics helps a person to think logically SD D N A SA

9. My math grades have usually been as high as my other grades. SD D N A SA

10. I tend to get so nervous and anxious on math tests that my grade suffers as a result. SD D N A SA

11. Mathematics is made up of unrelated topics. SD D N A SA

In questions 12 through 14 please circle the number indicating <u>how often</u> you feel what is described: 1 = none of the time, 3 = about half of the time, 5 = all of the time.

12. If a teacher says a problem will not be on a test, I still write it down. 1 2 3 4 5

13. If I get a problem wrong on a homework assignment, quiz, or exam, I do it over until I understand it. 1 2 3 4 5

14. I would rather have someone show me how to do a difficult math problem than to try to work it out myself. 1 2 3 4 5

15. At this time what grade would you predict that you will get in this class?

F D C/D C B/C B A/B A

16. What is the lowest grade that you could be satisfied with in this class?

F D C/D C B/C B A/B A

17. What was your last math class? How did you do?

18. If you did poorly, place two checks beside primary reasons and one check beside contributing (but less important) reasons:

_____ I didn't study enough.
_____ I studied enough but my study habits were poor
_____ I did poorly on the tests.
_____ I've always had trouble in math.
_____ Outside factors--sports, romance, family problems, illnesses, etc.
_____ Teacher didn't like me
_____ I didn't like the teacher
_____ Other (specify):

Any additional comments (use back of page if necessary):

APPENDIX B
ESSAY QUESTIONS

Directions: The purpose of this assignment is to have you spend some time thinking about your own beliefs about learning. Because there are no "right" answers to these questions, the only requirement for this assignment is that your responses to each question be more than just one sentence. All completed assignments will receive a check plus.

1. When struggling to learn a new concept or formula (for example, solving equations or percent problems) there are a variety of learning strategies. Some students find it best to memorize the formula or techniques at first even if it doesn't make sense. After doing a number of problems, the formula or techniques "sinks in." Other students find it best to keep trying to understand the concept or technique until it makes sense. Once it makes sense the problems are easier to do. Which strategy are you most likley to follow? Explain. If neither strategy fits you. explain how you usually go about learning new concepts and formulas.

2. Some teachers are not content just because you get the right answer. They also focus on uderstanding how you got the answer. Sch teachers feel that sometimes students just memorize the correct technique for doing a problem without really understanding what they are doing. On the other hand, students often feel that such teachers are being too picky. The students maintain that sometimes you know what you are doing even if you can't explain it in words. They feel that if you know how to use the technique and can get the right answer, that's suggicient. Do you favor one position over the other or do you believe both positions have merit? Explain.

APPENDIX C
INTERVIEW GUIDE

Introduction:

I am trying to learn what attitudes and beliefs about learning and about mathematics seem most beneficial to learning and which ones seem to block learning and how they block learning.

Often I will ask you why you answered a question in a particular way. This does not mean you gave a poor answer. It means that I am interersted in the reason why you think that way.

1. Why are you taking 010?
   (advisor, low skills, need it for your major, need stat., calculus, etc.)
   what are your goals, expectations from this class?

   Are there aspects of the course you particularly like? dislike?

   Grade at this point? predicted final grade?

   High sdchool: years of math, approx. grades?

   Basically like or dislike math or neutral?

2. Problem-solving:
   Some student like the way MAth 010 is taught more than high school. Some liked high school better. Some like aspects of both. Where do you stand?
   I know that the worksheets are often quite challenging. How do you feel about the worksheets? (frustration, practice, increased understanding of concepts, more confidence, etc.)

   When you get stuck, what thoughts go through your head?
   Do you get anxious or nervous? If so, why?

   If you had your choice, would you use DMS or worksheets, or both? Why?

3. Self-ratings: F-A
   attention in class when teacher is talking; while problem solving
   attention while problem-solving
   persistence: on assignments, on class problems
   consistency: doing assignments, grades on quizzes & assignments
   effort: overall; steady from week to week

4. Study patterns: for assignments, for quizzes, for exam how often? less than, more than, same as other classes?
with whom--friends, help room, tutor?

Exam
how did you feel before the exam?
when turning in the exam?
when getting back the exam
informal attributions
accurate reflection of how much (well) you know the material?
how have you done since the exam?

5. Unknown
Advice for yourself for next unit? What could you do to do better?
Weaknesses & strengths as a student?
Changes in beliefs about learning and math since September?

