**AN EXPLORATION OF EXTRA AND CLASSROOM VARIABLES FOR THREE MEASURES OF COLLEGE MATHEMATICS ACHIEVEMENT**

by

Margaret Godwin Jamison

Dissertation submitted to the Faculty of

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Educational Research and Evaluation

APPROVED:

Jimmie C. Fortune, Chair

John K. Burton

Elizabeth H. Koball

Javaid Kaiser

Paul B. Siegel

August, 1994

Blacksburg, Virginia

C. 2

LD
5655
V856
1994
J365
C.2

# AN EXPLORATION OF EXTRA AND CLASSROOM VARIABLES FOR THREE MEASURES OF COLLEGE MATHEMATICS ACHIEVEMENT

Margaret Godwin Jamison

Dr. Jimmie C. Fortune, Chairman

Educational Research and Evaluation

This study was an exploration into the effects of four categories of extra-student variables: high school performance, demographic characteristics, Myers-Briggs personality preferences and mathematics attitudes on three measures of college mathematics achievement (a Problem-Solving Test, an Algebra Skills Final Examination and course grade for all seven classes of 175 undergraduate students taking Pre-Calculus I Fall semester 1993). High school performance explained the most variation for all measures of mathematics achievement. Demographic characteristics and mathematics attitudes do not significantly influence any measure of mathematics achievement. The Myers-Briggs Type Indicator (MBTI) preference Extravert versus Intraverts (E versus I) was a significant predictor for the Problem-Solving Test; the Judging versus Perception (J versus P) preference was a significant predictor for the Algebra Skills Final Examination, and both E versus I and J versus P were predictors for the course grade.

An experimental design was used to explore four classroom variables--3 class times, 2 instructional settings, MBTI E versus I and J versus P-- in six classes. Students taking 8:00 classes averaged 9 points lower than students taking 10:00 classes and 11 points lower than students taking 1:00 classes for all measures of mathematics achievement. There was no significant difference for

the two instructional settings--cooperative learning or traditional lecture-- for any measure of mathematics achievement. Students who were Introverted averaged 8 points higher on the Problem-Solving Test. Students who had the Judging preference averaged 11 points higher on the Algebra Skills Final Examination and 5 points higher for the course grade. There was a significant interaction ($p<.01$) for the Problem-Solving Test of class Time x instructional setting caused by the poor performance of the 8:00 Cooperative Learning class. The interaction of E versus I x J versus P or the EIJP learning styles was significant ($p<.05$) for the Algebra Skills Final Examination and course grade. The students with the IJ learning style averaged 13 to 20 points higher for scores on the Algebra Skills Final Examination and 11 points higher for scores on the course grade than students with the other three learning styles--EP, EJ and IP.

## ACKNOWLEDGMENTS

*It is good to have an end to journey towards; but it is the journey that matters in the end.*

**--Ursula K. Le Guin**

*I know no individual who can accomplish his or her goals without assistance from many people. I certainly have many friends and family who have helped me on my journey toward a new understanding of educational research. While my children, Judith and Jeffrey, have added the sidepaths that enrich any journey, my husband, Jerry, has always given me the freedom to pursue the goals I wish to seek.*

*My special thanks to my colleagues at Ferrum College and especially to my friends in the mathematical and computer science department. But the three people who have helped with this study, more than any others, are the three teachers who gave so much patience and time in helping me understand what goes on inside their classrooms.*

*I would also like to thank my new friends and members of the writing workshop who helped me smooth the rough edges. My very special friend, Liz, made my journey back to graduate school fun and reflective.*

*Gratitude and appreciation to all the faculty at Virginia Tech who built the foundation of knowledge I needed to undertake such a study ( especially members of my committee). Thanks to Dr. Siegal who has anchored both my disserations. Lastly, a special thanks to my adviser, Dr. Fortune, who made a bet on the time it would take to complete my journey and was right on target!*

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

# CHAPTER I
# INTRODUCTION

"Mathematical sciences departments have as one important goal the creation of a rich and vibrant environment in which mathematics education thrives effectively for all students" (Leitze, 1994, p. 1). Students can represent more diversity than gender or ethnic differences; for example, they can be underprepared or have different learning styles. As colleges are being swept by the K-12 reform in mathematics (NCTM, 1989), many reports and recommendations have been produced regarding the revitalization of undergraduate mathematics (NRC, 1991). Most mathematical science departments have a mission of excellence in undergraduate education. These departments have or are currently reexamining their goals for student learning. A necessary tool for creating an effective learning environment for mathematics students is faculty members dedicated to educational research. By using appropriate research within their own program and being aware of the perspectives, methodologies, and conclusions of mathematics education research, teachers can create an environment in which quality mathematics education can thrive for all college students.

The goals of this dissertation were to take just one course, Pre-Calculus I, the mathematics course required by most majors, to look at as many variables as possible that affect student achievement in that one set of classes, and to step-back and examine the mathematics education research concerning these variables were the goals of this dissertation.

Classroom research should address real issues that affect our schools or colleges. The research questions raised in this dissertation came from real concerns faced by the members of the mathematics faculty at Ferrum College. Analyses of 1991 data from this Pre-Calculus class showed that approximately 47% of the students taking the course got a D or an F or withdrew. Another area of faculty concern is that many Ferrum College students are not taking this class in their freshman year. Many students are unprepared or anxious and are falling through the cracks for a class critical to their college success. Add to these problems the need for reforming the way we teach mathematics and we have a real need to know what is going on in our own mathematics classrooms.

The body of literature in support of mathematics reform is huge and growing every day. There is no doubt that we can do a better job teaching our students mathematics. The real questions are how to implement these changes and how these changes affect the learning of our students. The literature on mathematics education seems to be in three basic areas : 1) theory on how and why we should change the way we teach mathematics, 2) a few experimental studies on the effects of affective beliefs in mathematics, and 3) small studies on the effects of problem-solving and cooperative learning. I found only one study (Clute, 1984) that addressed mathematics anxiety, instructional method (not cooperative learning), and achievement in the same experiment.

Most of mathematics education research looks at single sets of variables but not a broader conceptual framework. We need to examine not only what factors a student carries into the classroom affecting achievement in mathematics but also what actually happens inside that classroom. Not a single study has looked at factors affecting two measures of college mathematics achievement -- skills acquisition and problem-solving ability. Almost all the classrooms which have been studied were contrived for research purposes and don't reflect real students trying to learn the skills necessary to succeed in their own majors and, ultimately, in their own careers. This study is proposed to be REAL classroom research.

Because this study was broad in its scope--**an exploration**-- the methodology was to address three basic questions:

- What are the instructional outcomes for student learning in mathematics, namely what are **measures of college mathematics achievement**?
- What **extra-classroom variables** effect these measures of mathematics achievement?
- What **classroom variables** or classroom processes effect our measures of mathematics achievement?

# CHAPTER II

## REVIEW OF RELATED LITERATURE

This review of literature is not meant to be an exhaustive search on each of the following topics but rather a list of evidence that supports the value of this study. More literature has been published on these topics on mathematics in the elementary and middle school and much less for colleges. Since I believe that students taking mathematics in college represent a different population than those in the K-12 grades, I have used concentrated on references to research in the area of college mathematics where it is applicable and supportive of K-12 research.

Because no single study addresses all the issues that this study does, this review of literature consists of studies that contribute to the overall question:

*What variables affect college mathematics achievement?*

The first section of the review of literature deals with the question, what actually are appropriate *measures of mathematics achievement.*? The researcher collected data on four measures of college mathematics achievement -- midterm grades, a grade on a problem solving test, a grade on an algebra skills final examination and a course grade. After intensively working with the last three measures of achievement, the researcher realizes that what we value as products of a mathematics course are not necessarily reflected in the student's final grade.

The second section of the review of literature deals with four different *models that predict mathematics achievement.* Two of these are based on structural equations, while the last compares two models with different learning theory bases.

The third section of the review of literature examines the independent variables that affect mathematics separately, apart from overall models. This section deals with what a student carries into the classroom with him/her as previous experiences, abilities, attitudes, or genetic attributes and the relationships of these variables to mathematics achievement. (It should be noted that the teacher also walks into the classroom the first day with his/her own similar characteristics, but this is beyond the scope of this research study except where the researcher asks questions of the teacher to help explain quantitative results.) The *student extra-classroom variables are divided into four broad categories: high school performance, demographic characteristics, mathematics attitudes and student groupings.*

The fourth section deals with variables *influencing the classroom*, the learning or teaching environment that in which the class is taught. Because the two instructional settings in this study were fixed as part of the experimental design, the review of literature will be focused toward looking at the *differences between lecture and cooperative learning* on mathematics achievement

*Contextual conditions* also affect what goes on within the classroom. One of these contexts measurable by the researcher, time of the class, had a definite effect on mathematics achievement. Other classroom contexts to be considered are the effects of implementing new teaching methods, support of new teaching methods by the college, in general, and the effect of the textbook on the content covered.

## Measures of Mathematics Achievement

What do we want students to learn? What are our concepts of educational achievement, in general, and in the area of mathematics specifically? Cole (1990) has two conceptions of achievement: 1) basic skills and facts, and 2) higher order skills and advanced knowledge.

The history of measuring mathematics achievement, similar to that of other subjects, explaining why these two distinctions exist. In the 70's the trend was toward criterion-reference testing or objectives-based testing, which promoted the idea that school skills could be broken down into discrete segments would could be individually tested and clearly linked to the objectives of a specific school curriculum -- *basic skills and facts*. In the late 70's, into the 80's, and continuing today, a more complex level of achievement --"the achievement of higher order skills (using such terms as *critical thinking* or *problem solving*) and of advanced knowledge of subjects (using words such as *understanding* and *expertise*" (Cole, 1990, p. 3)--came to be considered a counterbalance or complement to a collection of basic skills and facts.

Another added dimension is "the issue of not only what we want students in school to learn today, tomorrow, and this year, but what we want them to remember and be able to do many years hence" (Cole, 1990, p. 6). We in mathematics are struggling with teaching problem solving or higher order thinking abilities when students don't even seem to comprehend the basic facts and skills. We know from various studies (Resnick, 1987 and Saxe, 1988) that students can work problems correctly using the algorithmic approaches of arithmetic, but when probed they often shown lack of understanding of the basic operations they have just used or the principles behind the algorithms. What aptitude will they carry away from the college as an adult?

The buzz word for mathematics in the 90's and into the year 2000 is "problem solving". Indeed much curricular change is taking place in mathematics so that we can teach this to our students. Problem solving has come to be viewed as "a process involving the highest faculties--visualization, association, abstraction, comprehension, manipulation, reasoning, analysis, synthesis, generalization--each needed to be 'managed' and all needing to be 'coordinated' "(Garofalo & Lester, 1985, p. 169). But teachers are floundering as to how to teach problem solving, because it is not easy to break into isolated parts, to assess and even to explain and describe.

Another measurement of mathematics achievement and the one the student most reveres is the grade he or she gets at the end of the semester--*the course grade*. What does this conglomerate of a grade represent? Did the student understand the algebraic concepts? Can the student use critical thinking or problem solving approaches in using mathematics? Does this student carry mathematics skills to the next mathematics course or to his or her major courses or job? No matter how diligently a teacher works in the classroom to teach higher order skills or create capable workers, if we place all the value on a course grade of basic skills and facts, then this is what the student will carry out of the classroom.

Even the way we measure *either* basic facts *or* skills *or* problem solving--*the test* is coming under scrutiny. A recent graduate exasperated by no job offers upon the completion of her degree was quoted in The Chronicles of Higher Learning as saying "all we learned in school was how to take a test. Maybe they should teach you how to get a job" (Gose, 1994, p. A28). Is a test the only way we can measure mathematics achievement? There is currently a great deal of attention given to assessing student learning in mathematics. Several alternative measures considered include portfolios, group tests, writing, projects, and classroom presentations (Stenmark, 1991).

This study looked at various factors that measures mathematics achievement in the Pre-Calculus classroom--a test grade on a problem-solving test, a test grade on a final exam consisting of basic facts and skills from the class, and an overall course grade. After diligently working with all the many factors that effected mathematics achievement, I found that the most intriguing results came from how differently each of these three measures of mathematics achievement responded to the same factors.

## Models for Predicting Mathematics Achievement

Various large databases of student information, notably High School and Beyond (National Opinion Research Center, 1983) and the Longitudinal Study of American Youth (Miller, Suchner, Hoffer, Brown & Pifer, 1991) have been used to examine structural equations models that estimate the effect of direct and indirect factors affecting mathematics achievement. By contrasting the standardized regression coefficients for the two studies, the reader can get an idea as to what factors were possible predictors of mathematics achievement.

*Table 1*

*Comparison of Two Structural Models Predicting Mathematics Achievement*

| ***Reynolds and Walberg*** **(1992) (3,116 8th graders)** | | ***Ethington and Wolfle*** **(1986) (16, 535 high school sophomores)** | | |
|---|---|---|---|---|
| **Construct** | **Total Effect** | **Construct** | **Men Effect** | **Women Effect** |
| Home environment | .45 | Mathematics ability | .37 | .30 |
| Motivation | .21 | Verbal ability | .15 | .21 |
| Math achievement-7 | .70 | Mathematics exposure | .29 | .29 |
| Mass media | .16 | Mathematics attitudes | .08 | .05 |
| Peer environment | .04 | | | |
| Instructional time | .12 | | | |

Table 1 indicates mathematics ability, exposure to other mathematics classes and achievement from a previous year are the largest factors or effects (b) influencing mathematics achievement. The Reynolds and Walberg (1992) model also found that the home environment has the second largest effect, as measured by the number of resources, parent expectations, and parent education. Other significant factors found by Reynolds and Walberg (1992) were academic motivation, mass media (out-of-school reading) and instructional time-content coverage. The Ethington and Wolfle (1986) model showed that verbal ability, as measured by tests on reading and verbal skill, did contributed significantly to mathematics achievement. Attitudes about mathematics were not as large a contributor as the other factors.

A non structural equations approach to defining models that predict mathematics achievement was proposed by Siegal, Galassi and Ware (1985) using 143 undergraduates. The analyses for two models of mathematics achievement -- the first, based on social learning theory and the second, based on mathematics aptitude and anxiety -- used forward regression analyses. A measure of which variables were important is shown by the amount of the increase in $R^2$ where $R^2$ is the amount of variation in mathematics performance explained by each of the independent variables entered into the model as shown in Table 2.

*Table 2*

*Comparison of Social Learning Theory and Math Aptitude-Anxiety Models*

| **Model 1 Social Learning Theory** | **Increase in $R^2$** | **Model 2 Math Aptitude-Anxiety** | **Increase in $R^2$** |
|---|---|---|---|
| Math SAT | .114 | Math SAT | .114 |
| Incentives | .029 | Math anxiety | .006 |
| Strength of efficacy | .133 | Gender | .013 |
| Length of efficacy | .003 | Sex roles | .031 |
| Outcome expectations | .009 | | |

Both models show the importance of Math SAT scores as a predictor of mathematics performance. The math aptitude-anxiety model indicates that math anxiety is not a large contributor to performance. Gender is a somewhat larger factor but the variable sex roles, a measure of separate masculinity and femininity scores that defines sex role orientation, was a larger contributor. However, neither of these represents important contributions to mathematics performance. The social learning theory model does have an important contributor besides Math SAT scores --strength of efficacy. This variable was measured by having the students rate their ability to solve each of the problems on the final exam (the measure of mathematical performance) on a scale from 1 to 10 (highly uncertain-completely certain) and adding up the score for each problem. Other factors such as incentives (measure of importance of the exam and extent to which students would prepare) and outcome expectations (students' belief in their ability and skills) increased $R^2$ only slightly.

Using a similar model to the Math Aptitude-Anxiety model utilized by Siegal, Galassi and Ware (1985), Lent, Brown and Larkin (1986) explored the extent to which efficacy beliefs along with other relevant variables could predict academic grades. Hierachial regression of 105 undergraduates for grades in math and science classes produced an $R^2$ of 6% for Math PSAT, 8% for high school rank, 0% for interests and 12% for two measures of self-efficacy.

A third model (Smith, Arnkoff & Wright, 1990), a cognitive-attentional model, which included negative thoughts and underlying concerns, was compared to the social learning model to predict the mathematics performance for 178 undergraduates. Compared to the social learning model, yhe cognitive-attentional model had more unique variation that explained performance.

*Table 3*

*Comparison of Cognitive-attentional and Social Learning Models*

| **Hierachchical Regression Predictors** | **Increase in $R^2$** |
|---|---|
| Ability | .102 |
| Cognitive-attentional | |
| Underlying concerns | .014 |
| Negative thoughts | .124 |
| Situational worry | .024 |
| Social learning | |
| Course importance | .001 |
| Self-efficacy for goal | .043 |
| Satisfaction (future) | .046 |

All these models are very different, not only in their theories and analyses, but even in the variables that the researchers felt contributed to mathematics achievement. The next three sections of the review of literature also offer some of the same variables and others that might contribute to mathematics achievement. But only these studies mentioned above had the breadth to look at several independent variables simultaneously. The studies mentioned in the next sections are narrower in their focus of factors affecting mathematics achievement.

## Student Extra-classroom Variables

An excellent conceptual framework for classification of factors that affect mathematics achievement and a guideline for this study is presented by Lester and Charles (1991) . This framework for research is first broken down into three broad categories--"*Extra-classroom Considerations, Classroom Processes, and Instructional Outcomes*" (p. 4). Each of these categories is further divided into research characteristics. The extra-classroom considerations are further broken down into six components:

- Teacher Presage Characteristics
- Teacher Affects, Cognitions & Metacognitions
- Student Presage Characteristics
- Student Affects, Cognitions & Metacognitions
- Contextual Conditions
- Task Features

Two of these considerations, those dealing with students, particularly pertinent to this study. Contextual conditions as they pertain to this study will be dealt with in a later section. The two factors involving teachers is beyond the scope of this study. It is quite impossible to address all these issues in one study, but I do believe that mathematics education research should be directed using this framework. Larger studies that encompass more variables are needed.

The following categories represent student extra-classroom variables explored in relationship to college mathematics achievement.

### High School Performance

There are many measures of high school performance. The two that first come to mind are SAT scores and high school grades, as these are the two that college admission offices most often use to determine the eligibility of students entering their colleges. This particular study looked at four different measures of high school performance to determine which, if any, of these measures of high school performance affected college mathematics achievement: *Math SAT score, high school grade point average, high school percentile rank* and what Ethington and Wolfle (1986) called *math exposure,* grades in certain high school mathematics classes.

We know that the SAT was designed to predict the success of entering college freshmen, so we would assume that this is an important predictor of mathematics achievement. As noted in the previous section of the review of literature, Siegal, Galassi and Ware (1985) did show that Math SAT scores were one of the most important predictors of college mathematics achievement accounting for 11.4% of the variation.

Another study by Gougeon (1984) used Math SAT scores and the average of all mathematics grades for the classes of 1968, 1973, 1978, 1981, 1982 and 1983 to ask the question: Do Math SAT scores really predict future college mathematics performance and, ultimately, the future mathematics ability of college students? Table 4 represents the $R^2$ for the six years studied.

*Table 4*

*$R^2$ for Mathematics Grades Predicted by Math SAT Scores for 1968-1983*

| **Years** | **Mean Math SAT Scores** | **Mean Math Grades** | $R^2$ |
|---|---|---|---|
| 1968 | 540 | 3.08 | .026 |
| 1973 | 536 | 3.26 | .013 |
| 1978 | 520 | 3.09 | .116 |
| 1981 | 520 | 3.14 | .271 |
| 1982 | 523 | 3.01 | .153 |
| 1983 | 530 | 2.93 | .298 |

The conclusion by the study's authors was that the Math SAT scores were not a good predictor of college math performance aas these scores accounted for 1.3% to 29.8% of the variation for the grades for college mathematics classes. The researcher's conclusions were based on descriptive observation and not tests of significance. Another point of concern and something researchers should consider is the variability in $R^2$ from year to year--this is not addressed in any study.

As to other measures of high school performance, the Ethington and Wolfle study (1986) did show a large effect for both men and women of mathematics exposure. This particular variable was the sum of four dichotomous variables indicating enrollment in high school courses in algebra II, geometry, trigonometry and calculus.

Demographic Characteristics

Many demographic characteristics have the potential to affect college mathematics achievement. Three of these were included in this study -- *major of interest, gender* and *student classification.* Another demographic variable, ethnicity, was part of this study, but 90% of the students enrolled in Pre-Calculus were Caucasian, leaving not enough minority students to make this a viable variable.