6. (a) Attributions scales
(b) LG and IEM questions from questionnaire

APPENDIX D
DECEMBER QUESTIONNAIRE

1. How satisfied are you with what you learned and how you did in this class this semester? Please explain briefly.

2. What is your overall rating of this course on a scale of 1 to 5 in which 1 means terrible and 5 means outstanding? ______

3. Have your attitudes and beliefs about learning or about mathematics changed as a result of this course? Explain briefly.

4. Check one of the following and briefly explain.
______ Basically I like math.
______ Basically I don't like math.
______ It depends on the course and the situation.

Please indicate your response to each statement below by marking whether you: strongly disagree (SD), disagree (D), are neutral (N), agree (A), or strongly agree (SA).

5. You may learn new things as you get older, but how intelligent you are stays pretty much the same.	SD D N A SA
6. You can't really tell how smart someone will be in the future by how smart they are now.	SD D N A SA
7. Much effort can increase one's intelligence considerably.	SD D N A SA
8. If you aren't very smart in math, there isn't much you can do about it.	SD D N A SA
9. People who weren't very good in math in high school could be much better in math when they become older.	SD D N A SA
10. Some people just don't have mathematical minds.	SD D N A SA
11. Some people may have more ability than others but anyone in college can master basic math and algebra.	SD D N A SA

12. Suppose you have been studying a topic for a few days and the instructor comes in and says, "Today you will spend the whole period working on problems and you can choose what kind of problems you will work on."

Which kind of problems would be most beneficial for you to work on? (If you are torn between two choices, list a first and second choice. Otherwise, list only your first choice.)

_____ problems that aren't too hard so you won't get a lot wrong.
_____ problems that you would learn something from, even if they were so hard that you might have difficulties at first
_____ problems that are fairly easy so that you will get a lot done.
_____ problems that are hard enought to show what level you are at.
_____ other (specify):

13. Do you feel you learned more this semester from DMS or from the worksheets in the workbook or were both equally helpful? Explain.

Indicate your response to the statements below by marking whether you:
strongly disagree (SD), disagree (D), are neutral (N), agree (A), or strongly agree (SA).

14. I know basic mathematics (e.g. fractions, decimals, percents, equations) pretty well.	SD D N A SA
15. For some reason even though I study, math seems unusually hard for me.	SD D N A SA
16. Working on word problems usually makes me feel extremely uncomfortable and nervous.	SD D N A SA
17. I tend to get so nervous and anxious on math tests my grade suffers as a result.	SD D N A SA
18. Learning mathematics is mostly memorizing.	SD D N A SA
19. Mathematics is made up of unrelated topics.	SD D N A SA
20. I would rather have someone show me how to do a difficult math problem than to try to work it out myself.	SD D N A SA

21. Let's say you are working on a problem in class and you're stuck. You think you might possibly be able to solve it on your own, but right now you really don't know what to do. Which of the following would you be most likely to do?

_____ ask the teacher for a hint.

_____ ask the teacher to show you how to do the problem and then make up a similar problem for you to do on your own.

_____ keep working on the problem until you get it or go on to the next problem and return to this problem later.

_____ ask the teacher to explain the part where you are stuck but not to do the rest of the problem for you.

22. Think back to quizzes or tests on which you did well. Why did you do well on those particular quizzes or tests? Please rate each reason below in terms of its importance in contributing to your success. The scale is from 1 (not important at all) to 5 (extremely important).

1 2 3 4 5 I studied hard for that quiz or test.
1 2 3 4 5 I knew the material on the quiz or test before the course.
1 2 3 4 5 I got help from a friend or at the Help Room.
1 2 3 4 5 The quiz or test that was easy.
1 2 3 4 5 I'm not sure why.
1 2 3 4 5 Other (specify):

23. Now think back to quizzes or tests on which you did poorly and rate each reason below in terms of its importance in contributing to your doing poorly. The scale is from 1 (not important at all) to 5 (extremely important).

1 2 3 4 5 I didn't work hard enough.
1 2 3 4 5 I've always had trouble with those parts of math.
1 2 3 4 5 I didn't go for help and should have.
1 2 3 4 5 It was a real hard quiz or test.
1 2 3 4 5 I'm not sure why.
1 2 3 4 5 Other (specify):

24. What final grade would you predict that you will get in this course?

F D C/D C B/C B A/B A

Please add any comments which you think would be useful to me. You can use the bck side also.