It could easily be assumed that students majoring in the sciences should have higher mathematics achievement than those majoring in the humanities or social sciences. Goldman and Hewitt (1976) used the Math SAT to predict the major field choices of students at four large universities and found that it could predict majors almost as well as the college students' grade point average. Their results strongly suggest that mathematical ability is an important determinant of major choices.

At the very heart of not only demographic characteristics but many of the other factors influencing mathematics achievement is gender. In 1972 a sociologist at the University of California - Berkeley (Kogelman and Warren, 1978) revealed that of all the freshmen admitted, 43% of the males and 92% of the females had not taken four years of high school math, a requirement of fifteen of the twenty majors at Berkeley. In effect, female students had limited themselves to only 25 percent of the possible majors. Since this report there has been a huge amount of research on the factor gender in learning.

Because this study found gender differences in only two instances, this review of literature will contend with those two issues. The first is why women get lower SAT, and especially Math SAT, scores than men. The second is why women get higher grades than men while in high school. This is such as current topic that the Roanoke Times and World News Report (Turner, 1994) ran an article entitled " Girls: better grades, fewer scholarships" just a few weeks ago. This article contends that 56% of students taking the SAT this year were females while 3 of every 5 National Merit Scholarship winners, a contest based on SAT test results, were males. Then why do girls make better grades in both high school and college?

The College Board has countered these accusations in two different ways. First, a new version of the SAT was just administered this spring. We have yet to see if the gender bias is still there in this new version. Second, a 1992 article in the College Board Review (Murphy, 1992) references a number of studies that explain why these difference occur. The College Board article (Murphy, 1992) contends that more women than men came from lower economic and/or minority backgrounds and were the first in their families to aspire to higher education. Also, fewer women than men attended private schools or enrolled in higher levels of study, especially in math and science.

The differences in the Math SAT scores by gender are represented in Figure 1 for the years 1967-1991.

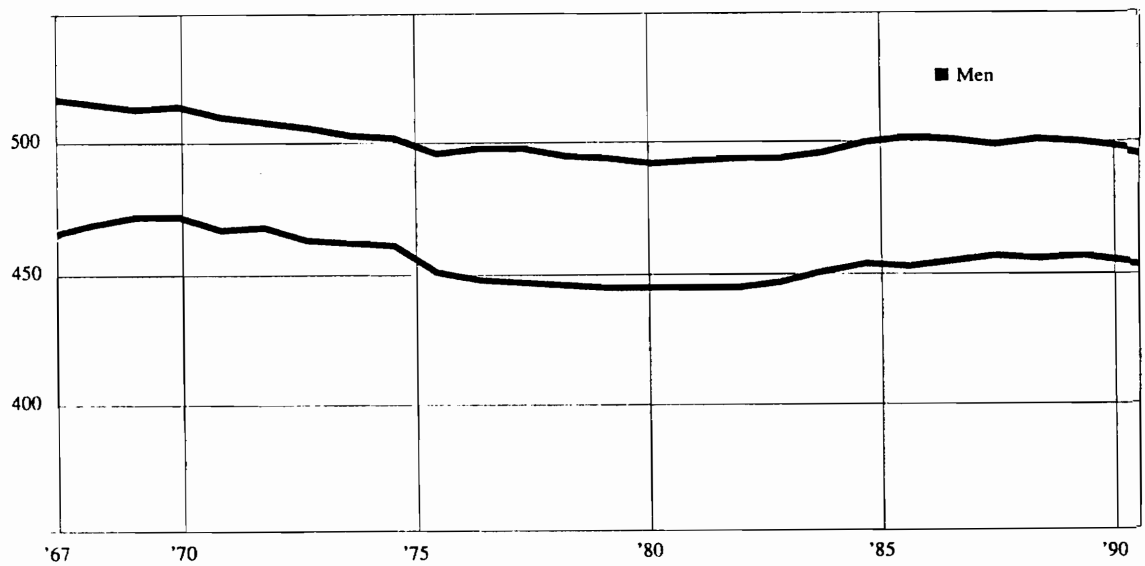



*Figure 1*

*Average math SAT scores for college-bound seniors 1967-1991*

Reasons why women get better grades (Murphy, 1992) are that women have better class attendance, do their homework more frequently, and seek help when needed. All theses reasons contribute to academic success. Women do not enroll in college-level math and science courses to the same extent as men, and it is in those courses, more often than not, that tougher grading exists.

<u>Student Groupings</u>

Student groupings are a way to arrange heterogeneous students in a such a way that learning in the classroom can be enhanced. The grouping of students by ability has been a topic of debate for some time. But grouping students, in this study, must be grounded by what we actually see in the college classroom. Freshmen, sophomores, juniors and seniors from a variety of majors with all types of attitudes toward mathematics and levels of preparedness have to get knowledge from this one class in Pre-Calculus so it will be applicable to their own field and career. Quite a task! So what type of grouping could best accomplish this?

A survey conducted at Sierra Community College (Whittlesy, 1991) involved all students enrolling in algebra classes. This study did not connect the survey results with achievement but did identify two groups represented in the mathematics classroom--the mathematics anxious and the underprepared.

Another possible way to group students is by their *learning styles.* Reckinger (1980) suggests that "teachers should combine the roles of 'farmer' in attending to optimum conditions for students' physical and mental development, and 'artist' in recognizing and respecting their natural talents" (p. 3). This particular article lists over 50 learning style variables grouped into environmental, physical, sociological, psychological, and mental categories. Teaching styles and learning styles are categorized according to the four basic personality preferences using the Myers-Briggs Type Indicator--*extraversion* or *intrversion, sensing* or *intuition, thinking* or *feeling and judging* or *perception.* This particular study combines the sensing/intuitive preference with one other preference to create four different learning styles.

A note here about the Myers-Briggs preferences: as stated above, there are four dichotomous pairs of preferences that make up a person's personality. Their four sets of preferences have been investigated in MANY ways--as sets of all four creating 16 different combinations, in sets of two, as shown above, to create 4 combinations of learning styles, or individually and each preference separately. A good synthesis of using the Myers-Briggs for learning style research is presented by Lawrence (1984). Since the Myers-Briggs used in this study compared the four preferences separately for mathematics achievement, this review of literature will focus on studies with this slant.* McCaulley and Natter (1974) compared mathematics test scores for eighth and twelfth graders at the Florida State University Development Research School as shown in Table 5.

*Table 5*

*Comparison the Four Myers-Briggs Type Preferences for Four Measures of Mathematics Achievement*

| **Myers-Briggs Type** | **12th Grade Math Test** | | | **PSAT** | | | **8th Grade Computation** | | | **8th Grade Prob Solving** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Preferences** | **N** | **Mean** | **t** | **N** | **Mean** | **t** | **N** | **Mean** | **t** | **N** | **Mean** | **t** |
| Extraversion | 40 | 60.6 | 2.17* | 39 | 47.9 | 3.16** | 90 | 62.8 | 0.31 | 90 | 66.7 | 0.52 |
| Intraversion | 46 | 72.7 | | 38 | 57.1 | | 65 | 61.5 | | 65 | 69.0 | |
| Sensing | 48 | 61.9 | 2.08* | 38 | 48.6 | 2.49 | 89 | 60.6 | 0.94 | 89 | 64.0 | 2.05* |
| Intuition | 38 | 73.6 | | 39 | 56.1 | | 66 | 64.5 | | 66 | 72.6 | |
| Thinking | 24 | 66.6 | 0.10 | 26 | 53.3 | 0.40 | 44 | 62.5 | 0.09 | 44 | 69.4 | 0.52 |
| Feeling | 62 | 67.2 | | 51 | 52.0 | | 111 | 62.1 | | 111 | 67.0 | |
| Judging | 26 | 63.0 | 0.95 | 20 | 48.5 | 1.53 | 62 | 58.2 | 1.63 | 62 | 62.5 | 2.02* |
| Perception | 60 | 68.8 | | 57 | 53.8 | | 93 | 65.0 | | 93 | 71.1 | |

* $p < .05$; ** $p < .01$.

Table 5 shows the Extraversion/Introversion (E vs I) and the Sensing/Intuition (S vs N) are the most important Myers-Briggs Preferences for the 12th grade math scores. The 8th grade scores show a difference between the computation and the problem-solving test with none of the preferences being significant for the computational test and the Sensing/Intuition (S vs N) and Judging/Perception (J vs P) significant for the problem-solving test.

Looking at institutional studies, Kaksbeek (1987) investigated the relationship between the four Myers-Briggs preferences and academic performance in colleges. He found that the greater the preference for introversion, the greater the preference for judgment and the greater the preference for intuition, the better the first semester GPA. The largest explaination of GPA by any one preference was determined by the introversion-extraversion preference. None of this is surprising since Introversion is related to aptitude scores such as ACT and SAT. The Judgment/Perception preference gives us an idea about the students' work habits, as judgment types favor closure, structure and order, certainly common academic expectations.

Fish (1984) examined the relationships between community college economics students for the Myers-Briggs preferences and their scores on economics achievement tests. None of the preferences significantly correlated with achievement. Fish also suggested was the possibility that these preferences were interrelated--in other words, each dichotomous preferences was not independent of the other three.

Nisbet, Ruble and Schurr (1982) found that high-risk college students who were helped by a university assistance program and who did not drop out or flunk out were more likely to be judging types. The success profile for high-risk students had four dimensions:

1. Preference for formalized, traditional classroom instruction: lectures, memorization, objective tests, concrete thinking, fact, teacher-directed time-management of assignment.
2. Desire for predictable academic routine: inflexible syllabus.

3. Preference for teacher established, group directed learning goals.
4. Desire for immediate closure in decision-making: teacher announces projects, test dates, types of tests, reading assignments.

These high-risk students "needed immediate and direct assistance in adjusting" to university instruction and needed "consistent counseling reinforcement of their progress" (p. 230) in study skills and habits.

## Mathematics Attitudes

The student carries attitudes or beliefs into any class; this is certainly, an extra-classroom variable. But these attitudes are different from demographic characteristics in that they change as the result of instruction. Even the words "mathematics attitudes" conjure up many definitions to many people. For this reason, I would like to concentrate on the three most commonly used test instruments that measure mathematics attitudes and discuss what attitudes they measure including the results of their use. These test instruments are the *Fennema-Sherman Mathematics Attitudes Scales* (Fennema & Sherman, 1976), *Mathematics Anxiety Rating Scale* (Richardson & Suinn, 1972), and the *Indiana Mathematics Belief Scales* (Kloosterman & Stage, 1992).

The cadillac and still the most widely used is the *Fennema-Sherman Mathematics Attitudes Scales.* The reason this particular test has been so widely used is because Fennema and Sherman divided mathematics attitudes into nine different subscales. These subscales are Confidence in Learning Mathematics, Mother Scale, Father Scale, Attitude Toward Success in Mathematics, Teacher Scale, Mathematics as a Male Domain, Usefulness of Mathematics Scale, Mathematics Anxiety Scale, and Effectance Motivation in Mathematics Scale.

Some studies use all nine subscales, while others only use those that have been found in the literature to be significant predictors.

Thorndike-Christ (1991) gave 1515 middle school and high school mathematics students the Fennema-Sherman Mathematics Attitudes scales along with a background/future plans questionnaire at the beginning of their classes. The final course grade was a measure of mathematics achievement. She found that two of the mathematics subscales, mathematics self-efficacy score and confidence in learning mathematics, along with gender, predicted 43% of the variation in mathematics performance as measured by final course grade.

Another study by Hackett and Betz (1989) involving 153 college women and 109 college men used a revised version of five of the Fennema-Sherman scales and another measure of self-efficacy. Both of these two studies did run product-moment correlations for the Fennema-Sherman subscales and a measure of mathematics achievement as shown in Table 6, suggesting that the Fennema-Sherman subscales would be useful in predicting mathematics achievement. The significance of these subscales is their suggestion that Confidence in Learning Mathematics seems to be the best predictor of mathematics achievement ($r = .53$ to .57). The Mathematics Anxiety subscale also seems to have a high r of .47 to .45 with the Confidence scale. This subscale was NOT a significant predictor of final course grade in the Thorndike-Christ study.

*Table 6*

*Correlations of Fennema-Sherman Subscales and Mathematics Performance Scores*

| | **Thorndike-Christ (n =1515) Final Course Grade** | **Hackett & Betz (n = 181) ACT Scores** |
|---|---|---|
| Confidence in Learning Mathematics | .53 ** | .57 ** |
| Mathematics as a Male Domain | .21 ** | .12 |
| Perceived Usefulness of Mathematics | .29 ** | .40 ** |
| Mathematics Anxiety | .47 ** | .45 ** |
| Effectance Motivation of Mathematics | .33 ** | .40 ** |

** $p < .01$.

The intercorrelations of the five subscales are quite high as shown in Table 7 (Thorndike-Christ, 1991).

*Table 7*

*Intercorrelations Among Five Fennema-Sherman Subscales*

| | **C** | **M** | **U** | **A** | **E** |
|---|---|---|---|---|---|
| Confidence in Learning Mathematics (C) | 1.00 | | | | |
| Mathematics as a Male Domain (M) | .40 | 1.00 | | | |
| Perceived Usefulness of Mathematics (U) | .58 | .46 | 1.00 | | |
| Mathematics Anxiety (A) | .85 | .25 | .49 | 1.00 | |
| Effectance Motivation of Mathematics (E) | .53 | .16 | .28 | .50 | 1.00 |

The second test instrument used quite often is the MARS, *Mathematics Anxiety Rating Scale* (MARS). A lot of research concerning mathematics anxiety, in particular, and test anxiety, in general, was done in the 1970's . Even though the Fennema-Sherman subscale that measures mathematics anxiety does not seem to have much effect on mathematics achievement, the MARS has proven significant in aptitude-treatment-interaction studies. Clute (1984) using the MARS survey instrument has found that students with a high level of mathematics anxiety has significantly lower achievement. She also showed that students with high anxiety benefited more from direct instruction or lecturing, while students with low anxiety benefited more from the discovery or questioning strategies.

Another study using a shortened version of MARS (RMARS) by Llabre and Suarez (1985) investigated the ability of mathematics anxiety to predict grades in an algebra course for 182 college students. The results showed that math anxiety had little to do with course grades.

A third and much newer test instrument is the *Indiana Mathematics Belief Scales* (Kloosterman & Stage, 1992). These scales were developed to measure beliefs which are related to motivation and thus to achievement. These five scales were:

Belief 1: *I can solve time-consuming mathematics problems.*
Belief 2: *There are word problems that cannot be solved with simple, step-by-step procedures.*
Belief 3: *Understanding concepts is important in mathematics.*
Belief 4: *Word problems are important in mathematics.*
Belief 5: *Effort can increase mathematical ability.*

Leitze (1994) complete a study using Belief 1, 2, 3, and 5 and adding six more belief scales to measure attitudes of two sequential, manipulative-based mathematics education classes for prospective elementary teachers.

Belief 6: *Mathematics is useful.*
Belief 7: *Mathematics is an asocial activity.*
Belief 8: *I learn best when I work with other people.*

Belief 9: *I am confident that I can teach elementary school mathematics.*
Belief 10: *The mathematics I'm studying this semester is useful to me.*
Belief 11: *Mathematics is enjoyable to me.*

Of the ten beliefs subscales given at the end of the first course (Belief 4 was not used), five (underlined above) were significant ($p<.01$). A positive significant change (from the beginning to the end of the semester) in the belief of useful of mathematics and useful to teaching mathematics was found. A significant change on the Asocial scale indicated that students felt more strongly at the end of the class that mathematics is an asocial activity. A significant change on the Collaborative scale suggested that at the end of the class students believed that they learned better individually than in a group. A significant change in Steps scale suggested that students felt more strongly that they could learn word problems using a step-by-step procedure. This means that the last four changes were not improvments; in fact , those students still felt that mathematics is just a set of rules to learn. The implications of these last three beliefs seem to be a clear violation of the NCTM's Curriculum and Evaluation Standards for School Mathematics, the Bible for reform in mathematics education.

## Classroom Variables

We have looked at student extra-classroom variables, characteristics and attitudes that students carry into the classroom. In fact, we can consider one of the extra-classroom variables, student groupings, also as a classroom variable as it relates to learning in the mathematics classroom. We also know that the teacher brings in his or her extra-classroom variables-- characteristics such as teacher experiences, IQ, personality, and teaching skills along with attitudes about self, students, and mathematics teaching (Lester and Charles, 1991). Add these to the host of teacher and student actions and interactions that take place during instruction and the complexity of the "instructional setting" becomes clear.

We also need to consider the teaching style of each instructor and this influence on what goes on inside the classroom. If the students can be grouped by personality preferences to create learning styles, then can't instructors be grouped together by what many call "teaching style"? Can the teacher change his/her teaching style to match that of the students? The teacher certainly is a key player in excellence of performance in any subject, mathematics notwithstanding.

In addition, we can add other contextual considerations, such as time of class, class size, departmental support of curriculum, etc., to the complex mix of what happens in the classroom.

## Instructional Settings

"When do instructional methods make a difference", an article by Sigmund Tobias (1982) suggests two hypotheses concerning when the instructional setting makes a difference in student achievement. The first suggests " all modes of assisting the learner or forms of instructional support might have an inverse relationship with prior achievement" (p. 5). This suggests that students with lower prior achievement need more instructional support than students with higher prior achievement. If an instructor is given out $x$

amount of instructional support to a class then the students' extra-classroom variables define how they will perform in that classroom. The second hypothesis is that any instructional setting that "stimulates students to actively attempt to comprehend the material, organize what is learned with what has been learned previously, and relate it to their prior experience will facilitate student learning" (p. 6). This hypothesis suggests that any arrangement which stimulates the student's cognitive processing will improve achievement.

Since this study addresses two different instructional setting, lecture and cooperative learning, with these two hypotheses in mind, let's consider the differences between these two settings. Which of these two settings will cause an increase in mathematics achievement? There is no doubt that all mathematics reform is gearing toward cooperative learning or group processing. The reasoning is obvious. Lecture represents instruction as a delivery of information by a teacher to passive students, a method consistent with many aspects of the basic skills and facts view of mathematics achievement. But educational reformers in all disciplines suggest that the student needs to be considered an active worker. Cooperative learning takes away the role of the teacher as a teller of information and give him or her a new role -- one as a coach or a monitor of the learning process. With this method, students are actively engaged in solving problems, hopefully using *higher order thinking and learning skills*, ideally, they are experts of their own learning.

Noddings, in a 1985 article, states that there are three features of small-group processes critical to cooperative learning:

- students need to encounter challenges and disbelief from their peers,
- group supplies background information that an individual may not

possess,

- students can internalize orderly approaches to solving problems.

Gains from cooperative learning seem to vary quite a bit among researchers. The most optimistic outlook is from Davidson and Kroll (1991), who reviewed 70 studies in mathematics comparing student achievement in cooperative learning versus whole-class traditional instruction. In more than 40% of these studies, students using small-group approaches significantly outscored the control students on individual mathematical performance measures. The other, 60%, showed no difference.

But many others studies have failed to find a difference. To understnd why, one should look back to the two hypotheses presented by Tobias. Does cooperative learning offer more instructional support to the student with lower achievement than does the traditional lecture? Does cooperative learning stimulate the student's cognitive processing more than traditional lecture? Another point to consider is the attitudes that students had after finishing a class using manipulatives in cooperative learning groups (Leitze, 1994); they believe that 1) mathematics is an asocial activity and 2) student learn better individually than in a group. Why haven't these students seen the benefits of group learning that Noddings (1995) suggests are so essential to learning problem solving?

If we look at the impact of "active learning" on college retention (Astin, 1993), we find that retention is facilitated by both student-student and student-faculty interaction. Three measures of the student's individual involvement measuring active learning had positive effects on retention--giving presentations in class, taking essays exams, and working on an independent research project all essentially asocial activities. Faculty reliance on active learning in the classroom seems to have a negative effect on college retention. Cooperative learning experts Johnson, Johnson and Smith (1991) have suggested that poorly designed cooperative learning --where individual responsibility within the group is not equally shared and where students are not held individually accountable--can produce worse results than traditional non-active learning. Before we force students into cooperative learning, we need to rethink the importance of the individual to mathematics achievement and how to correctly design cooperative learning groups.

Teaching Styles

If students and teachers "want different things; they have different motives, purposes, aims, values, needs, drives, impulses and urges...They believe differently: they think, cognize, conceptualize, perceive, understand, comprehend, and cogitate differently" (Keirsey & Bates, p.2), then teaching styles must be addressed along with student learning styles. Does the teaching style of the instructor determine the way the lesson will be presented? Reckinger (1980) suggests that teaching styles do affect the classroom environment as they connects with student learning styles in three ways:

1. *Classroom Organization*--grouping, power relationships, decision-making patterns, division of labor, communication patterns, relations among staff, students, peer influence, etc.
2. *Student-oriented Teacher Attitudes*--educational goals, concepts about the teacher role and the student role, attitudes toward teaching, acceptance or rejection of student, etc.
3. *Teacher Behavior*--teaching practices, specific teaching techniques, response to student behaviors, changes in teaching strategies, materials used, etc.