APPENDIX E
CONSENT FORM

I, Tom Bassarear, am doing a dissertation examining how students' attitudes and beliefs about mathematics and about learning mathematics can help or hinder students' persistence, improvement, and ultimate performance in a mathematics class. If you agree to participate in the study, I will ask you:

(1) to fill out a questionnaire during class time at the beginning and at the end of the semester;

(2) to give me permission to look at an essay assignment, concerning your attitudes and beliefs about learning, which you will be given in about two weeks;

(3) to give me permission to look at your grades and some of your assignments, quizzes, and tests.

If you are willing to participate in the study, you can help me by filling out the questionnnaire as honestly as possible by telling me what you actually believe or actually do in situations as opposed to what you would like to do or what you think a "good" student would do. Also, I encourage you to make any additional comments to questions which you think are incomplete or ambigouous and comments which you think will help me to better understand your attitudes and beliefs about learning and about mathematics.

Your participation or nonparticipation in the study will not affect your grade in any way. None of your responses will be passed on to your instructor. If I discuss a comment you make or if a comment you make appears in my dissertation or in an article, I will not use your real name.

You are free to ask me questions about the research procedure now or at any time during the semester. My office is in 314 Hasbrouck. At the beginning of next semester, I will be glad to give you a brief report of what I learned this semester.

After the first exam, approximately 20 students will be selected to come for several interviews related to their beliefs about learning mathematics for which they will be paid.

I have read the above statement and agree to participate in the study under the conditions stated above

____
Signature of participant

____
Date

APPENDIX F
DIAGNOSTIC TEST OF CONCEPTUAL SKILLS

1) Four people share a pizza in the following way: Tom got a third and Mary got a third of the remainder while Dick and Harry shared equally what Tom and Mary did not get. What fraction of the whole pizza did Harry receive?

a. $\frac{1}{3}$ b. $\frac{1}{6}$ c. $\frac{2}{9}$ d. $\frac{1}{4}$ e. $\frac{3}{2}$

2) A bicycle that regularly costs $360 is on saale for $306. By what percent has the price been reduced?

a. 10% b. 11% c. 6% d. 54% e. 15%

Evaluate, when x = -2

3) $x - 2(3 - x) - x(x-5)$

a. 6 b. 0 c. 4 d. -26 e. none of the above

4) 5^x

a. -25 b. $\frac{1}{25}$ c. -10 d. 25 e. 10

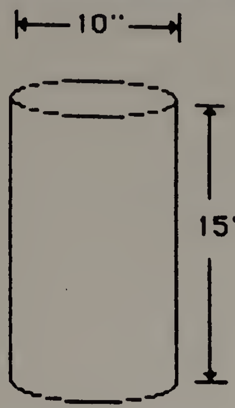
5) 5 3 + 2 - x ÷ 2

a. 18 b. 21 c. 9-1/2 d. 7-1/2 e. 8-1/2

6) 1/2 ÷ 1/x ÷ 3

a. 3 b. 4 c. 2 d. -1 e. -1/2

7) Calculate the outside surface of a hollow tube:



a. 12.5 feet

b. 150 square inches

c. 50 inches

d. 471 square inches

e. 75 inches

Write the following numbers in scientific notation:

8) 3,583,000

a. 3.5×10^6 b. 3.58 c. 3.583×10^3 d. 3.583×10^6 e. 3583×10^3

9) .00004

a. $.4^5$ b. 4×10^{-5} c. .04 d. $.4 \times 10^{-4}$ e. none of the above

Solve the following equations (find the solution set):

10) $2(5 - t) + 6t = t + 22$

a. 4 b. 6 c. 15 d. -1 e. 12/5

11) $4(r + 1) = 6 - 2(1 - 2r)$

a. 0 b. 1 c. 12 d. r e. none of the above

12) For every three people who order chocolate milk, twenty-five order white milk. Write an equation which shows the relationship between "C", the number of people who order chocolate milk, and "W", the number of people who order white milk.

a. $25W + 3C = T$ b. $3C=25W$ c. $\frac{3C}{25W}$ d. $25C = 3W$ e. $C + W = 28$

13) What day precedes the day after tomorrow if four days ago was two days after Wednesday?