Studies have explored "effective" teaching and the use of the Myers-Briggs personality preferences in these outstanding professors (Provost, Carson & Beidler, 1987), who are judged on the following criteria (p. 222):

- extraordinary effort as a scholar or teacher,
- service to the instituition and/or the profession,
- a balance of achievement in teaching, scholarship, and service to the instituion,
- evidence of impact and/or involvement with students,
- evidence of achievement by former students, and
- the quality of nominations by former students.

The teaching style of eighteen chosen professors, (using the Extravert/ Introvert and the Judging/Perceiving preference), were identified as follows: 2 were IJ, 2 were IP, 4 were EP and 10 were EJ. Obviously, 14 of the 18 were Extraverted. The EJ teaching style can best be explained by a quotation from one of these outstanding EJ professors:

> ...I put so much effort into communicating the importance of the subject, [;] ... my syllabi are organized, clear, detailed, ... I work like hell in preparing every class (p. 229).

The IJ style, on the other hand, is built not so much on communication but on using energy to find resources:

> I like to try new arrangements of information...My talent is less a matter of performance...than an ability to assemble resources in support of the efforts of others who I respect greatly as colleagues (p. 231).

Teachers with the EP style seem to exhbit flare in their presentations and thrive on responding spontaneously to people. One such professor notes,

> ...the most distinctive thing about my teaching is my enthusiasm...I must admit that I have a streak of 'ham' in me and I don't mind some of that showing in the classroom: it keeps the students awake (p. 232).

The IP style is like the IJ style with less preference on classroom performance and more on persuasiveness:

> ...I make it clear that it is [students'] enjoyment that I am after, not their grade...My aim is to make them comfortable with the strange manner of writing that poetry is; and then, when they are used to that, to enable them to perceive the means the poet is using to enact experience (p. 233).

These professors seem to know their strengths and weaknesses and yet have adapted their style to meet the needs of their students. This is what has made them outstanding. But are certain teaching styles, less valued by the students that others? Certainly, it must be harder to be an effective teacher when you have the Introverted preference. This brings us to the question of whether we have to like the teacher who teaches us the most?

Contextual Considerations

Contextual considerations are conditions external to the teacher and student, which, nevertheless, directly affect instruction. Lester and Charles (1991) list several examples of contextual conditions:

- *classroom contexts* (time of class, class size, use of technology, textbook used)
- *school and community contexts* (ethnicity, faculty and administrative support)
- *social, economic and political forces* (math in workplace, use of technology, world standing in math and science)
- *mathematics content to be learned* (NCTM Standards).

Often these conditions are impossible to measure and are a result of department action or administrative policy. One of these variables, time of classes, was measured in this study. Unfortunately, the literature contains no research that has addressed these issues, except for faculty support. The contextual conditions are always there, always changing and never seem quantifiable.

Faculty support or teacher development has been looked at, in some detail, for the simple reason that in order for any instructional setting to succeed, the teacher must internalize how this instructional setting will affect his or her own attitudes and beliefs about the way students should learn mathematics. The outcome of implementing new instructional materials, for example, for an algebra course brought this out (Swafford & Kepner, 1980):

> In the present study, teachers chosen to participate had, for the most part, only limited knowledge of the experimental materials. They received no external moral or technical support in the form of in-service, local coordinators or consultants, visits by the developer, or repeated site visits by the evaluators. Based on site visits and end-of-chapter reports, it was evident that many experimental teachers endeavored to present the materials in a manner consistent with their intent. But even for these, uncertainty in using materials for the first time limited their effectiveness. Emphases were inappropriately placed or topics inadvertently omitted or never reached. Other experimental teachers, unable to reconcile the experimental approach with the traditional approach, worked against the experimental approach (p. 200).

Certainly any teacher can be motivated for individual reasons to make changes that benefit student learning in his or her own classroom . Secada & Byrd (1993) have stressed the need for this support from the school or a school unit (a department, for example) to "take concerted, coordinated actions to achieve a particular mission" (p. 6). If any lasting beneficial changes are to take place, the department and the administration should back these changes.

Even though the textbook's effects on mathematics achievement is not measurable in this study, a point needs to be made concerning its effect on student learning. As we continue to re-evaluate our mathematics curriculum and change our instructional strategies, we need to step back and look at the role of the textbook we use to promote that learning. When we choose a textbook, we are telling the students and faculty that this is the content we value. A textbook is "a comprehensible statement of a discipline, a national consensus of what constitutes its essential core and standards, validated in the marketplace. [A textbook] is a common intellectual platform in the classroom... and a easy-to-use "second voice" in the course, available 24 hours a day (class is only 50 minutes)" (Lichtenberg, 1994, p. A48). What effect does the textbook have on changing structured pedagogy, on using new instructional strategies in the classroom, and even on assessment of mathematics? Plenty. Perhaps the textbook is the single most important criterion that determines what the student will take away from the class. Certainly it is most often the student's lasting permanent record of that class.

## Hypotheses

From the foregoing review of the literature, the following experimental hypotheses were made. For the study, in general, and the hypotheses, in particular, the questions are always on two separate levels-- *first,* what effect does a list of independent variables have on each dependent variable, and *second,* how do these results compare within the three dependent variables?

*General*

**Research Questions:** (i) What student extra-classroom and classroom variables affect college mathematics achievement?

(ii) What influence will these variables have on the three measures of college mathematics achievement-- grade on the Problem-Solving Test, an Algebra Skills Final Examination or a course grade?

Hypothesis #1: (i) For the four categories of <u>student extra-classroom variables</u> -- high school performance, demographic characteristics, student groupings and mathematics attitudes -- high school performance <u>will contribute most</u> to the variation in <u>college mathematics achievement</u>. The other three categories of student extra-classroom variables will have a lesser yet significant effect.

(ii) All categories of student extra-classroom variables except student groupings will have the <u>same effect for the three measures</u> of college mathematics achievement.

Hypothesis #2: (i) Students in cooperative learning classes will not outperform students in traditional lecture classes. <u>Interactions between</u> time of class, instructional settings and student groupings based on Myers-Briggs personality preferences will overshadow the significance of each variable separately.

(ii) Time of class and instructional setting will not vary according to the measure of college mathematics achievement. Students groupings, on the other hand, will change based on the measure of college mathematics achievement.

Hypothesis #3: (i) A "qualitative" look inside each classroom will reveal three very different teaching styles.

(ii) Students can identify the most "effective" instructor who creates the highest level of achievement for the three measures on college mathematics achievement.

Hypothesis # 4: (i) Success or lack of success in college mathematics can be differentiated by high school performance variables. Other student extra-classroom variables do not contribute significantly to predicting success or lack of success for college mathematics achievement.

(ii) Unfortunately, success or lack of success depends only on the measure of a student's course grade--a mastery of basic skills and facts -- not achievement of a high level critical thinking or problem solving proficiencies.

# CHAPTER III

# THE RESEARCH STUDY

## Method

One hundred and seventy-five students from Ferrum College who enrolled in Pre-Calculus I Fall 1993 started in this study. A total of seven Pre-Calculus I classes with four different professors were implicated.

The method utilized in this study consisted of eight steps:

1. *Before pre-registration Spring 1993,* three mathematics professors were asked to teach two Fall Pre-Calculus I classes--one in the traditional lecture setting and the other in the cooperative learning setting. Each professor was allowed to choose two time slots from a choice of three times-- 8AM, 10 AM and 1 PM.

2. *At the first class meeting* the instructors and the researcher met with all the students together registered for the Pre-Calculus I classes for each of the three time slots. The students were invited to participate in this research study and asked to sign a consent form. The consenting students were asked to fill out the Initial Mathematics Student Survey, were introduced to the course, and were given instructions as to how to find their classes for the next meeting. For each time slot the students were randomly assigned by classification and gender into one of two classes except for students registered jointly for both a Pre-Calculus I and an introductory chemistry class taught by the same instructor.

3. *Three weeks into the fall semester,* the Myers-Briggs Type Indicator was administered to every student taking Pre-Calculus I.

4. *During the first three weeks in November,* all seven Pre-Calculus class were videotaped using two VCR cameras, one focused towards the front of the room on the teacher and the second focused towards the body of students.

5. *On the third Friday and the fourth Monday in November,* the Problem-Solving Test was administered to all classes. Each instructor graded one question on all the tests.

6. *Two weeks before the end of the semester,* the Final Mathematics Student Evaluation was given to all classes.

7. Sunday night *before final exam week,* all students finishing the Pre-Calculus I class were given the Algebra Skills Final Examination. Each instructor graded one section of the exams on all the tests.

8. *After the final* course grade for each class had been computed by the instructor, these were recorded. High school performance data was obtained from the registrar.

## Design

The research design of this study was implemented with four goals in mind: 1) to determine what independent variables affected the three measures of college mathematics achievement--score on the Problem-Solving Test, score on an Algebra Skills Final Examination and the course grade; 2) to determine the effects of time of class, two instructional settings, and student personality preferences on the three measures of mathematical achievement; and 3) to use videotapes and observation to determine the teacher and students behavior in each classroom, and 4) to determine which ndependent variables can be used to classify students who are successful or unsuccessful in the Pre-Calculus I class, .

The Initial Mathematics Student Survey and the Myers-Briggs Type Indicators, along with high school data obtained from the registrar, provided four separate categories of study variables that were thought to affect both problem solving, algebra skills and course grade: *high school performance, demographic characteristics, Myers-Briggs personality preferences* and *mathematics attitudes.*

**Independent Variables**

<u>High School Performance</u>

- Math SAT
- High School Percentile
- High School GPA
- Grades in Math Classes

<u>Demographic Characteristics</u>

- Major of Interest
- Ethnicity
- Gender
- Student Classification

<u>Myers-Briggs Preferences</u>

- Extraversion vs Introversion
- Sensing vs INtuition
- Thinking vs Feeling
- Judgment vs Perception

<u>Mathematics Attitudes</u>

- Anxiety
- Self-Confidence
- Efficacy

**Dependent Variables**

<u>Measures of College Mathematics Achievement</u>

- Problem-Solving Test
- Algebra Skills Final Examination
- Course Grade

Regression Analyses were used to determine what percent of the variation for the dependent variables--Problem-Solving Test, Algebra Skills Final Examination, and course grade were explained by each of these independent variables.

The effects of class time, two instructional settings and student personality preferences were designed as a 3 x 2 x 2 x 2 factorial analysis of variance. By looking at the significance of $R^2$ of the independent variables, it was determined that two personality preferences were determined useful in grouping students for the three times and the two instructional settings (within each classroom).

**FALL SEMESTER 1993**

| **M W F** | **Lecture** | **Cooperative Learning** | |
|---|---|---|---|
| 8 - 8:50 | Teacher B<br>[ E vs I<br>J vs P ] | Teacher C<br>[ E vs I<br>J vs P ] | Teacher DN |
| 10 - 10:50 | Teacher C<br>[ E vs I<br>J vs P ] | Teacher D<br>[ E vs I<br>J vs P ] | |
| 1 - 1:50 | Teacher D<br>[ E vs I<br>J vs P ] | Teacher B<br>[ E vs I<br>J vs P ] | |

*Figure 2*

*Experimental design for the study*

There are two class effects --three class times (8 AM, 10 AM and 1 PM) and two instructional settings (lecture and cooperative learning) -- and two student effects--extraversion vs introversion and judgment vs perception personality preferences. Since this was an experimental design setup in which each instructor used two different teaching methods, the class belonging to DN was not used in the analysis of variance factorial analyses but was used in both the regression and discriminant analyses.

The transcripts of the videotapes were used to further identify factors more subjective or "qualitative" in nature that would influence the six classrooms represented by the experimental design above.

If a student received a 70 or higher, then the student was called successful in the Pre-Calculus class. If the student received less than a 70 or withdrew, then that student was designated unsuccessful. The variables that were found significant from the regression analyses were used in the discriminant analysis. Since classifying groups needed to be as homogenous as possible, of seven classes included in the analysis only freshmen were used. A prediction equation was determined and success of classification was noted.

## Null Hypotheses

The following null hypotheses were tested using a p-value less than or equal to .05 level of significance (notation i) stands for effect of independent variables have on each dependent variable and ii) results compared within the three dependent variables):

Hypothesis #1: *(Regression Analyses the foundation for hypothesis #2 and #4)*

i) The linear model for the four categories of independent variables is not adequate to predict college mathematics achievement.

ii) Subjective observation comparing $R^2$ for each measure of achievement.

Hypothesis # 2: *(Factorial Analysis of Variance)*

i) There are no difference in the four main effects of three class times, two instructional settings (lecture and cooperative learning), Extraversion versus Introversion and Judgment versus Perception Myers-Briggs preference for college mathematics achievement.

There is no interaction between class times and instructional settings for college mathematics achievement.

There is no interaction between extraversion vs introversion and judging vs perceptive personality preferences for college mathematics achievement.

There is no third-order interaction between instructional settings and the two personality preferences.

ii) Subjective observation of the mean square effect and significance of null hypotheses i) above.

Hypothesis #3: *(Qualitative and Survey Research)*

i) Student and teacher interactions in each of the six classroom affect college mathematics achievement.

ii) Student evaluations can determine which classroom are the most "effective" in learning college mathematics.

Hypothesis # 4: *(Discriminant Analyses)*

i) There is no discriminant function that will successful classify students into successful and unsuccessful.

ii) Qualitative overview in what was measured by the course grade.

The first null hypothesis was tested by determining if the $R^2$ value for each independent variable was significant for the Problem-Solving Test, the Algebra Skills Final Examination and the course grade.

Hypothesis # 2 was testing by looking at the main effects of class time, instructional settings, extraversion vs introversion and judgment vs perception on the three measures of mathematics achievement. The null hypotheses testing for the second-order interactions between class times and instructional settings and the two personality preferences (E vs I and J vs P) was determined. The last hypothesis tested was the third-order interaction between the instructional settings and the two personality preferences on mathematics achievement.

Not being quantitative in nature, the third hypothesis (#3) was a condensation of transcripts created by watching the 18 fifty minute segments for all the classes of the three teachers for three lessons. Survey questions were analysed using chi-square tests and F-ratios for both student evalution questions and questions concerning the students in each of these six classes.

Hypothesis # 4 was tested using the chi-square test for the one latent root found for the predictor variables. The success of the procedure was in comparing the predicted outcomes with the observed outcomes using the discriminant function.

## Sample

The sample was Ferrum College students taking Pre-Calculus I Fall 1993. It was assumed that this sample for the Fall semester represented what has been happening in Pre-Calculus I for the last two years since the textbook and the instructors teaching this class are approximately the same for the last two years.

Whether this sample is representative of all college students taking Pre-Calculus I, depends largely on the type of college offering the course. To determine if this sample is indeed representative, the researcher will have to look at not only the students who take this class Fall of 1994 but also students who take this class Spring semester. Many small private and even public universities teach this type of mathematics class.

This particular course was picked for the study because almost all students at Ferrum College must take this class for their majors. The students who don't take this class are either liberal arts majors who take a mathematics topics course or computer science/mathematics students who start in Calculus. This class represents the largest population taking any single mathematics class at Ferrum College with about 160 to 175 students taking these classes Fall semester. Table 8 shows the actual number of students who participated in this study. These classes were chosen because of the proximeity to the researcher, the ease of getting permission from the students, and the concerns of the mathematics faculty

From the Initial Mathematics Student Survey given the first day, demographic characteristics were collected to help define who was included in the sample used for this study.

Table 9 gives demographic characteristics about the students taking Pre-Calculus I Fall of 1993. The four types of information of interest were *major of interest, ethnicity, student classification* and *gender*. Since most of these students were freshmen (almost 80%), they had not committed to a major but expressed interest in one of five possible areas. A further consideration on this table is the

*Table 8*

*Number of Pre-Calculus I Students Involved in the Study*

| **Semester Time Table** | **Number** |
|---|---|
| Started the Semester and completed the Initial Mathematics Student Survey | 175 |
| Completed the Myers-Briggs Type Preference | 172 (and 4 instructors) |
| Withdrew before Midterm | 6[1] (2 Lecture, 4 Coop-L) |
| Received Midterm Grades | 169 |
| Withdrew between Midterm and Final | 7[2] (1 Lecture, 6 Coop-L) |
| Completed Problem-Solving Test | 162 |
| Completed Algebra Skills Final Examination | 162 |
| Received a Final Grade | 162 |

[1] Of the six withdrawing before midterm, 3 came from Teacher B, 1 from Teacher C and 2 from Teacher D.

[2] Of the seven withdrawing after midterm, 3 came from Teacher B and 4 from Teacher C.

percent of males and females for each major of interest, ethnicity, and student classification.

*Table 9*

*Demographics of Students Taking Pre-Calculus I Fall 1993*

| | One way Classification Tables | | | |
|---|---|---|---|---|
| | **N** | **% of Students** | **%Male** | **%Female** |
| *Major of Interest* | | | | |
| Social Science/History | 28 | 16.8 | 54 | 46 |
| Biology/ Env Sci/ Pre-Prof Sci | 72 | 43.1 | 67 | 33 |
| Business/ Accounting | 35 | 21.0 | 66 | 34 |
| Humanities/Fine Arts/ English | 18 | 10.9 | 33 | 67 |
| Computer Sci/ Math | 14 | 8.4 | 64 | 36 |
| *Ethnicity* | | | | |
| Caucasian | 152 | 89.9 | 60 | 40 |
| African American | 14 | 8.3 | 71 | 29 |
| Hispanic | 1 | 0.6 | 100 | 0 |
| American Indian | 1 | 0.6 | 0 | 100 |
| Other | 1 | 0.6 | 0 | 100 |
| *Student Classification* | | | | |
| Freshman | 135 | 79.9 | 61 | 39 |
| Sophomore | 10 | 5.9 | 80 | 20 |
| Junior | 20 | 11.8 | 50 | 50 |
| Senior | 4 | 2.4 | 75 | 25 |
| *Gender* [a] | | | | |
| Males | 103 | 60.9 | | |
| Females | 66 | 39.1 | | |

[a] *For the total student body the gender ratio was 55% males and 45% females.*

## Definitions

### Mathematics Attitudes Scales

Since prior research (Thorndike-Christ, 1991; Hackett and Betz, 1989) has shown that *three* of the Fennema-Sherman Mathematics Attitudes Scales affected mathematics achievement significantly at the high school level, these scales were part of the Initial Mathematics Student Survey given the first day of class. The three subscales were *Confidence in Learning Mathematics, Mathematics Anxiety Scale,* and the *Effectance Motivation Scale in Mathematics.* The original subscales were written with a choice of five responses, but was changed to four responses so that the student had to make a commitment to agreeing with or disagreeing with each questions. Each of these subscales is made up of twelve questions, six of which were positively stated and six of which were negatively stated. Each item had response options of strongly agree, agree, disagree or strongly disagree. Each scale was then totaled, taking into account the weight of positive or negative contribution to creating a total score for each student for the three scales.

The total score in Confidence in Learning Mathematics Scale was intended to measure confidence in one's ability to learn and to perform well on mathematical tasks. A high score represented definite confidence while a low score represented a distinct lack of confidence. The total score in Mathematics Anxiety Scale was intended to measure feelings of anxiety and nervousness associated with doing mathematics. A high score represented a distinct anxiety including bodily symptoms to doing mathematics while a low score represented a feeling of ease. The total score in Effectance Motivation Scale in Mathematics was intended to measure effectance as applied to mathematics. A high score represented active enjoyment of the challenge of mathematics while a low score represented a lack of involvement in mathematics. The means and standard deviations for Total Anxiety, Total Self-Confidence, and Total Effectance for gender and student classification are presented in Table 10.

*Table 10*

*Means and Standard Deviations for Total Anxiety, Total Self-Confidence and Total Effectance Scores*

| | **Total Anxiety** | | | **Total Self-Confidence** | | **Total Effectance** | |
|---|---|---|---|---|---|---|---|
| | **N** | **Mean** | **Std** | **Mean** | **Std** | **Mean** | **Std** |
| | | | | *Gender* | | | |
| Males | 103 | 31.5 | 5.4 | 33.8 | 4.9 | 30.1 | 4.7 |
| Females | 66 | 30.0 | 7.7 | 32.0 | 7.4 | 30.7 | 6.3 |
| | | | | *Student Classification* | | | |
| Freshman | 135 | 31.5 | 6.0 | 33.6 | 5.7 | 30.9 | 5.4 |
| Sophomore | 20 | 28.1 | 8.0 | 31.3 | 8.2 | 29.3 | 5.2 |
| Junior | 10 | 28.2 | 5.5 | 29.5 | 5.5 | 26.4 | 2.7 |
| Senior | 4 | 29.8 | 8.1 | 32.8 | 3.8 | 26.5 | 3.7 |

Appendix A contains a sample of the Initial Mathematics Student Survey. The first twelve questions were the Mathematics Anxiety subscale; questions 13-24 were the Confidence in Learning Mathematics subscale, and questions 25-36 were the Effectance Motivation subscale.

Lecture Instructional Setting

The Lecture Instructional Setting was designated as the method whereby the instructor presented the information in a lecture format for the full fifty-minute period Monday, Wednesday, and Friday. This type of instructional setting stresses that the teacher is the conveyer of the information to be learned, and the student will learn by passively listening to the instructor. The instructor is the authority in this situation, and the student is responsible for his or her own learning. No interaction between classmates usually occurs, unless two students are talking to each other about either other matters or a mathematics concept that is troublesome.

Cooperative Learning Instructional Setting

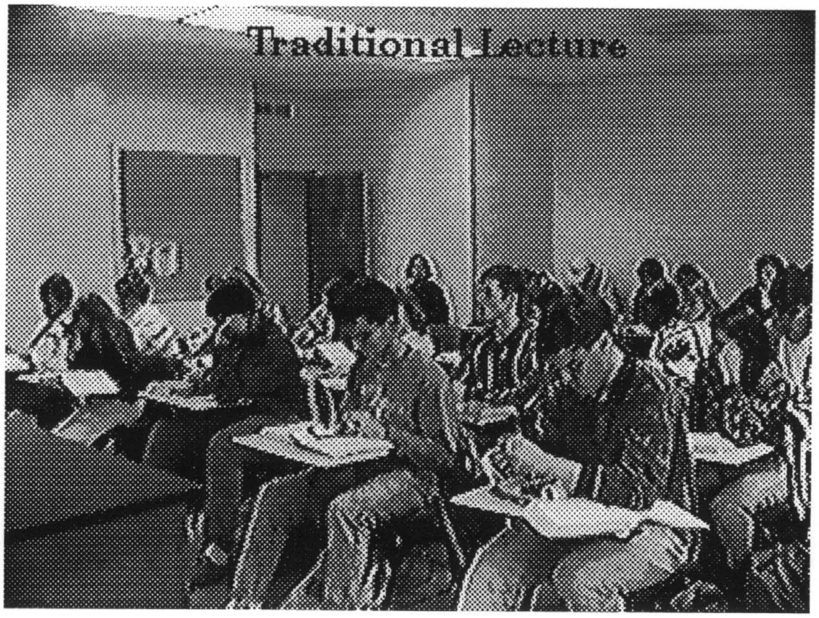
The Cooperative Learning Instructional Setting for this study was to be an environment where the teacher's talking was limited to ten minutes and the rest of the time the students would be in cooperative learning groups working interactively to learn the mathematics concepts. There was some problem implementing cooperative learning for four of the classes because the two teachers had no exposure to cooperative learning except in the form of supplemental reading materials on the topic. One of the instructors teaches a mathematics education class and had considerable experience in the use of cooperative learning. This instructor had also implemented this instructional setting in some of his earlier classes.

Implementing cooperative learning was not easy to do not only because the instructors were not sure how to do it but also because there was considerable resistance on the part of students to work in groups. Students wanted the teacher to present the material and did not have faith that other students in their groups knew any more than they did or could help them learn. Some students wanted to change classes when they found out they were in a cooperative learning class. This presented stress not only to instructors who were trying to do their best with a new instructional setting but to other students who hadn't made up their minds about working in groups. After the first month they did start to see the advantage of cooperative learning, but I do not think it was possible to implement this instructional setting as we had first intended. Figure 3 represents an example of the typical classroom for each instructional setting. Videotapes of the three cooperative learning classes showed that each class averaged 20 minutes working in a group and 30 minutes listening to the instructor lecture on the mathematics content.

Myers- Briggs Type Preferences

The four type preferences based on Jung's theory of psychological types are measured through the use of the Myers-Briggs Type Indicator (MBTI). The MBTI was based on Jung's ideas about perception and judgment and the way these modes are employed by different types of people. Each of these four type preferences have distinct uses of perception and judgment. The preferences affect not only what people *attend to* in any given situation but also how they draw conclusions about what they perceive. Each of the four preferences has two outcomes with one being dominant. The four preferences are *extraversion or intraversion, sensing or intuitive perception, thinking or feeling* and *judgment or perception*. . A summary of how each of these four preferences is used in learning style research is presented in Table 11 (Jensen, 1987).

These four preferences have been used in learning style research. Lawrence (1984) states that the MBTI can be used to predict "preferred or habitual



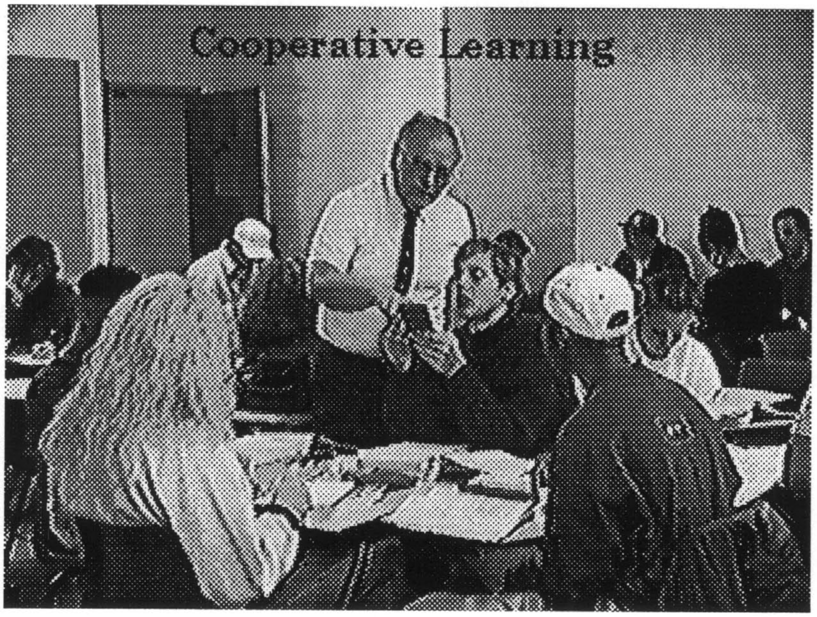




*Figure 3*

*Comparison of two instructional settings, lecture and cooperative learning*

*Table 11*

*Myers-Briggs Type Preferences and Learning Styles*

| | |
|---|---|
| **Extraversion (E)** Es learn best in situations filled with movement, action and talk. They prefer to learn theories or facts that connect with their experience and they will usually come to a more thorough understanding of these theories or facts during group discussions or when working on cooperative projects. Es tend to leap into assignments with little "forethought," relying on trial-and-error rather than anticipation to solve problems. | **Introversion (I)** Since Is may be more quiet and less active in the classroom, teachers may feel the need to press them into taking part in group discussions. Such pressure, however, will often only increase their withdrawal. Teachers need to respect their need to think in relative solitude, for that is how they think best. Is will be more willing to share their ideas when given advance notice. This will allow them time to think about how they will become active in the classroom. |
| **Sensory Perception (S)** Ss learn bet when they move from the concrete to the abstract in a step-by-step progression. They are thus at home with programmed, modular, or computer-assisted learning. They value knowledge that is practical and want to be precise and accurate in their own work. They tend to excel at memorizing facts. | **Intuitive Perception (N)** Ns tend to leap to a conceptual understanding of material and may daydream or act-up during drill work or predominately factual lectures. They value quick flashes of insight but are often careless about details. They tend to excel at imaginative tasks and theoretcal topics. |
| **Thinking Judgment (T)** Ts are most motivated when provided with a logical rationale for each project and when teachers acknowledge and respect their competence. They prefer topics that help them to understand systems or cause-and-effect relationships. Their thought is syllogistic and analytic. | **Feeling Judgment (F)** Fs are most motivated when given personal encouragement and when shown the human angle of a topic. Fs think to clarify their values and to establish networks of values. Even when their expressions seem syllogistic, they usually evolve from some personally held belief or value. |
| **Judgment (J)** Js tend to gauge their learning by the completion of tasks: reading "x-amount of books, writing "x"-amount of papers, or making "x"-amount of reports. They thus prefer more structured learning environments that establish goals for them to meet. | **Perception (P)** Ps tend to view learning as a free-wheeling, flexible quest. They care less about deadlines and the completion of tasks. They prefer open and spontaneous learning environments and feel "imprisoned" in a highly structured classroom. |

patterns" or "dispositions " (p. 5). In this study, these four preferences were looked at separately to determine which one or ones of the four preferences might influence solving word problems or learning algebra skills. Table 12 presents each of the four preferences and grade distribution for both the Problem-Solving Test and the Algebra Skills Final Examination.

*Table 12*
*Myers-Briggs Preferences and Grade Distribution for the Problem-Solving Test and Algebra Skills Final Examination*

| | | | Row Percents by Grades for each Preference | | | | |
|---|---|---|---|---|---|---|---|
| **MBTI** | **N** | **% of N** | **100->90** | **90->80** | **80->70** | **70->60** | **<60** |
| | | | *Problem-Solving Test* | | | | |
| Extraversion (E) | 100 | 62 | 4.0 | 5.0 | 12.0 | 11.0 | 68.0 |
| Introversion (I) | 62 | 38 | 6.5 | 9.7 | 19.0 | 15.0 | 50.0 |
| Sensing (S) | 105 | 65 | 3.8 | 6.7 | 16.0 | 10.0 | 63.0 |
| Intuition (N) | 57 | 35 | 7.0 | 7.0 | 12.0 | 16.0 | 58.0 |
| Thinking (T) | 77 | 48 | 6.5 | 9.1 | 16.0 | 13.0 | 56.0 |
| Feeling (F) | 85 | 52 | 3.5 | 4.7 | 14.0 | 12.0 | 66.0 |
| Judgment (J) | 62 | 38 | 3.2 | 3.2 | 23.0 | 11.0 | 60.0 |
| Perception (P) | 100 | 62 | 6.0 | 9.0 | 10.0 | 13.0 | 62.0 |
| | | | *Algebra Skills Final Examination* | | | | |
| Extraversion (E) | 100 | 62 | 4.0 | 24.0 | 21.0 | 16.0 | 35.0 |
| Introversion (I) | 61 | 38 | 9.8 | 25.0 | 21.0 | 16.0 | 28.0 |
| Sensing (S) | 104 | 65 | 3.8 | 29.0 | 22.0 | 11.0 | 35.0 |
| Intuition (N) | 57 | 35 | 11.0 | 16.0 | 19.0 | 26.0 | 28.0 |
| Thinking (T) | 78 | 48 | 6.4 | 28.0 | 22.0 | 13.0 | 31.0 |
| Feeling (F) | 83 | 52 | 6.0 | 20.0 | 20.0 | 19.0 | 34.0 |
| Judgment (J) | 62 | 39 | 11.0 | 27.0 | 26.0 | 13.0 | 23.0 |
| Perception (P) | 99 | 61 | 3.0 | 22.0 | 18.0 | 18.0 | 38.0 |

Since each preference represents a dichotomous variables and preferences are independent of each other, these preferences were used as a way to look at how students learn in the classroom.

## Instruments

### Initial Mathematics Student Survey

The Initial Mathematics Student Survey consists of the three Fennema-Sherman Mathematics Attitudes subscales, a table for self-reporting of grades in high school mathematics classes, questions on previous college mathematics classes, and demographic information about major, ethnicity, gender, and student classification. Stapled on top of the Initial Mathematics Student survey was a consent form which was read to the students. All but one student signed the consent form and continued to answer the survey. A copy of this survey and the consent form are shown in Appendix A. The three Fennema-Sherman scales made up of twelve questions each were the Mathematics Anxiety Scale, the Confidence in Learning Mathematics Scale, and the Effectance Motivation Scale. The split-half reliabilities (Fennema & Sherman, 1976) are .89, .93 and .87 respectively. The means and standard deviations for the total scores for these three mathematics attitudes scales were presented in Table 10.

The table of self-reported grades for high school mathematics classes was used to measure how prepared each student was when they entered the Pre-Calculus class. This particular table of self-reported grades was pretested during a two-week summer session of incoming freshmen to determine if all types of mathematics classes were listed. The table consisted of a checklist of courses and grades for, each ranging from A to F, including "didn't take". Because of the unreliability of self-reported scores, sixty sets of grades were checked for accuracy. Of the sixty sets of transcripts checked, eight showed some discrepancies, with most students reporting one grade higher than they received and two reporting one grade lower than they received. The letter grades were converted to 4 points for an A, 3 points for a B, 2 points for a C, 1 point for a D, and 0 for an F or "didn't take the class". The most difficult and confusing part of the self-reporting procedure was section concerning classes past the level of Algebra II and Geometry. Algebra II seem to be a standard term, but higher level mathematics classes were called by many different names, such as Math Analysis, Algebra III, Pre-Calculus I and even higher level classes such as Probability and Statistics, mathematical modeling and mathematics 5. Another confusing question was when the students took the Trigonometry they had checked. Did they take it with Algebra II, or with Math Analysis or even with Algebra III? All of these student who had self-reported taking Trigonometry were checked against their high school transcripts.

Other information was gathered concerning whether students had taken mathematics in their senior year, whether they had taken any mathematics classes in college, and background information such as a major in interest, ethnic heritage, gender and student classification (Table 9).

Myers-Briggs Type Indicator

Form G of the Myers-Briggs Type Indicator was administered to every Pre-Calculus I student in the Fall 93 semester three weeks after classes started. Form G developed in the late 1970's and is now the standard form of the MBTI.

The form consists of 126 questions or word pairs in three parts with multiple choice answers. Part I and III consist of 26 and 55 questions, respectively, with the respondent giving the answer that comes closest to how he/she usually feels or acts. To get an idea as to the type of questions asked in Part I and III, shown below are two sample questions:

8. Are you successful
   - (A) at dealing with the unexpected and seeing quickly what should be done, or
   - (B) at following a carefully worked out plan?

11. When you don't approve of the way a friend is acting, do you
   - (A) wait and see what happens, or
   - (B) do or say something about it?

Examples of the word pairs presented in Part II are shown with the questionnaire asking "which word in each pair appeals to you more?"

57. (A) punctual leisurely

69. (A) accept change

Since the main objective of the MBTI is to identify four basic preferences, the indices E vs I, S vs N, T vs F and J vs P are designed to point in one direction or the other. All choices to the questions reflect the two poles of the sample preference. Each of the responses may be weighted 0, 1, or 2 points. Responses that best predict total type with a prediction ratio of 72% or greater carry a weight of 2; items that predict to type with a prediction ratio of 63% to 77% carry a weight of 1; overpopular responses carry a weight of 0. Scoring for each preference is done by placing the a template on the OpScan sheet of answers. Persons with a higher total of points for E than for I are classified as E's or extraverts. This continues for each preference with a score and a direction computed for each preference. An example of a report form given to every student who participated (only one refused) displays their scores for each dominant preference on a scale from 0 to 62 is shown in Appendix B and gives information about each preference measured by the MBTI. Since it is common to discuss Myers-Briggs according to the 16 possible types, the back of the report sheet contains characteristics for each of these 16 types so the students can get feedback as to their type. Since the MBTI was given not only for research purposes but to help incoming freshmen get feedback about possible major and career choices, a more in-depth sheet of information about their type including personality description, possible blindspots, popular occupations and recommendations for the job search was given out with the report form. An example of the the description sheet for the researcher is also presented in Appendix B.

The internal consistency derived from product-moment correlations with continuous scores with Spearman-Brown prophecy formula correction for traditional college students is .82 for E vs I, .81 for S vs N, 82 for I vs F and .86 for J vs P preferences (Myers & McCaulley, 1985). Validity for the MBTI has been addressed in two ways: 1) do the MBTI continuous scores correlate with other instruments that appear to measure the same constructs? and 2) is there evidence that the MBTI is consistent with behavior predicted by theory? As to education validity of the MBTI, preferences can be related to aptitude, interest, application, achievement and other aspects of teaching and learning. This use of the MBTI as it applies to the students in the classroom is presented in the Review of Related Research chapter under Student Groupings.

Problem-Solving Test

The Problem-Solving Test was developed by the four instructors of the Pre-Calculus class and the researcher. These problems were developed from similar word problems presented in the text and different word problems from other college mathematics texts that stressed problem solving. The topics these word problems covered were:

Fundamental Concepts of Algebra
Solving Equations and Inequalities
Functions and Graphs

which came from Chapters 1-3 of the textbook by Demana, Waits & Clemens (1992), College Algebra and Trigonometry. Eight word problems were chosen and given to each instructor teaching Pre-Calculus Fall semester. Since the Problem-Solving Test was given in a fifty-minute class, only the four problems that had the most support were included on the test. Each question had three to five parts, so the students could be prompted to think of one concept at a time. Since graphing calculators are an essential part of this course, each question required the student draw a graph. Two of the questions asked for written solutions and explanations. The four questions that were not used on the test were given to the instructors to use as review for the test if they wished to do so. In general three questions were similar to those worked out in the text and the fourth question was a problem students had never worked before. A copy of this Problem-Solving Test can be found in Appendix C.

Each of the four instructors one question for all the tests. The researcher added up the points and assigned a numerical grade.

Algebra Skills Final Examination

The Algebra Skills Final Examination consisted of 31 questions dealing with algebraic concepts covered during the semester. Many of the questions on the exam were covered in more than section of the text. This exam was given to all students, at the same time, the day before the exam period started. The 31 questions were chosen from six previous final exams given by each course instructor. The concepts covered were:

Fundamental Concept of Algebra

1.1 Real Numbers and the Coordinate Plane
1.2 Graphing Utilities and Complete Graphs
1.3 Graphing $y = x^n$ and Properties of Exponents
1.4 Algebraic Expressions

Solving Equations and Inequalities

2.1 Solving Linear and Quadratic Equations Algebraically
2.2 Solving Equations Graphically
2.3 Applications and Mathematical Models
2.4 Solving Linear Inequalities
2.5 Solving Inequalities Involving Absolute Value
2.6 Solving Higher-Order Inequalities Algebraically and Graphically

Functions and Graphs

3.1 Graphs of Relations
3.2 Functions
3.3 Linear Functions and Linear Inequalities
3.4 Analytic Geometry of Lines
3.5 Graphs of Quadratic Functions
3.6 Operations on Functions and Composition of Functions

Polynomial Functions

4.1 Graphs of Polynomial Functions
4.3 Real Zeros of Polynomials: The Factor Theorem

A copy of the Algebra Skills Final Examination can be found in Appendix D.

Each instructor teaching the Pre-Calculus classes was involved in grading the Algebra Skills Final Examination. The questions were divided up equally and each instructor graded that section for all exams. The researcher totaled the exam and assigned a numerical grade.

Final Mathematics Student Evaluation

The Final Mathematics Student Evaluation was a survey instrument that did several things. The first seven questions dealt with an evaluation of the students' classroom teacher, with the first five of the seven questions coming from differences seen on the videotapes. The last two of the seven were questions that have been shown in the literature (McCutcheon, Schmidt & Bolden, 1991) to have different values based on the teaching style of the instructor. The second part of the Final Mathematics Student Evaluation consisted of completing the same questions from the self-confidence subscale from the Fennema-Sherman Mathematics Attitude tests given the first day of class on the Initial Mathematics Student Survey. This gave the researcher a way to measure the change in self-confidence for doing mathematics based on the class the student was in. The third part consisted of questions or statements which measured the study habits of the students. No only did the questions measure how well the students kept up with their homework and reading but also how they persevered in working a math problem. Also included on this section of study habits was a questions concerning how many hours students studied before coming to class and how many times they missed their class. At the very bottom, was a question asking the student if he or she had been satisfied with the class and why or why not.

A copy of the Final Mathematics Student evalutation is found in Appendix E.

## Procedure

### Data Collection

Each student was given a unique code that included the class section and a number from 1 to the number in the class. This allowed work-study students to key in the data from the Initial Mathematics Student Survey. Each variable was placed in a field in a database. An example of the form view of the database for one student is shown in Figure 4. The use of the database allowed for easy summing up to get the total values for each of the three Fennema-Sherman subscales collected the first day of class. Other work-study students, from both my department and Career Services, helped grade the Myers-Briggs Type Indicator. The Myers-Briggs preferences, midterm, score on the Problem-Solving Test, score on the Algebra Skills Final Examination and the student's course grade were entered into the database by the researcher along with the responses from the Final Mathematics Student Evaluation. Other variables needed for the analyses such as instructional setting, time of class, etc. were also added.