a. Tuesday b. Wednesday c. Thursday d. Sunday e. none of the above

14) A recipe for Crisp Crackers:

1-1/2 cups wheat flour

1/2 cup seeds (sesame or caraway)

1/4 cup peanut oil

3/4 teaspoon salt

1/2 cup water

If all I have is 1 cup of wheat flour, how much salt should I use?

a. 1 teaspoon b. 3/4 teaspoon c. 1/2 teaspoon d. 2/3 teaspoon e. 1/4 teaspoon

15) How many jars of water are needed to fill a 23-1/2 liter jug if each jar contains 0.4 liters?

a. 0.4(23.5) b. 23.5 - 0.4 c. $\frac{2}{5}(\frac{47}{2})$ d. $\frac{2}{5}(\frac{7}{47})$ e. $\frac{5}{2}(\frac{47}{2})$

16) All items in a store are discounted 20%. Identify the expression which will calculate the sale price of an item.

a. 20P b. 0.2P c. 4/5 P d. P-20 e. 120P

17) A bathtub can hold 124 liters of water. 1/4 of the tub was filled in 20 minutes with the faucet turned on. How much longer will it take to fill the tub completely?

a. 3/4 of an hour b. 40 minutes c. 104 minutes d. 1 hour e. none of the above

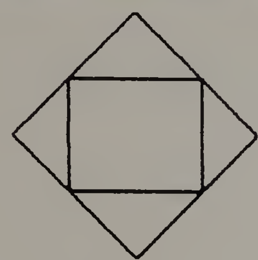
18) How many millions are in 1.8 billion?

a. 18 b. 1800 c. 18,000 d. 1.8 e. 0.18

19) Which number is closest to 3/100?

a. one third b. 1.003 c. 3.100 d. 0.103 e. 0.031

20) The following illustration is a section of a tiled floor which is repeated over the surface of the entire floor.



Using "S" for the number of square tiles and "T" for the number of triangular tiles, write an equation which shows the relationship between the number of square tiles and the number of triangular tiles on the floor.

a. 4S = T b. 4T = S c. T - 3 = S d. $\frac{4}{S} = \frac{1}{T}$ e. none of the above

APPENDIX G

DIAGNOSTIC TEST OF MANIPULATIVE SKILLS

1. $\frac{5}{6} + \frac{1}{4}$

(a) $\frac{6}{10}$ (b) $\frac{7}{12}$ (c) $1\frac{1}{12}$ (d) $\frac{13}{24}$ (e) none of the above

2. $2\frac{1}{4} \times \frac{8}{15}$

(a) $1\frac{1}{5}$ (b) $2\frac{8}{60}$ (c) $2\frac{2}{15}$ (d) $4\frac{7}{32}$ (e) none of the above

3. $3\frac{3}{4} \div \frac{3}{5}$

(a) $2\frac{1}{4}$ (b) $\frac{4}{25}$ (c) $3\frac{1}{20}$ (d) $\frac{4}{9}$ (e) none of the above

4. Convert 5/8 to a decimal.

(a) .5 (b) .625 (c) 1.6 (d) .58 (e) none of the above

5. Convert .7 to a percent.

(a) 70% (b) 7% (c) .7% (d) .07% (e) none of the above

6. Add .06 + 4 + 3.8

(a) 8.4 (b) 7.86 (c) 7.8 (d) 4.8 (e) none of the above

7. Divide .048 by 2.4

(a) .002 (b) .05 (c) .02 (d) .005 (e) none of the above

8. What is 20% of 7.5?

(a) 1.5 (b) 15 (c) 3.75 (d) 37.5 (e) none of the above

APPENDIX H

ADDITIONAL TABLES

TABLE 21

Results of Regression Analysis Indiciating Influence of Ability and Attitudes on Final Grade

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
ABILITY	.1857	10.12	.000	2	78
ATTITUDES	.2931	2.18	.029	12	68

TABLE 22

Results of Regression Analysis Indiciating Influence of Ability, Expectancies and Values, and Attitudes on Final Grade

	ADJ R SQ	FCH	SIG CH	DF	RESIDUAL
ABILITY	.1601	8.63	.000	2	78
EXPECTANCIES AND VALUES	.2046	2.47	.070	5	75
OTHER ATTITUDES	.2288	1.39	.231	12	68