The database file was then saved as a dBase III file and imported into the statistical software CSS's Statistica. Any other variables that were created for ease of analyses were added to the statistics file using the programming language of Statistica.

### Statistical Analyses

Each hypotheses stated at the end of the Review of Related Research chapter used a different statistical analysis. Let me say right here that much

Math Anxiety

Q1: 2 Q2: 2 Q3: 3 Q4: 2 Q5: 2 Q6: 3
Q7: 2 Q8: 2 Q9: 2 Q10: 3 Q11: 2 Q12: 3

Self-Confidence

Q13: 3 Q14: 3 Q15: 3 Q16: 2 Q17: 3 Q18: 3
Q19: 2 Q20: 2 Q21: 2 Q22: 3 Q23: 3 Q24: 2

Self-Efficacy in Math

Q25: 2 Q26: 2 Q27: 3 Q28: 2 Q29: 2 Q30: 3
Q31: 2 Q32: 2 Q33: 3 Q34: 3 Q35: 2 Q36: 2

Math Preparedness

AlgI: 2 Geometry: 2 AlgII: 2 MathAnal: __
Trig: 2 Calculus: __ HSPrepared: 38

Teacher Evaluation

TEQ1: 4 TEQ2: 3 TEQ3: 4 TEQ4: 3
TEQ5: 1 TEQ6: 4 TEQ7: 3

END Self Confidence

ESQ1: 4 ESQ2: 3 ESQ3: 4 ESQ4: 3
ESQ5: 4 ESQ6: 4 ESQ7: 1 ESQ8: 2
ESQ9: 2 ESQ10: 2 ESQ11: 3 ESQ12: 2

Study Habits

KeepUp: 4 Wait: 4 Read: 2 PersV: 2
Hrs: 1 Abs: 1 WhyAbs: sick

**Section: A12** Tch: B
InstM: L Time: 8 Sec: A

Math Subscales

TotAnxiety: 30
TotSelf: 33 ETotSelf: 40
TotEff: 30 CSelf: -7

Academics

Midterm: 78
WordProb: 71
AlgSkills: 79
CourseG: 77

Myers-Briggs

Extra/Intro: E
Sense/Intui: S
Think/Feel: F
Judge/Perc: P

Background

Interests: C
Ethnic: C
Gender: M
Class: F
Major: ________

*Figure 4*

*Example of data collected from a Pre-Calculus student* analyzing and reanalyzing was done before the analyses that is mentioned here were used. Analyses started as the data was collected. It was especially interesting to look at teacher differences and how well the cooperative learning classes were doing compared to the lecture. Everyone gets a little nervous when something new is tried, researcher and instructors alike. The instructors handled it well and very professionally. The students were another problem. There was quite a bit of scuffling around in the first two weeks of class. Some students didn't come in the first day; some didn't like cooperative learning; some wanted to get a different teacher; some couldn't find the right classroom. But with a little firmness, only one student had to be relocated because of disruptions to the study.

The first analysis and the first hypothesis tested used simple linear regression. The amount of $R^2$, percent variation of the dependent variable explained, and whether the beta coefficient was significant was noted for each of the independent variables separated into the four categories of student extra-classroom variables. An example of the regression results for one independent variable for the Problem-Solving Test is presented in Table 13. All the independent variables within each category were used in a correlation matrix to determine the relationship between these independent variables .

The second analysis that tested hypothesis # 2 consisted of three runs (one for every measure of mathematics achievement) of a 3 x 2 x 2 x 2 factorial analysis of variance. The 3 x 2 (3 class times, 2 instructional settings) part of the ANOVA was built into the experimental design before class schedules came out. This design was shown in Figure 3. The other two variables were an attempt to look at some way to group students and notice if the students in these different

*Table 13*

*Example of Regression Results for Math SAT Predicting Problem-Solving Test*

| Multiple Regression Results | | | | | |
|---|---|---|---|---|---|
| Dep. Var. : | WORDPROB | Multiple R: | .36623 | F = | 24.32 |
| | | $R^2$: | .13412 | df = | 1, 157 |
| No. of cases: | 159 | adjusted $R^2$: | .12861 | p = | .000002 |
| | | Standard error of estimate: | 19.309 | | |
| Intercept: | 11.974970033 | Std.Error: | 8.5527 | t( 157) = 1.4001 | p <.16 |
| | SATM ß=.36624 | | | | |

groups performed differently within each classroom. As stated before, the only choices other than grouping by ability were the mathematical anxious (not significant by the first analysis), the underprepared (ability grouping) and use of personality preference to define learning styles. The last grouping, by learning styles, was used in this study. Lawrence (1984) shows learning styles to be a combination of two of the Myers-Briggs preferences. Besides, analysis of the first hypothesis suggested that the same two learning preferences were not significant for all three measures of college mathematics achievement.

With a little knowledge of ANOVA you know that factorial design can get unmanageably big. This 3 x 2 x 2 x 2 is a case in point. The full analysis has 4 main effect times, 6 second-order interaction terms, 4 third-order interaction terms and 1 fourth-order interaction term. Because comparison of the three dependent variables was critical to the analysis, the same set of terms where used to analyze scores from the Problem-Solving Test, Algebra Skills Final Examination and course grades. After many runs and comparison, I decided to keep the terms that were consistently significant and were conceptually based in what was going on in those six classrooms (remember, the seventh classroom was not used in this analyses). These effects and interactions are shown in Table 14 shown on the next page.

The mean squares were computed for the three measures of college mathematics achievement. All the adjusted means and standard deviations for each main effect for the three measures were computed. For any interaction found significant, those means and standard deviations were also computed and multiple comparison procedures used. A plot of means for each significant interaction was also graphed.

*Table 14*

*Main Effects and Interactions Used in Testing Hypothesis # 2*

| **Effect** | **What This Means** |
|---|---|
| Time of Class (1) | *Comparison of 8 AM, 10 AM and 1 PM classes* |
| Instructional Method (2) | *Comparison of Lecture vs Cooperative Learning* |
| MBTI E vs I (3) | *Comparison of Extravert vs Introvert Preference* |
| MBTI J vs P (4) | *Comparison of Judging vs Perceiving Preference* |
| Time x Instruct Method | *Each individual class separately* |
| MBTI E vs I x J x P | *Possible usefulness of EIJP Learning Styles* |
| Instruct M x E vs I x J vs P | *Comparison of EIJP Learning Styles in the Two Instructional Settings* |
| Residual | *Everything else or 13, 23, 14, 24, 123, 124, 134 , 1234 interactions and error* |

The third analysis, addressing hypothesis #3, was a rebellion against the constant use of numbers to explain what is actually happening in the classroom. Now is the time to realize that numbers in a table don't capture what is really going on inside these six classrooms. It might be a good start to look at differences, but it wasn't enough. It took a researcher and a camera's eyes to see what when on between the teacher and the student in each of the six classrooms that represented the experimental design. Since the researcher had never done her own qualitative experiment, this study was a good place to start. One of the major flaws in any qualitative study is researcher bias, and this was a problem in this study, as I was a faculty member in that department and had been a student in many classes in the past. As I was taping each classroom, I tried to identify differences and similarities. I looked for examples of teacher. I picked out five measures of teacher performance that seemed different for each of the three teachers. To validate what I had seen on the videotapes, I gave the students an evaluation that addressed those five measures. I also added two other questions to see if these responses would be different. Because I had always thought that self-confidence in mathematics was an important factor to measure, I repeated this subscale given the first day of class also. My advisor suggested that the largest factor in achievement was motivation, so I created survey questions to address the issue of students' study habits. All of these survey questions were really a validation procedure to back up the classroom descriptions I was to create from viewing the videotapes. Since I had two camera views, I got two TVs and two VCRS and watched the teacher and students simultaneously. With just a little bit of pausing, I could match the two videos. From there, I created transcripts of what I had seen, concentrating on teacher and student behaviors along with the interactions between the two. The classroom descriptions presented in the results section represent a condensation of the transcripts along with the survey results. The analysis presented in the discussion addressed several issues that were observed by the videotapes and backed up by the survey results.

The fourth analysis, addressing hypothesis #4, came from the need to know who was succeeding and not succeeding in this class. Over the past three years, we have changed the class considerably by using graphics calculators and a more functional approach. The failure rate was 20% in Fall 1991, 19% in Fall 1992 and 17% in Fall 1993. Even though the failure rate has fallen, students still apparently do not take the skills that they learned from this class into classes in their majors. There is also another group of students that we were concerned about but have not addressed-- the underprepared. Are these the students who are failing or is some other variable causing their lack of success?

Discriminant analysis is a useful technique to determine whether student extra-classroom variables collected before the student enters college can be used to predict success in this class. A discriminant function is used to classify students into two groups--successful and unsuccessful. The discriminant function takes the form

$$D_i = b_1X_{1i} + b_2X_{2i} + b_3X_{3i} + \dots b_pX_{pi} + a,$$

where $D_i$ is the categorical variables predicting group membership, $b_i$'s are regression weights for variable $X_i$ and $a$ is a constant. The raw discriminant score can be computed by multiplying the student's raw score for each variable $X_i$ by the correct regression coefficient and adding the constant. An excellent explanation of this procedure is described in Betz (1987). Group membership is determined by which group centroid is closest to the student's discriminant score where the groups centroid, of say the successful students, is

$$\overline{D_s} = b_1\overline{X_{1s}} + b_2\overline{X_{2s}} + \dots b_p\overline{X_{ps}} + a.$$

where $\overline{D_s}$ is the mean group centroid, $b_i$ are the regression weights and $\overline{X_{is}}$ is the mean for variable $X_i$ for the successful students. The percentage of correct predictions based on the function can be compared with percentage of observed successful students.

The question is: Is the prediction useful, or what would be expected on the basis of chance alone? The Apparent Error Rate ( Johnson and Wichern, 1992) can be computed by subtracting the percent correctly classified from 1. Looking at this error rate and comparing how well the discriminant function breaks the two groups gives the researcher an idea as to whether this particular function is a good first step in classification of successful versus unsuccessful students.

If we could find a way to classify students into whether they were expected to succeed or not succeed, we could offer alternatives to see that any student does not fail. It would also allow us to determine whether the reason they are failing is because of lack of preparation in high school.

# CHAPTER IV

# RESULTS OF THE STUDY

## Percent of Mathematics Achievement Variation Explained by Student Extra-classroom Variables

*(i) Which of the four categories of student extra-classroom variables--demographics, high school performance, mathematics attitudes and Myers-Briggs Preferences significantly affect mathematics achievement?*

Each of the study variables were run separately using regression analysis techniques with the student extra-classroom variables, the independent variables, and the Problem-Solving Test scores, Algebra Skills Final Examination scores, and course grades as dependent variables. The amount of variation, $R^2$, explained by each of the variables is presented in Table 15. The intercorrelations within each category were computed for the three categories of independent variables. As shown in Table 15, none of the *demographic variables*-- interest of major, ethnicity, gender or class of student -- were significant ($p<.05$). An interesting point to note is that gender, a "hot" issue in the literature, was not an important variable in this study. The category of variables that did contribute the most to the $R^2$ of the three measures of college mathematics achievement was the high school performance. Math SAT scores contributed the most for scores on the Problem-Solving Test (15.9%), second highest for Algebra Skills Final Examination (15.8%) and third highest for course grade (5.0%). High school

*Table 15*

*$R^2$ and Intercorrelations Among Demographic, High School Performance, Mathematics Attitudes and Myers-Briggs Preferences*

| Correlations | | | | | | $R^2$ Problem Solving Test | $R^2$ Alg Skills Final Exam | $R^2$ Course Grade |
|---|---|---|---|---|---|---|---|---|
| Demographics | | | | | | | | |
| Interest | | | | | | 0.000 | 0.000 | 0.020 |
| Ethnicity | | | | | | 0.018 | 0.000 | 0.011 |
| Gender | | | | | | 0.000 | 0.024 | 0.020 |
| Class | | | | | | 0.000 | 0.003 | 0.000 |
| High School Performance | | | | | | | | |
| Math SAT | 1.00 | 0.10 | 0.12 | 0.18 | 0.30 | 0.159** | 0.158** | 0.050** |
| HS Percentile | | 1.00 | 0.76 | 0.27 | 0.07 | 0.101** | 0.161** | 0.079** |
| HS GPA | | | 1.00 | 0.37 | 0.11 | 0.046** | 0.086** | 0.058** |
| Alg II Grade | | | | 1.00 | 0.24 | 0.052** | 0.121** | 0.042** |
| Trig Grade | | | | | 1.00 | 0.028* | 0.086** | 0.049** |
| Mathematics Attitudes | | | | | | | | |
| Anxiety | | | 1.00 | 0.81 | 0.59 | 0.004 | 0.037 | 0.022 |
| Self-Confidence | | | | 1.00 | 0.69 | 0.005 | 0.039* | 0.011 |
| Efficacy | | | | | 1.00 | 0.007 | 0.026* | 0.006 |
| Myers-Briggs Preferences | | | | | | | | |
| E vs I | | 1.00 | 0.09 | 0.04 | 0.02 | 0.038* | 0.008 | 0.024* |
| S vs N | | | 1.00 | 0.14 | 0.23 | 0.010 | 0.000 | 0.008 |
| T vs F | | | | 1.00 | 0.24 | 0.007 | 0.010 | 0.000 |
| J vs P | | | | | 1.00 | 0.000 | 0.040* | 0.023 |

* p < .05; ** p < .01.

percentile accounted for the second highest $R^2$ for the Problem-Solving Test (10.1%), highest $R^2$ for the Algebra Skills Final Examination (16.1%) and the highest for the course grade (7.9%). High school GPA was not nearly as good a predictor of mathematics achievement as was high school percentile computed as (class rank) * 100/(class size). The grade received in the student's Algebra II class was significant for all measures of mathematics achievement and, in most cases, a better predictor than high school GPA.. This is not surprising since this Pre-Calculus course is very similar in some of its content to an Algebra II high school class. The trigonometry class also showed up as a significant contributor to mathematics achievement. This, too, is not surprising, as students who take Trigonometry either with Algebra II or later math classes are in the higher achievement tracks in high school.

The correlation for high school percentile and high school GPA was quite high, .76. The correlation between high school GPA and grades in high school mathematics classes were not very high, the highest being .37 between high school GPA and the grade received in their Algebra II class. Math SAT scores was correlated only weakly with most measures of high school performance. Again the trigonometry grade shows up moderately correlated with Math SAT with the possible reason being that students in higher ability take trigonometry and these are the students who do better on the SATs.

The three Fennema-Sherman Mathematics Attitude scales--mathematics anxiety, mathematics self-confidence, and mathematics efficacy did not show up as significant contributors to the variation in scores on the Problem-Solving Test or the course grade. Self-confidence and efficacy in mathematics did show up as significant predictors for $\alpha = .05$ for scores on the Algebra Skills Examination.

These three mathematical scales were strongly correlated with each other with a correlation between anxiety and self-confidence of .81, a correlation between anxiety and efficacy of .59 and a correlation of .69 between self-confidence and efficacy.

The Myers-Briggs preferences were also not as important a contributor to mathematics achievement as the high school performance variables. Which preference(s) was (were) significant varied with the measure of mathematics achievement. The preference Extraversion vs Intraversion predicted 3.8% of the variation in Problem-Solving Test scores and 2.4% of the variation in a student's course grade. The preference Judging vs Perception was the significant contributor for Algebra Skills Final examination scores with 4.0% of the variation explained. The other two preferences, Sensing vs Intuition and Thinking vs Feeling, were not significant for any measure of mathematics achievement.

All the preferences were only weakly correlated with E vs I, having correlations ranging from .04 to .09 with the other three preferences. The other preferences had much higher correlations, with Sensing vs Intuition being negatively correlated with thinking vs feeling (-.143) and Judgment vs Perception (-.232). The Thinking vs Feeling preference was weakly correlated (.245) with judgment and perception.

*(ii) Will all four categories of student extra-classroom variables rank the same in importance for all three measures of college mathematics achievement?*

In the beginning I was going to use multivariate analysis on the Problem-Solving Test and the Algebra Skills Final Examination as a composite measure of mathematics achievement. But once I completed these first analyses and others not mentioned, I began to see that these measures of mathematics achievement were NOT similar at all and a composite would represent a variable that wasn't interpretable. There are some similarities among the three measures of college mathematics achievement. The most obvious is that high school performance is the largest contributor to college mathematics performance. Mathematics attitudes which were disappointing predictors for the Problem-Solving Test and the course grade did have some significance for the Algebra Skills Final Examination. At first I wasn't going to use the course grade in the analysis because this is a composite grade and each teacher had a different way of computing it, but it became more apparent that the Algebra Skills Final Examination and the course grade were the measures of mathematics achievement which the instructors and the mathematics department valued the most. The scores on the Problem-Solving Test were also considered as cast-offs because the instructors knew the students couldn't do it even in the simplest form. I found this very troubling and certainly worth watching for in later analyses, discussion, and reflections.

Probably the most interesting categories of variables and the most time-consuming to collect and understand is the Myers-Briggs preferences. For the Problem-Solving Test, being Introverted over being Entraverted was the only significant preference. For the Algebra Skills Final Examination, the Judgment vs Perception preference was significant, but none of the others was. For the course grade, the two preferences came together to what might be called different classroom learning styles.

This first analyses, certainly simple in its statistical procedures, gave a hint to the researcher of interesting things to watch for in subsequent analyses.

This analyses also added the second dimension to each of the stated hypothesis--that each measure of mathematics achievement was different.

## Effect of Time of Class, Two Instructional Settings and MBTI Preferences on College Mathematics Achievement

*(i) Which main effects-- time of class, two instructional settings or MBTI preferences or interactions -- will significantly contribute to college mathematics achievement?*

*(ii) Will the significant main effects or interactions change for each of the different measures of college mathematics achievement?*

As stated previously, the Fall Pre-Calculus classes were set up in a 3 x 2 x 2 x 2 factorial experimental design as shown in Figure 3. The 8:00 class that teacher DN taught was not part of this analysis, although this class was used in the two previous analyses. The hypotheses and analyses for this part of the study allows the researcher to focus on what is going inside each classroom. Even though the time of class is a contextual condition, it does affect what goes on inside those classrooms. Instructional settings or methods also affect what goes on inside that classroom. This is also true of the Myers-Briggs Preferences. The student comes into the classroom with these personality preferences, but these also affect how the student learns in that classroom.

As Table 14 indicated, not all the interactions were separated out as effects but instead placed in the residual term. This left the effects shown in the ANOVA table shown as Table 16. The mean squares, degrees of freedom, and F-ratios are shown for each of the three measures of college mathematics achievement. As you can see from Table 16, for all measures of mathematics

*Table 16*

*Analysis of Variance of Scores for the Problem Solving Test, Algebra Skills Final Examination and Course Grade*

| | | Problem Solving Test | | Algebra Skills Exam | | Course Grade | |
|---|---|---|---|---|---|---|---|
| **Effect** | **df** | **MS Effect** | **F-ratio** | **MS Effect** | **F-ratio** | **MS Effect** | **F-ratio** |
| Time of Class | 2 | 1679.68 | 5.44** | 1470.38 | 4.56* | 840.18 | 6.75** |
| Instructional Method | 1 | 202.82 | 0.66 | 5.68 | 0.02 | 223.17 | 1.79 |
| MBTI E vs I | 1 | 1519.79 | 4.93* | 518.00 | 1.61 | 784.59 | 6.30* |
| MBTI J vs P | 1 | 183.04 | 0.59 | 3182.84 | 9.91** | 821.72 | 6.60* |
| Time x Instruct Method | 2 | 3887.68 | 12.60** | 497.23 | 1.55 | 89.00 | 0.71 |
| MBTI E vs I x J vs P | 1 | 251.27 | 0.82 | 1893.84 | 5.90** | 822.10 | 6.60** |
| Instruct M x E vs I x J vs P | 1 | 1127.45 | 3.65 | 743.03 | 2.31 | 320.51 | 2.57 |
| Residual | 131 (129)[a] | 308.46 | | 321.13 | | 124.50 | |

* $p < .05$.
** $p < .01$.
[a] *Degrees of freedom for Algebra Skills Examination and Course Grade.*

achievement, the time of the class was significant, very significant for the Problem-Solving Test and course grade. The effect of the two instructional settings, lecture and cooperative learning, was not significant for any measure of college mathematics achievement and has consistently a very small mean square. The first of the Myers-Brigg Type Indicator personality preference, Extraversion vs Introversion, was significant for alpha = .05 for both the Problem-Solving Test and the course grade but not significant for the Algebra Skills Final Examination. The other Myers-Briggs preference, Judgment vs Perception, was very significant for the Algebra Skills Final Examination and significant at $\alpha = .05$ for the course grade.

The two interactions that were important in this study were the Time x Instructional Method and E vs I x J vs P, an interaction between the two Myers-Briggs Preferences. As Table 16 makes clear, the first interaction which is significant (very) for the Problem-Solving Test represents differences between individual classes. This is the single largest contributor to variation for the Problem-Solving Test, thus overshadowing the significant main effects, time of class, and E vs I preferences. The interaction between the two Myers-Briggs preferences E vs I and J vs P for the Algebra Skills Final Examination and course grade represents some superiority of one or more of the EIJP learning styles.

Table 17 on the next page shows the adjusted means and standard deviations for the four main effects -- time of class, instructional settings, E vs I, and J vs P. Table 18 reveals significant contrasts using Scheffe's post hoc multiple comparison tests. You can see that the 8:00 classes performed much worse than the 10:00 or 1:00 classes; in fact, students averaged 9 to 11 points worse than students in the 10:00 or 1:00 classes. As stated previously, there

*Table 17*

*Adjusted Means and Standard Deviations for Main Effects Time, Instructional Method and MBTI Variables for the Problem-Solving Test, Algebra Skills Final Examination and Course Grade*

| | Problem Solving Test | | | Algebra Skills Exam | | | Course Grade | | |
|---|---|---|---|---|---|---|---|---|---|
| **Main Effect** | **N** | **Mean** | **Std** | **N** | **Mean** | **Std** | **N** | **Mean** | **Std** |
| | | | | *Time of Class* | | | | | |
| 8 AM | 51 | 46.49 | 21.35 | 49 | 59.69 | 21.81 | 49 | 68.39 | 14.36 |
| 10 AM | 55 | 57.98 | 18.50 | 54 | 69.60 | 15.95 | 59 | 77.63 | 9.79 |
| 1 PM | 36 | 59.17 | 18.87 | 36 | 72.14 | 18.09 | 36 | 76.13 | 9.40 |
| | | | | *Instructional Setting* | | | | | |
| Lecture | 77 | 53.12 | 18.85 | 76 | 66.90 | 9.33 | 76 | 72.55 | 12.99 |
| Coop-L | 65 | 55.98 | 21.51 | 63 | 67.38 | 19.23 | 63 | 75.55 | 10.58 |
| | | | | *MBTI E vs I* | | | | | |
| E | 87 | 50.64 | 19.37 | 86 | 64.85 | 19.22 | 86 | 71.23 | 12.26 |
| I | 54 | 58.46 | 19.78 | 53 | 69.43 | 19.34 | 53 | 76.86 | 11.14 |
| | | | | *MBTI J vs P* | | | | | |
| P | 92 | 53.19 | 20.50 | 90 | 61.47 | 10.05 | 90 | 71.16 | 11.97 |
| J | 49 | 55.91 | 18.65 | 49 | 72.81 | 18.47 | 49 | 76.93 | 11.34 |

*Table 18*

*Significant Contrasts for Main Effects, Time, Instructional Method and MBTI Variables, for the Problem-Solving Test, Algebra Skills Examination and Course Grade*

| **Significant** | **Problem-Solving Test** | | **Algebra Skills Exam** | | **Course Grade** | |
|---|---|---|---|---|---|---|
| **Contrasts** | **Diff** | **p-level** | **Diff** | **p-level** | **Diff** | **p-level** |
| | | | *Time of Class* | | | |
| 8 vs 10 | -11.49 | .005 | -9.92 | .021 | -9.24 | .000 |
| 8 vs 1 | -12.68 | .006 | -12.45 | .007 | -7.74 | .006 |
| 10 vs 1 | Not different | | Not different | | Not different | |
| | | | *Instructional Setting* | | | |
| L vs Coop L | Not different | | Not different | | Not Different | |
| | | | *MBTI E vs I* | | | |
| E vs I | -7.82 | .012 | Not different | | -5.63 | .003 |
| | | | *MBTI J vs P* | | | |
| P vs J | Not different | | -11.34 | .000 | -5.76 | .003 |

was no difference between the two instructional settings. The most interesting variables in this analysis are the Myers-Briggs preferences. The Extraverts averaged almost 8 points less than the Introverts for the Problem-Solving Test while the Judgment vs Perception preference was not significant for this measure of mathematics achievement. Yet on the Algebra Skills Final Examination, the students whose preference was Judgment averaged 11 points higher on the final exam than those students whose preference was Perception.

For the course grade, both Myers-Briggs preference E vs I and J vs P were significant with both the I's and the J's having almost a 6-point advantage.

But all these results must be carefully appraised only after evaluating what the interaction is doing to the dependent variable. As stated previously, the *Time of Class x Instructional Method interaction* was the most important variable for the Problem-Solving Test. Table 19 shows what is going on within

*Table 19*

*Significant Interaction of Class Time by Instructional Methods for the Problem-Solving Test*

| | | | | | Significant Scheffe's Post-Hoc | | |
|---|---|---|---|---|---|---|---|
| **Time** | **Instruct M** | **N** | **Mean** | **Std** | **Contrasts** | **Diff** | **p-level** |
| 8 AM | Lecture | 26 | 56.03 | 18.51 | 8C -8L | -19.08 | .017 |
| 8 AM | Coop L | 25 | 36.95 | 19.08 | 8C -10C | -32.82 | .000 |
| 10 AM | Lecture | 32 | 46.19 | 15.56 | 8C - 1L | -20.18 | .022 |
| 10 AM | Coop L | 23 | 69.77 | 17.49 | 8C - 1C | -24.25 | .004 |
| 1 PM | Lecture | 19 | 57.14 | 22.41 | 10C-10L | 23.58 | .001 |
| 1 PM | Coop L | 17 | 61.21 | 13.30 | | | |

these classrooms. Contrasts between the 8:00 Cooperative Learning class and every other class were significant. In fact, this class was responsible for much of the significant differences that occurred between the classes (interaction term) and the time of class main effect.

Figure 5 is a plot of means for the three class times and two instructional settings interaction for all measures of mathematics achievement which graphically shows how poorly this class performed on the Problem-Solving Test. The plot of means shows the other two cooperative learning classes were the best of the six classes. The 10:00 Cooperative Learning class performed an average of almost 24 points better than the 10:00 Lecture class. As will be discussed later, the 8:00 Cooperative Learning class and the 10:00 Lecture class were both taught by the same instructor. It is important to notice how much better the 10:00 Cooperative Learning class did than the 8:00 Cooperative Learning Class.

Before we leave the results from the Problem-Solving Test, let me ask you to look back to Table 12 in the Research Study chapter. One thing that might not be so obvious is the poor performance of the students on the Problem-Solving Test. Even though Table 12 points out grades for Myers-Briggs preferences, please note that no matter what their preference more than 60% of the students failed the test (got 60 or worse). Compare this to the percent of students who failed the Algebra Skills Final Examination (23-38%).

The significant interaction for the Algebra Skills Final Examination and the course grade was the *interaction between the two Myers-Briggs preferences E vs I and J vs P*. Means and standard deviation for each EIJP combination along with significant contrasts between these means are presented in Table 20. I am not really sure what learning style is, but Lawrence (1984) seems to use this term when two of the preferences create combinations that behave differently. What comes from Table 20 and the significant contrasts is the SUPERIORITY of the IJ learning style for these two measures of college mathematics achievement. The

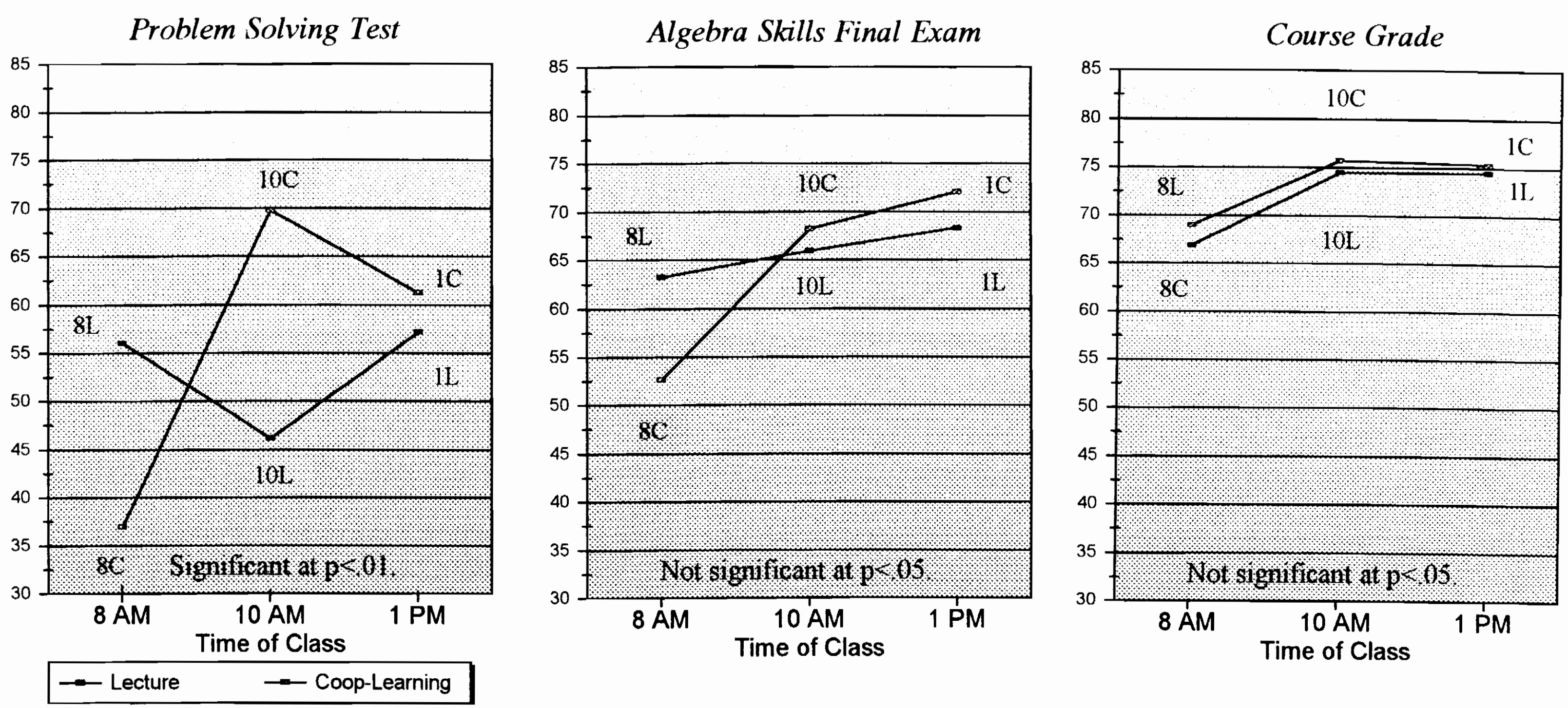



*Figure 5*

*Plot of means for time of class by instructional methods for three measures of mathematics achievement*

*Table 20*

*Significant Interaction of MBTI Preferences E vs I by J vs P for Algebra Skills Examination and Course Grade*

| MBTI | | | | | Significant Scheffe's Post-Hoc | | |
|---|---|---|---|---|---|---|---|
| **E vs I** | **J vs P** | **N** | **Mean** | **Std** | **Contrasts** | **Diff** | **p-level** |
| | | | *Algebra Skills Examination* | | | | |
| E | P | 56 | 63.56 | 19.30 | IJ vs EP | 15.92 | .013 |
| E | J | 30 | 66.15 | 19.14 | IJ vs EJ | 13.32 | .095 |
| I | P | 34 | 59.38 | 18.86 | IJ vs IP | 20.09 | .002 |
| I | J | 19 | 79.48 | 15.68 | | | |
| | | | *Course Grade* | | | | |
| E | P | 56 | 71.23 | 12.80 | IJ vs EP | 11.40 | .002 |
| E | J | 30 | 71.23 | 11.22 | IJ vs EJ | 11.40 | .006 |
| I | P | 34 | 71.10 | 10.57 | IJ vs IP | 11.53 | .004 |
| I | J | 19 | 82.63 | 10.24 | | | |

other three learning style combinations (EP, EJ and IP) are not significantly different from each other but the IJ student averages from 13 to 20 points higher on the Algebra Skills Final Examination and 11 points higher on the final course grade.

Before looking at the plot of means for the interaction of the Myers-Briggs preferences E versus I x J versus P, consider how these grouping using the two preferences EIJP would appear in each classroom. Figure 6 gives some idea as to how these four combination IJ, IP, EP and EJ are scattered in the six classrooms.

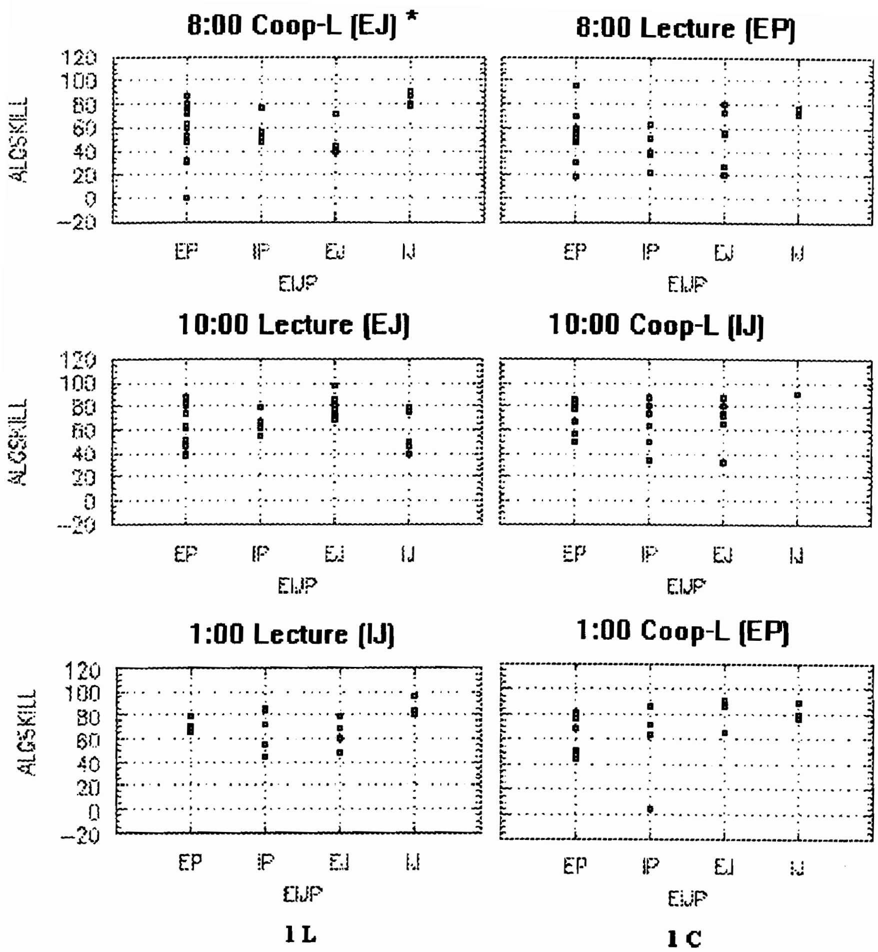



*Figure 6*

*Multiple scatterplot of Algebra Skills Examination for EIJP learning styles for students within each class*

Not only does this diagram clarify how many of each learning style are distributed in the classes, but also represents the EIJP teaching style of the three teachers. These are shown next to the time of the class.

Figure 7 is the plot of means for the EIJP learning styles. The superiority of the IJ learning style is quite obvious. No other learning style can compete with it in this Pre-Calculus course. If we could describe this particular learning style, then the best description is presented in Table 21.

*Table 21*

*Description of MBTI I and J as a Learning Style*

| Introversion (I) | Judgment (J) |
|---|---|
| Since Is may be more quiet and less active in the classroom, teachers may feel the need to press them into taking part in group discussions. Such pressure, however, will often only increase their withdrawal. Teachers need to respect their need to think in relative solitude, for that is how they think best. Is will be more willing to share their ideas when given advance notice. This will allow them time to think about how they will become active in the classroom. | Js tend to gauge their learning by the completion of tasks: reading "x" amount of books, writing "x" amount of papers, or making "x" amount of reports. They thus prefer more structured learning environments that establish goals for them to meet. |
| **Words that appeal Is:** thoughtful, serious, sincere | **Words that appeal to Js:** complete, finished, decisive, hard working, punctual |

As the description above suggests, these types of students are a "teacher's dream" as learners. They are quiet and thoughtful, causing no disruption. Their study habits are such that they tend to turn their assignments in on time.

One last point. The three instructors who taught these six classes also agreed to take the Myers-Briggs Type Indicator. One of the instructors tested IJ, another EJ and the last EP. I was interested in seeing if students learned more effectively if their learning style matches that of their teacher. It was not part of this study to test the differences in teachers, but the teacher with the IJ learning

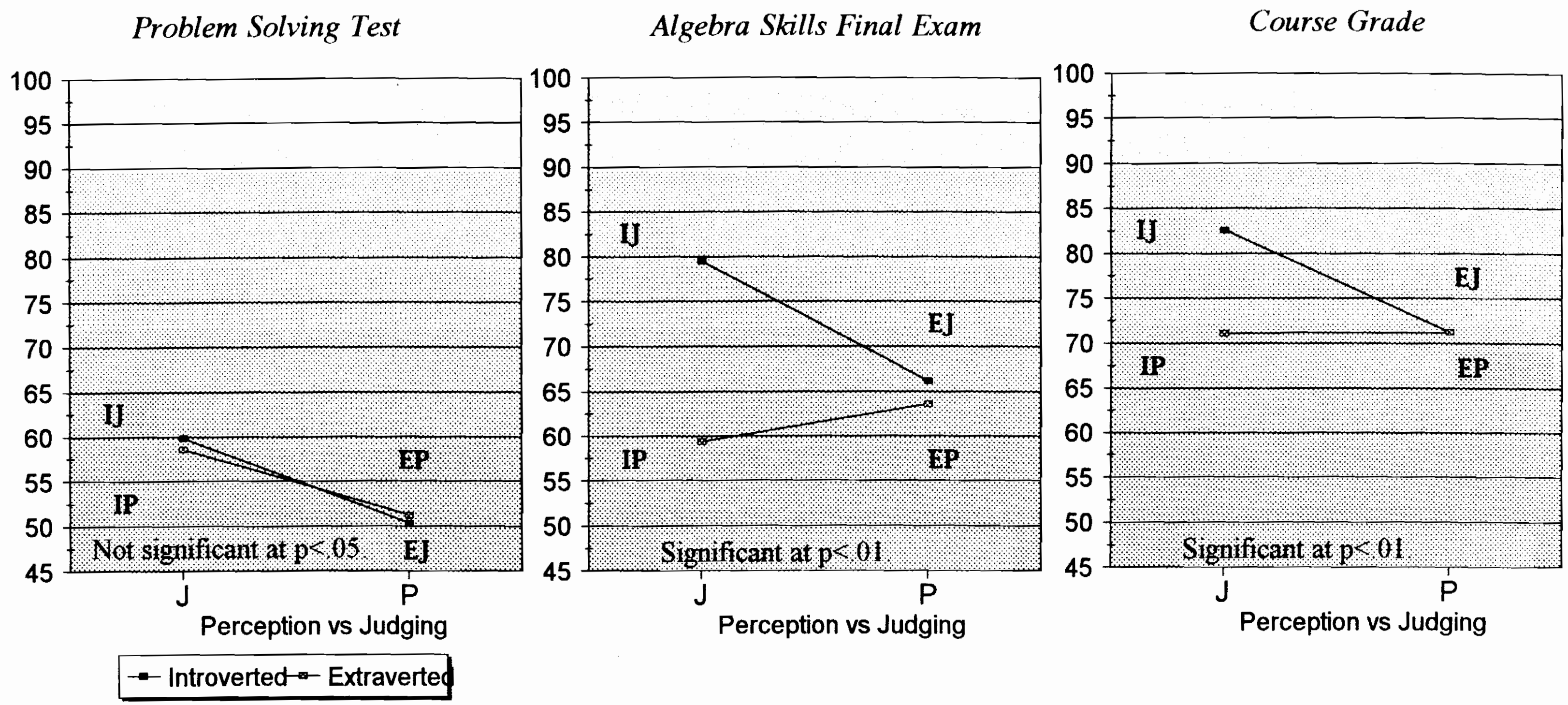



*Figure 7*

*Plot of means for MBTI preferences E vs I and J vs P for three measures of mathematics achievement* style also had the class with the highest grades on the Problem-Solving Test and the Algebra Skills Final Examination.