TABLE 23
Complete Table of Pearson Correlation Coefficients

N=140	DIAGC	DIAGM	PRED	CON	ANX	USE	ATTF	ATTS	IEM	LG	ACTIVE	MEM	MATH	EX	GR
DIAG															
DI	.31														
PRED	.14	.34													
CON		.23	.55												
ANX			-.21	-.40											
USE					.14										
ATTF			-.16	-.25											
ATTG			-.29	-.28	.30	.32									
IEM			.31	.25				-.20							
LG									.22						
ACTIVE				.26		.23			.18	.31					
MEM			.20	.16			-.29	-.24	.36	.32					
MATH	.14		.16			.14	-.19			.28	.19				
EX	.40	.56	.39	.14			-.25	-.24	.15						
GR	.25	.43	.29	.15			-.19	-.15	.14					.88	

TABLE 24
Descriptive Statistics of Certain Groups

	ALL		FEMALE		MALE	
	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.
N	145		82		63	
SEX	1.43		1.00		2.00	
DIAG(C)	5.12	2.35	5.08	3.94	5.16	7.61
DIAG(M)	4.20	2.02	4.30	3.71	4.08	4.60
PRED	2.92	0.60	2.93	0.57	2.92	0.65
CON	2.71	0.98	2.53	0.97	2.94	0.85
ATTF	0.73	1.50	0.68	2.29	0.80	2.26
ATTS	1.87	1.65	1.90	2.70	1.84	2.78
IEM	3.40	0.94	3.51	0.89	3.26	0.83
LG	3.09	0.97	3.19	1.07	2.95	0.74
ACTIVE	3.44	0.77	3.36	0.68	3.55	0.48
MEM	3.11	0.66	3.09	0.74	3.13	0.55
MATH	3.48	0.60	3.51	0.39	3.43	0.33
USE	3.88	1.14	3.88	1.30	3.86	1.35
ANX	3.14	0.80	3.20	0.85	3.07	0.72
EXAM	69.4	16.7	71.1	16.8	67.3	16.4
GRADE	2.79	0.95	2.91	1.01	2.63	0.84

Table 25
Changes in Attitudes Between September and December

	ALL	FEMALE	MALE	HIGH ABILITY	LOW ABILITY
Number	104	61	43	58	46
Confidence (r=.53)					
September	2.87	2.72	3.09	3.11	2.69
December	3.34	3.32	3.37	3.62	3.12
t-value	6.20	6.26	2.39	4.37	4.37
Significance	.000	.000	.021	.000	.000
Anxiety (r=.33)					
September	3.18	3.21	3.13	3.20	3.14
December	3.17	3.16	3.1`9	2.91	3.37
Learning Goals (r=.23)					
September	3.14	3.10	3.19	2.96	3.28
December	3.74	3.75	3.74	3.84	3.66
t-value	3.29	2.69	1.89	3.40	1.49
Significance	.001	.009	.066	.001	.141
Conceptions of Mathematical Intelligence (r=.37)					
September	3.42	3.51	3.31	3.51	3.35
December	3.59	3.66	3.48	3.47	3.69
t-value	1.63	1.15	1.14	-.20	2.70
Significance	.107	.254	.262	.779	.009
Beliefs About the Nature of Mathematics (r=.47)					
September	3.39	3.49	3.25	3.34	3.44
December	3.33	3.42	3.21	3.37	3.31

Table 26
Descriptive Statistics for the Four Types

	(Low PRED Low CON) HELPLESS	(High DENIAL) DENIAL	(High ANX High USE) PRESSURED	(Low MATH Low MEM) NAIVE
N	15	15	11	11
SEX	1.40	1.60	1.36	1.64
DIAGC	4.20	3.80	4.00	4.00
DIAGM	2.80	3.27	3.36	3.46
PRED	1.89	3.03	2.66	2.32
CON	1.10	2.73	1.93	2.14
ATTF	1.07	0.87	0.91	1.50
ATTS	3.13	2.00	2.90	2.64
IEM	2.63	3.47	3.73	2.95
LG	2.63	2.90	2.90	2.68
ACTIVE	3.05	3.59	3.43	3.07
MEM	2.78	3.20	3.43	2.12
MATH	3.36	3.64	3.48	2.60
USE	3.80	3.83	5.36	3.18
ANX	3.39	3.30	3.86	2.98
EXAM	60.0	63.9	63.9	60.9
GRADE	2.50	2.43	2.55	2.56