## Classroom Descriptions

These descriptions are a qualitative "look" into each of the six classroom used in factorial experiment where two of the main effects were the 3 (class times) and 2 (instructional settings). For each of the six classroom, the researcher videotaped a week's worth of lessons--three fifty-minutes segments for each teacher, eighteen in all, using two VCR cameras on tripods, the first focused on the teacher and the second on the students. The purpose of these descriptions is to concentrate on the teacher's and students' behaviors and, most importantly, on the interaction between the two.

All the videotapings were produced in the same classroom, a large classroom in the mathematics department. This particular classroom was no different from the rest with the exception of a lab table at the front of the room. Two large blackboards are located behind this lab table. The students sit in desk lined up into six rows, a typical college classroom.

This particular mathematics class, Pre-Calculus I, is the class in which the faculty in the mathematics department would like to see all freshmen start their college careers (an exception being those who start in Calculus). This course was created to help the college student build a foundation into the structure of algebra and functions, in particular. Graphics calculators were adopted two years ago and are an integral part of learning about functions. Almost every teacher in the mathematics department has taught this course at one time of another (the exception being the researcher). The mathematics department consists of only ten faculty members, some of whom also teach statistics, computer science, physics, and physical science; thus, the faculty has a broad base for the use of mathematics. The experimental design of this study was such that the class size was supposed to be limited to 25 students. This was accomplished in all but one of the classes. Statistical analyses comparing the means for the high school performance variables-- math SAT scores, high school percentiles, algebra II and trigonometry grades -- show that none of these classes had better prepared students than any other (the p-level ranged from .15 to .79 for the four comparisons).

The following descriptions represent a condensation of transcripts of three lessons for each classroom. If the actions of the teacher and the students were similar for each of the three lessons, then the concise description represented a typical lesson. One class, the 8:00 Cooperative Learning class, had no such typical lesson, so for this particular class, all three days are presented.

**8:00 Lecture class**

At 8:00 in the morning the difference between the attitude of the teacher and students surprises me. Teacher B jokes with several students while other students enter the classroom. Teacher B starts this particular class by asking for any questions about the homework. One student asks her to work a graphing problem. She uses this problem as a platform to question the understanding of the students as she quickly works this problem using bold, large strokes on the blackboard. Yawning and rubbing their eyes, no students answer her questions ,with many leaning their heads on their hands. Three or four students are four minutes late to class. Her 26 students fill the classroom. She continues to ask for other problems that students found difficult. A student asks about another homework problem, which again she works but only after questioning the students about several steps. The general body of students are the target of her questions. No one answers her questions. Asking them to graph another difficult homework problem, she walks among the students to see their graphs. She looks at one student's graph and says, "Wow! What's that? That's neat -- it looks like a little robot!" (two graphs on top of each other create weird designs). She again asks students to graph another equation while she walks around the class looking at other students' graphs. Talking to a few students, she stops and says "Cool. We love our graphers!" This is indeed true because using their calculators is only action most do--only half take notes. She continues to work the next homework problem, again asking many questions. The students' eyes are starting to wander. Some are still yawning and stretching. She prods, making the comment, "do you have a vague notion of what that is?" One student responds. She continues, stopping to encourage her students. "You are awfully quiet, soaking up every word?" Next, Teacher B works example problems from the textbook that are key to the concepts in the next section. Continually, she asks questions generated from each problem, working quickly on the board, and sometimes stopping to make a comment. The students look at her sleepily. She says to them, "You're not going to smile no matter what." She is going very fast, working problems from one blackboard to another, and using hand actions to explain what the students should see from the problems. "Everybody follow that?" she asks. A couple of students nod and the rest don't respond. Towards the end of the period she hints of a quiz, reassures the students that their poor showing on the last test will be curved, and asks them jokingly not to run to her with drop slips.

Positive and enthusiastic, Teacher B displays an energetic style, working many problems to help her students understand the material from the textbook. At 8:00, however, no amount of prodding seems to help her tired and yawning students. Her typical class time is 15 minutes spent working homework problems assigned from the previous day and the rest of the time spent working examples from the book. Occasionally she hints of a quiz when students need prodding. She usually does give a short quiz each week.

**8:00 Cooperative Learning class**

Teacher C enters the classroom and writes the instructions for a group activity on the blackboard. He carefully takes roll and tells the students that each group will pick a problem from a set of nine (there are nine cooperative learning groups). They will not only solve this problem, and interpret its meaning but work on writing out a solution in such a way that anyone reading this solution can work this problem. The students, forming their groups, start to work. This class has 25 students enrolled, yet 4 are missing on Monday, 5 on Wednesday and 8 on Friday. This leaves the class, most of the time, with groups of 2 or 4 students per group. Students stare blankly at the board and the instructions. The teacher goes to each group and lets them pick the problem that they will work on, each contained on a short, separate sheet of paper. The classroom becomes noisy as students struggle to read the problem to other members of their groups and focus on its meaning. Several students are yawning. One group member is talking while the rest are looking at the person talking. Many seem tired and lost. Teacher C is slowly circling the classroom, helping each group interpret their own problem. He has a stern look on his face. When a student gets an idea as to how the solve the problem, he or she is smiling and happy proud of their progress. But most groups are slowing thumbing through their textbooks, lost. The teacher methodically circles the room, stopping to help every group. Occasionally a group will have a question and summon the instructor over for help. Even though this class is more alert than the 8:00 lecture, they are still leaning on their hands, yawning and stretching. Some members of the group are not contributing, letting one or two members dominate the conversation. The teacher continues to circle the classroom, stopping at each group to help or note progress. Many students can't seem to focus on their problem and are waiting for the class to end. The students are still stretching and yawning as the class ends. The instructors tells the students that they will continue this activity on Wednesday. One student in her group says " we are real close" (this student is absent both Wednesday and Friday).

On Wednesday, Teacher C has written on the board a short quiz with the homework assignment in the corner. The students are slow to come into the class and seem confused as to what is one the board. Two students come in one minute late; two more are three minutes late, and another student is ten minutes late. They slowly get to work on the quiz. As the students are working on the quiz, the instructor makes a comment to the researcher: "In all my years teaching, I have never had a class that skipped this much." After 14 minutes of class time, the quiz is taken up. The instructor slowly goes over how to work each question on the quiz. He make the comment, "You haven't studied. The problems are just like those you did for homework." After going over the quiz, he asks, "Any questions?" One student asks a question, but the rest stare as if in a daze. Because he is missing 5 students, the instructor doesn't continue the group work and instead lectures the rest of the class period on piecewise functions.

On Friday at exactly 8:00, Teacher C closes the door and announces that he is giving a pop quiz. He has become quite disgusted with the number of students skipping class and coming in late. Today eight students are missing and many are late. He asks the students two questions: "Without looking at your textbook, what is the name of your textbook?" and "What is the name of Roy Rogers dog?" (hints that it is similar to something that comes out of a gun). After the quiz, he opens the door and lets three late students come in. The rest of the class is laughing. He starts discussing where he left off on Wednesday continuing to lecture on the importance of the slope intercept form. The students seem to drift off, yawning and rubbing their eyes. When he asks a question, one student answers. Many are just watching him; later they start to take notes. He carefully extends the concept first introduced in a careful, methodical manner. He then asks, "Any questions?" Two students asks questions. About 18 minutes have been used for lecture. The rest of the class period (about 28 minutes) is spent working in their cooperative learning groups on the problem given to them on Monday. Many group members are missing and some of the students here today were not here on Monday. They don't have a clue what's going on. Another problem with two of the groups is that the group member who had the slip of paper with the problem written on it is missing. These groups start on the homework assignment, not sure how they will be graded on this assignment

Monday. Many groups are still rereading the problem, wondering if they are going about this correctly. The instructor is helping some of the groups and individual students who are working. Toward the end of the class period, three of the groups are talking about something other than their problem and are getting much noisier. Two of the groups start to put up their books and seem ready to leave. The instructor quite disgusted with today's events says "You come in 5 minutes late and you want to leave 5 minutes early." He then tells them the class is not over, get out their books and continue to work on their homework.

It should be quite evident that this class is in trouble. Teacher C had intended to spend much more time in cooperative learning groups, hopefully working together to solve a problem, and then express the solution in such a manner that anyone could read it. Certainly these are higher-order skills that students need for all classes. But because of so many absentees, he was forced to try to salvage his class by lecturing on topics in the textbook on Wednesday and hoping more would show up on Friday. As on every Friday with almost every class, more students are missing. This was a very trying class for Teacher C and it started to become apparent that something was wrong with cooperative learning at 8:00 in the morning.

**10:00 Lecture class**

Teacher C enters the classroom and takes roll for his very large class of 32. He has more students than the other 10:00 teacher because six couldn't find the correct classroom when they were assigned the second day of class. These students seem more alert than those at 8:00. The teacher starts the class by giving a definition and then asks a questions about this definition. He waits three seconds for the students to respond. Two or three students answer. Teacher C continues to explain his definition by carefully generating a table that helps create a pattern as an example of his definition. He asks the students to help him fill in the table. He is very methodical, always waiting at least three seconds for them to answer; by this time four or five students are answering. One student comes in eight minutes late. The instructor continues to reinforce the definition by creating a function on the overhead grapher that everyone can see. All students get out their graphers. He waits for all students to complete the graph. Teacher C goes to a student to answer a question about a problem the student is having with her grapher. He extends the function by using different numbers in the same type of function. Again he uses the overhead grapher to illustrate the function. He asks a question with two or three students responding. Next he uses a similar function; waiting patiently he says, "Is everyone with us up to this point? (Waits.) All there now?" Everyone has completed the graph. He continues asking questions using the same example. He then asks, "Any questions about this type of function? Other questions?" One student asks a very good question. He then asks if anyone has any problems with the homework. It is obvious that some have worked the problems and others have not. Before working problems, he asks several questions as to how to proceed. A few students answer. Several students ask questions. He patiently works each problem constantly asking questions about how these would be worked. Interestingly, the arithmetic problem that Teacher B will quickly work out at 1:00, he methodically asks students to do (1/(2/t + 1)) step-by-step. Both he and the students work it out. Five or six students question him about this fraction problem.

Teacher C is patient and methodically builds on his examples. He continually builds from one example to the next. If it takes 12 minutes to explain one problem completely, then this is what he does. He involves the students in the graphing, waiting for them to get the correct graph before proceeding. He spends the entire class, carefully working examples. He doesn't cover as many problems as Teacher B. Instead he gives the students time to complete the work on the problem themselves. Most of the students do take notes because they are not sure where the examples are coming from. He is not using problems straight from the textbook. He usually gives about one short quiz a week, reviewing the answers after the quiz. If he needs to, he will give a pop quiz; this is sometimes needed, especially on Friday. This Friday; only 21 students came from his enrollment of 32. Teacher C gives a quiz similar to the one he used in his 8:00 Cooperative Learning class, except changing the Roy Rogers question to one about the Lone Ranger.

**10:00 Cooperative Learning class**

Teacher D starts class by asking students to get a handout of problems from which the quiz was taken the previous day. All of her 23 students are in class today. She calls on a student to read the problem and the student responds. She asks a questions about that problem and one student answers. Two students come in two minutes and another three minutes late. The teacher asks a student to put the graph of the function on the board. At first no one volunteers. She gives the range of the function, and finally, a students puts the graph on the board. She asks if there are any questions, but no one responds. Another student comes in four minutes late. She asks if anyone has questions about the homework problems. A student asks for a problem to be worked. Teacher D asks a student to read the problem, which she does. The teacher quickly works the problem on the board, then stops to ask a question. She waits three seconds then five seconds, with no responses. She continues to work the problem and asks for a student to put the graph on the board. After a few minutes, one student has the graph and walks up to her to check it for accuracy. The student then put the graph on the board. Teacher Dquickly starts another problem that a student asked about for homework. She works the problem rapidly to get the function but doesn't explain the steps. "Any questions?" she asks, smiling. No response from the students. Another student asks her to work another homework problem. She draws a picture and asks a question, then waits five seconds for a response. No response. She continues to work the problem and stops to ask a question, waiting. Two students respond. She slows down and asks another question, to which two or three students respond. She asks for a student to put the graph on the board. She patiently waits a couple of minutes for the students to complete the graph; only about a third are using their graphers. A student finally has a graph and puts it on the board. Teacher D explains the graph. She has lectured and worked homework problems for 26 minutes of the class period. For the rest of the class period (about 20 minutes), she asks students to get in their cooperative learning pairs. (She uses pairs because students complained about using four in a group.) She gives the students three problems to work for a quiz. The problems she picked were word problems, applications to graphing functions. She also passes out a worksheet which the students can complete for extra credit. When the pairs are formed, the class becomes noisy. Students seem unsure as to what to do. Most are working on the quiz problems, but one student continually goofs off, making fun of the whole procedure. The teacher stands in front of the room and patiently looks for questions from the students. Since they are working in pairs and the desks are scattered everywhere, it is difficult to walk around the classroom. She helps a student with the grapher.

Teacher D seems chaotic in her teaching style. For one question, she will wait for a student to answer, yet at another time she doesn't wait and continues to work the problem. She starts most problems by quickly determining what function is appropriate for the problem. Then she leaves it up to the students to find the graph and put the graph on the board. Any student can walk up and put the function on the board. Teacher D uses handouts to help the students summarize the material in each section. Added to this handout are key problems to work and usually a list of homework problems. It is sometimes confusing as to what handout the class is working on because they do not finish the problems on time so there can be an overlap of materials to be turned in for a grade. Teacher D does give a quiz every class period, which usually take 15-20 minutes.

**1:00 Lecture class**

Teacher D starts class by working a problem from a previous handout. She waits patiently for the students to answer her questions about this problem. Two students answer. One student seems unable to grasp how to work the problem and asks another student sitting next to him. The other student explains. This class is much more relaxed and happy to help each other out than the 10:00 class. It is a rather small class of 19 students. Next, Teacher D works a problem, from the homework assignment. She reads the problem and works it on the board but doesn't explain the steps. Students ask her to explain what she is doing. Most students are taking notes. For the next problem, she calls on a student to read the problem which the student does. All students are taking notes. She starts to work the problem and then stops after developing the function, asking, "Right?" No one answers, but students are intensively working on how to do it. She waits for them to develop the graph of this function and the dimensions for the viewing rectangle. Determining the dimensions of a viewing rectangle is a difficult part of the problem because it will vary depending on the particular problem she is working. After waiting for most of them to draw this graph (two or three minutes), Teacher D puts the graph on the board. Everyone is graphing and working on the problem. Continuing with the same problem, she asks them to use the graph to answer the next problem. They are not sure how to do this. She suggests using the trace function, zooming in if more accuracy is required. She works another homework problem quickly, deriving the function from the work problem. She uses complex terms such as "vertical shift" and "vertical stretch" to explain how the graph will look. She asks if students are ready for their quiz. A student asks if she would work another word problem. She does this, finding the function for this word problem. She stops and asks them to graph it. With her calculator, she starts to find the graph herself. All the students are watching intensely, half of them trying to get this graph. Once she graphs it, she puts it on the board. Next, she asks students to find the x-intercept. No response. She gives the answer. Students are working together to get the graph, but many are having trouble. A student asks about the dimensions of the viewing rectangle. After 44 minutes of working problem, she gives them a quiz of three problem which they must work individually. She also gives out the homework assignment and passes around previus quiz. She stays at the front of the room waiting for questions. The students work past the end of the class period.

As with her 10:00 class, her teaching style is chaotic. The students never know if they must put the graph on the board or if she will do it. All they know is that she is going to give them a quiz. They are desperately trying to work the problems and keep up with her. Classmates seems to rely on their neighbors if they have a questions. Even though this style seems rough compared to Teachers B and C, there is no doubt that this is the teacher who has the students actively engaged.

**1:00 Cooperative Learning class**

At 1:00 joking and smiling, Teacher B talks to two or three students individually before class starts. Alert with some chewing gum, the students seem ready for class. Working an example problem from the textbook, the teacher starts class. She uses this problem to questions the students. Unlike the no response from the 8:00 class, three or four students answer her questions. Some even initiate questions about the problem they are working. These students seem much more relaxed and comfortable with their teacher than her 8:00 Lecture students. This is a smaller class with about 17 students. Teacher B continues to work problems from the textbook, quickly filling both blackboards several times. When she does ask a question, several students answer.

Sometimes students stop her to ask their own questions. When this happens, she always praises them saying "Great!" From time to time, she does work the problems too fast and when this happens, students' eyes do wander. She then stops, asking "Does this make sense?" (no response) and answering her own question:"Yes!" About halfway through the class, she assigns problems on the board that are part of students' graded group exercise. The groups, generally consist of two or three students, some of whom face each other, while students in other groups sit side by side. Immediately the classroom becomes noisy and active. Teacher B constantly moves around the classroom from group to group, stopping to answer a question or just to lean over to see what they have accomplished. Sometimes she is so engrossed in what a group is doing that she doesn't see the hands from another group who has a question. When students in a group have a question, they stop and wait for the teacher to answer their question before proceeding. One of the groups is stuck on the same arithmetic problem that other classes have encountered (1/(2/t+1)). Walking to the blackboard, she quickly works this problem out. Once a group is finished, Teacher B looks at their work and makes suggestions as to how to improve it. The teacher continues to work around the room helping each group. She even takes time to tell one student to "work on that cold." She tease students at the end of the class period, "What could be more fun than this math class?" They smile, turn in their work, and leave.

It doesn't seem possible, but this teacher is more energetic than at 8:00. She treats her students in a positive and enthusiastic manner, and at 1:00 they respond in a similar manner. Instead of no one responding to her as at 8:00, several students in her 1:00 class respond to her barrage of questions. A few students even ask their own questions. When they work in groups, she spends time with each group, either helping or answering questions. She ends the class in the same manner in which she started, joking and smiling.

Since it was quite evident while videotaping that there were considerable differences in the way these three teachers taught this class, the researcher used the survey instrument in Appendix D, the Final Mathematics Student Evaluation, to let the student validate the performance of these three teachers in these six classes. The first five questions on the student evaluation seen in Table 22 are the main differences the researcher saw while videotaping. The last two questions are student evaluation questions that should be different based on the MBTI teaching style of the instructors (McCutcheon, Schmidt & Bolden, 1991). Table 22 shows the students did, indeed, evaluate the three teachers differently. Teacher C, the instructor who patiently explained each problem so that all students could understand, received the highest evaluation. Teacher B, the personable and energetic instructor, also received high ratings, but in most cases not as high as Teacher C. Teacher D was not all evaluated highly by the students, receiving considerably lower ratings that those of Teachers C and B.

Yet the plots of means in Figure 5 for the three measures of mathematics achievement, verify that Teacher D's classes performed the best of all the cooperative learning classes on both the Problem-Solving Test and the Algebra Skills Final Examination. Teacher B, on the other hand, the teacher rated hieghest by the students, had the lowest scores for a cooperative learning class on any measure of college mathematics achievement. His lecture class at 10:00 scored low on the Problem-Solving Test but higher than the 8:00 lecture class.

*Table 22*

*Students' Evaluation of Teacher Performance by Class*

| | 8L | 8C | 10L | 10C | 1L | 1C | |
|---|---|---|---|---|---|---|---|
| | **Teacher B** | **Teacher C** | **Teacher C** | **Teacher D** | **Teacher D** | **Teacher B** | $\chi^2$ |
| Q1. Communicates enthusiasm for subject matter and teaching. | 3.52[1] | 3.54 | 3.71 | 2.56 | 2.95 | 3.41 | 75.18 ** |
| Q2. Uses instructional time effectively. | 3.30 | 3.75 | 3.74 | 2.65 | 3.16 | 3.29 | 79.45 ** |
| Q3. Implements learning activites in a logical manner. | 3.15 | 3.46 | 3.68 | 2.74 | 3.05 | 3.11 | 47.93 ** |
| Q4. Uses examples to clarify difficult concepts or content. | 3.18 | 3.71 | 3.90 | 2.70 | 2.94 | 2.95 | 78.77 ** |
| Q5. Makes changes based on criticism. | 2.63 | 3.13 | 3.29 | 2.48 | 2.95 | 2.65 | 40.64 ** |
| Q6. Senses when students do not understand material. | 3.04 | 3.38 | 3.32 | 2.07 | 2.53 | 2.94 | 68.54 ** |
| Q7. Tailor instruction to students with varying interests. | 2.85 | 3.29 | 3.45 | 2.22 | 2.59 | 2.74 | 70.01 ** |

[1]Means of scales 1-4 where 1=Strongly Disagree, 2=Disagree, 3=Agree,4=Strongly Agree.
** $p<.01$.

If students' self-reported results can accurately measure how each studied, then Table 23 shows that there was no difference in how much study was taking place for each class. I initially thought that Teacher D was motivating her class to study more because she was giving a quiz every class period. But this was not the case. Every class reported a mean of around an hour of study time for each class. An interesting trend in Table 26 is the change of mathematics self-confidence. At the first day of class, the students had been given three of the subscales of the Fennema-Sherman Mathematics Attitudes Scales. One of these subscales, the one that measured a student's level of self-confidence in doing mathematics, was measured again at the end of the semester. This change in self-confidence was measured by subtracting the measure taken at the end of the semester from the one taken at the beginning of the semester. As you can see from Table 26, Teacher B, the teacher who praised the students the most, had students with a change in mathematics self-confidence that was positive. The other teachers, Teacher C and D, has students with negative changes in self-confidence. All other questions that measured motivation or effective study habits for students showed that none of the classes were any more motivated and none produced better study habits. Another point was that the number of absentees for each class was about the same, three. The videotapes suggested that the 8:00 Cooperative Learning class had more students missing while Teacher D has almost no students missing the week of videotaping. Table 23 shows no difference in the means for the number of classes missed. But remember Table 8 reveals that of the seven students who withdrew after midterm, four came from this 8:00 Cooperative Learning class and none came from Teacher D's classes.

*Table 23*

*Student Measures of Change in Mathematics Self-Confidence and Study Habits by Class*

| | 8L | 8C | 10L | 10C | 1L | 1C | Tests of | |
|---|---|---|---|---|---|---|---|---|
| | Teacher B | Teacher C | Teacher C | Teacher D | Teacher D | Teacher B | Sign | p-level |
| Q1. Change in mathematics self-confidence. | 0.37[1] | -1.35 | -1.13 | -0.09 | -0.47 | 1.42 | F=0.80 | .55 |
| Q2. I keep up with my homework. | 2.85[2] | 2.83 | 2.77 | 2.73 | 2.84 | 2.77 | $\chi^2$=10.30 | .80 |
| Q3. When studying for a test, I wait till the night before. | 2.65 | 2.54 | 2.64 | 2.64 | 2.63 | 2.35 | $\chi^2$=11.01 | .75 |
| Q4. I read each assigned section in my math book. | 2.31 | 2.54 | 2.39 | 2.36 | 2.21 | 2.18 | $\chi^2$=11.95 | .68 |
| Q5. If I can't work a problem, I wait for my teacher to do it. | 2.46 | 2.38 | 2.61 | 2.64 | 2.53 | 2.41 | $\chi^2$=14.20 | .51 |
| Q6. How many average hours do study before coming to class? | 1.24 | 0.96 | 1.07 | 0.94 | 1.24 | 1.16 | F=0.64 | .67 |
| Q7. How many times have you been absent from this class? | 2.96 | 3.63 | 2.87 | 2.77 | 3.15 | 2.41 | F=0.80 | .55 |

[1] For Q1, Q6 and Q7, these are means of continuous variables.
[2] For Q2-Q5, means of scales 1-4 where 1=Strongly Disagree, 2=Disagree, 3=Agree,4=Strongly Agree.

## Use of Study Variables in Classifying Success or Lack of Success in a Pre-Calculus Course

*(i) Can success or lack of success be predicted by student extra-classroom variables?*

Discriminant analysis can be used to predict group membership based on the best linear composite or combination of predictors scores. This second analysis takes the significant variables from the dependent variable course grade and uses discriminant analysis to determine if, before the Pre-Calculus class starts, the researcher can determine whether that student will likely succeed or not succeed. A student was considered successful if his or her course average was 70 or greater. After talking to several instructors, I and the instructors decided that students who get a D or F or who withdrew would be considered unsuccessful. This broke the continuous dependent variable course grade into two categories--successful or unsuccessful. As you can see from Table 24, the comparison of means for significant high school predictors, shows that of the 131 students 83, or 63%, were considered successful, and 48, or 37%, were considered unsuccessful. There were quite a few D's in this class leading to a much higher unsuccessful rate than first reported (17% failure rate) using just F's and withdrawals.

Table 15 shows us that high school percentile was the largest contributor to variation in the course grade. There is a considerable difference in high school percentile between the successful and unsuccessful students. Gender differences were noted, with only two of the predictors showing significance ($p<.05$) when successful males and females were compared. As shown in previous studies, females did get higher grades than the males. But contrary

*Table 24*

*Comparison of Mean High School Predictors for Successful and Unsuccessful Freshmen Pre-Calculus Students*

| | Successful | | | Unsuccessful | | | All students | | |
|---|---|---|---|---|---|---|---|---|---|
| | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** |
| Math SAT | 83 | 466.8 | 101.2 | 48 | 413.7 | 58.0 | 131 | 444.2 | 73.9 |
| HSPER | | 59.5 | 27.4 | | 46.6 | 26.4 | | 54.8 | 23.7 |
| Alg II grade | | 2.5 | 1.0 | | 2.0 | 1.0 | | 2.3 | 0.9 |
| Trig grade | | 1.1 | 1.8 | | 0.3 | 0.7 | | 0.8 | 1.2 |

*Significant Differences in Gender for Successful Students*

| | Males | | | Females | | | |
|---|---|---|---|---|---|---|---|
| | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **p-level** |
| HSPER | 49 | 55.3 | 21.2 | 35 | 65.4 | 18.5 | .03 |
| Alg II grade | 50 | 2.3 | 0.9 | 37 | 2.7 | 0.8 | .04 |

to some studies, there was not difference in Math SAT scores (p<.05).

Significant student extra-classroom variables were included in the first run of the discriminant analysis. The variables included are shown in Table 25.

If two of the non-significant variables are removed from the first run, the remaining significant predictor variables are *Math SAT scores, high school percentile, grade in Algebra II* and *in Trigonometry.* Once the significant predictors are determined, the discriminant function can also be determined. The discriminant function for classifying students as successful or unsuccessful, along with the distributions is shown in Figure 8.

*Table 25*

*Variables Used in Discriminant Analysis to Differentiate Success or Lack of Success for Freshmen Students in Pre-Calculus*

| Variables in the model with df for all F-tests: 1,123 | | | |
|---|---|---|---|
| **variable** | **Wilks' Lambda** | **F to remove** | **p-level** |
| SATM | .791 | 7.70 | .006 |
| HSPER | .757 | 2.18 | .143 |
| HSGPA | .744 | 0.04 | .839← |
| ALGII | .759 | 2.43 | .121 |
| TRIG | .777 | 5.37 | .022 |
| MBTI | .746 | 0.43 | .517← |

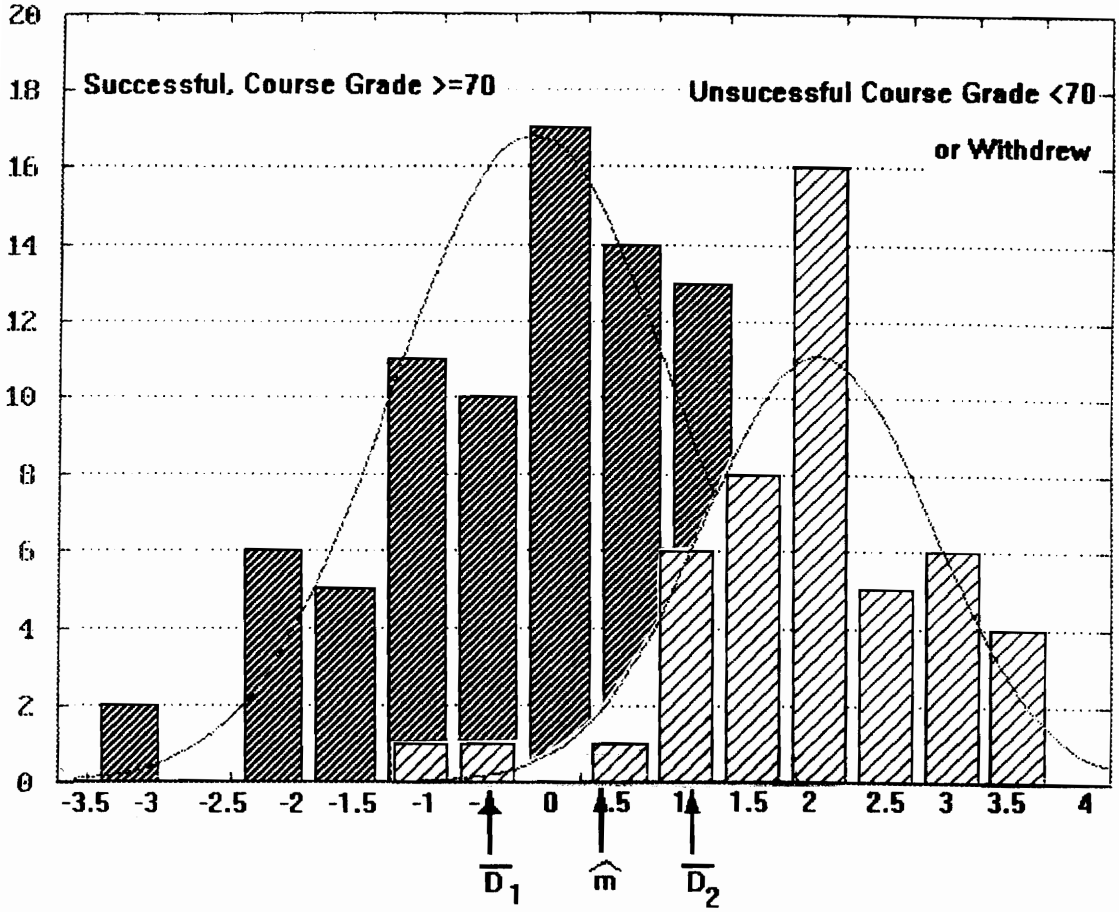
*removing HSGPA and MBTI*

| Variables in the model with df for all F-tests: 1,125 | | | |
|---|---|---|---|
| **variable** | **Wilks' Lambda** | **F to remove** | **p-level** |
| SATM | .812 | 6.93 | .009 |
| HSPER | .804 | 5.58 | .020 |
| ALGII | .754 | 4.00 | .049 |
| TRIG | .806 | 5.90 | .016 |

*Chi-Square test for the discriminant function is 33.02 (p-level = .000)*

The Discriminant Function is:

$$D_i = 5.488 - .007 * \text{Math SAT Score} - .020 * \text{High School Percentile} - .438 * \text{Alg II Grade} - .388 * \text{Trig Grade}$$




$$\hat{m} = 5.488 - .007 * 444.2 - .020 * 54.8 - .438 * 2.3 - .388 * 0.8 = -0.04$$

$$\bar{D}_1 = 5.488 - .007 * 461.8 - .020 * 59.5 - .438 * 2.5 - .388 * 1.1 = -0.47$$

$$\bar{D}_2 = 5.488 - .007 * 413.7 - .020 * 46.6 - .438 * 2.0 - .388 * 0.3 = 0.68$$

*Figure 8*

*Plot of discriminant scores for successful versus unsuccessful freshmen students in Pre-Calculus* *(ii) Can this discriminant function be used to accurately classify students as successful or unsuccessful?*

One must remember that this type of analysis, as it has been conducted so far, can only be used on this particular group of students, Fall 1993 Pre-Calculus. This analysis is only a first step to see if, using high school performance data and maybe an entrance achievement test, we can determine with some accuracy whether a particular student can succeed in this class. Again, remember this class is where we expect freshmen to start mathematics. A few start with Calculus. But too many freshmen students have in the past not been able to handle this course. In fact, the department currently offers a remedial class to prepare students for this one class.

One way to determine if this function can do the job we want is to look at the accuracy of our "hit rates", or success in correct classification. Table 26 shows the percents predicted versus observed for the two groups.

*Table 26*

*Predicted versus Observed Classification of Successful and Unsuccessful Freshmen Pre-Calculus Students Using the Discriminant Function*

| **Group** | **Percent Correct** | **Predicted Successful** | **Predicted Unsuccessful** | **Total Observed** |
|---|---|---|---|---|
| Observed successful | 86.75 | 72 (correctly classified) | 11 (did better than expected) | 83 |
| Observed unsuccessful | 58.33 | 20 (did worse than expected) | 28 (correctly classified) | 48 |
| Total | 76.34 | 92 | 39 | 131 |

Apparent Error Rate = 1 - 76.34% = 23.66%

| **Possible Reasons Why Did *Better* Than Expected:** | **Possible Reasons Why Did *Worse* Than Expected:** |
|---|---|
| • 45% completed a summer workshop | • 75% had 8:00 classes |
| • 55% were male; 45% were female | • 65% were male; 35% were female |

An overall error rate of 24% is fairly high. In trying to determine how a student could be misclassified, I looked at several factors that might cause a student to do better or worse than expected. I got a hint as to why students might have done better, because I was the teacher in the summer two-week workshop. I noticed that several of these students did better than expected. This was one clue that might affect classification. Another factor that showed up, actually in the third analysis, that was a hint as to why a student might do worse than expected, was the time of day when he or she took the class. Students taking 8:00 classes did not do well compared to the those taking the Pre-Calculus at two other times in the study (10:00 and 1:00). As shown above, 75% of the students who did worse than expected took 8:00 classes.

I still haven't answered my question above: Can accurately predict classification into successful or not successful be accurately predicted?. At this point, I'd say no. Figure 8, indicates that plot of the discriminant scores overlap considerably. Mean discriminant score for the successful ($D_1$) and nonsuccessful groups ($D_2$) at the bottom of the figure are too close to the mean (m) for all the students. I would like the two distributions to be further apart and not overlap so much. But it is important to remember that this type of analysis has steps, and this is the first step. Yes, I do feel that high school performance variables can be used to predict success or lack of success. But other variables are needed to decrease my error rate. My next step is to include the freshmen mathematics entrance exam in this equation ti see if this helps lower the Apparent Errror Rate. Probably at the same time, I will include other promising variables from the literature--home environment (Reynolds and Walberg, 1992) and a measure of motivation.

## Summary of Findings

### Extra-classroom considerations

- Math SAT scores are the best predictor for scores on the Problem-Solving Test. High School Percentile is the best predictor for scores on the Algebra Skills Final Examination and for course grade.
- High school performance, explained more variation for all measures of college mathematics achievement than any other student extra-classroom variable.
- The three Fennema-Sherman subscales, anxiety, self-confidence and efficacy, and demographic characteristics disappointedly explain very little variation in college mathematics achievement.

### Classroom Experimental Design

- High school performance variables, by themselves, should not be used to classify students as successful or unsuccessful in Pre-Calculus.
- Students taking 8:00 classes averaged 9 to 11 points lower on all measures of college mathematics achievement.
- For this study, there was no difference in the two instructional settings, lecture and cooperative learning.
- 8:00 class time and cooperative learning were a lethal combination in that students in that class averaged 19 to 33 points lower than any other class for the Problem-Solving Test.
- Students with the Introversion preference averaged 8 points higher on the Problem-Solving Test.

- Students with the Judging preference averaged 11 points higher on the Algebra Skills Final Examination and 5 points higher on the final course grade.
- Students with the IJ learning style (which are 14% of the total number of students taking the class) averaged 13 to 20 points higher for scores on the Algebra Skills Final Examination and 11 points higher for scores on the final course grade.

Inside the classroom

- Students taking classes at 8:00 are not awake enough to understand the mathematics content being presented by the instructor.
- The class that had the highest level of interaction between teacher and student and attended to task had the best mathematics achievement.
- Accountability for the students to get a good grade is a better motivator than the teaching style of the instructor.
- Student evaluations of instructors and performance on the three measures of college mathematics are not related.
- No single instructor or type of class, either lecture or cooperative learning, caused an increase in measures of the study habits of students.

# CHAPTER V

# DISCUSSION AND REFLECTIONS

## Importance and Use of Student Extra-classroom Variables

When I first looked at the results presented in Table 15, I was disappointed in that I could not predict more than about 32% of the variation for any measure of college mathematics achievement. But after reviewing studies using undergraduates (Siegal, Galassi and Ware,1985; Lent, Brown and Larkin, 1986), I realised that my $R^2$ was not only similar but, in fact, somewhat larger. The Siegal, Galassi and Ware study (1985) had an $R^2$ of 11.4% for the Math SAT scores compared to the almost 16% from this study with mathematics performance measured by a skills test. The Lent, Brown and Larkin study (1986) used a more composite measure of mathematics achievement, the grades for math and science classes, and found that Math PSAT explained 6% and high school rank 8% of the variation for this measure of achievement. These $R^2$ from this composite measure is very similar to the course grade presented in this study with an $R^2$ of 5% for Math SAT and 8% for high school percentile.

It is critical to note that high school performance variables were definitely the largest contributor to all measures of math achievement and that whether the Math SAT or high school percentile was the largest contributor is determined by the particular measure of college mathematics achievement. It is not surprising that the Math SAT was the largest predictor for the Problem-Solving test, as the same abilities are needed to be successful on these two tests. Ferrum students were not successful at either. Table 16 indicates the average Math SAT score for the successful students is about 470 and Table 12 shows more than 60% failed this test. All the instructors were surprised at how poorly their students performed but the instructors did not change the way they continued to teach the class. It was more like they didn't really want to know. They spend time in the class going over a few word problems every week and more before the actual administration of the test. Very little if any instruction was given on techniques for solving word problems. But this Fall (1994) an attempt will be made to increase the time spent on useful problems and to teach problem solving techniques. The department's adoption of a new textbook is the first step to change (note that the textbook is the agent of change).

The Algebra Skills Final Examination and course grade were best predicted by high school percentile or rank and not by Math SAT. This too is not surprising because the way this course was taught, chopped up symbolic manipulation of skills with no apparent usefulness, is the way an algebra course would be taught in high school. Whatever strategies students used in high school to get good grades in mathematics class would also work in this Pre-Calculus course. For the same reason, the grade for the Algebra II class in high school explained 12% of the variation for the Algebra Skills Examination. The Ethington and Wolfle study (1986) also found a large effect explained by mathematics exposure to high school classes . The good part from all of this is that textbook publishers are being forced to publish texts that stress more problem solving, thanks to associations such as Mathematical Association of America (MAA) and National Council of Teachers of Mathematics (NCTM). The bad part is that most of the instructors would not change what they emphasize in this class without the textbook making the changes first.

Even though demographic characteristics show hardly any contribution to the $R^2$ for any measures of college mathematics achievement, there are still gender issues which seem to be smoldering under the surface. I did not find a significant difference in mean Math SAT scores for male versus female students, but I did find difference in high school percentiles for successful male and female students as Table 16 shows. Female successful students had significantly higher high school percentile (65.4%) than male successful students (55.3%). The female successful students had higher average Algebra II grades. These women also did not vary in the trigonometry grade. This suggests that females ARE taking upper level mathematics classes as often as successful male students and are generally getting higher grades. This does not suggest avoidance of higher level mathematics classes in high school. But the demographics table, Table 9, suggests that females students are still not entering the science, math, or business major at the same rate as the male students. I did expect that students who expressed an interest in the science majors would perform better on these measures of mathematics achievement, but this was not the case. Lent, Brown and Larkin (1986) also found none of the variation explained by interest for a specific major for the variable of technical grades in mathematics and sciences.

The most disappointing part of the study was the low or non-existent part that mathematics attitudes played in predicting college mathematics achievement. I really expected at least the self-confidence or self-efficacy subscale of the Fennema-Sherman Mathematics Attitudes test to significantly explain some of these measures of mathematics achievement. The Thorndike-Christ (1991) predicted 43% of final course grade for middle and high school students using the self-efficacy and self-confidence scores along with gender.

But if I look back at the structural equations model of Ethington and Wolfle (1986), I see that mathematics attitudes was a very small effect. Siegal, Galassi and Ware (1985) found an $R^2$ of .6% for mathematics anxiety. The Llabre and Suarez study (1985) showed that math anxiety had little to do with course grades. These are comparable to the results of this study.

One possible consideration was that students' attitudes were deflated at the beginning of the school year. I gave the self-confidence scale again at the end of the semester and found that their self-confidence had actually decreased excepted in one instance. Compare this with the Leitze study (1994) in a more manipulative and problem-solving based course, where attitudes were more positive. I have now come to the conclusion that if a mathematics attitude survey is to be given, it should be used to gather information about the course one is teaching such as the Indiana Mathematics Belief Scales (Kloosterman & Stage, 1992) rather than to predict mathematics achievement.

The most interesting set of variables for this study was the Myers-Briggs personality preference used for student groupings. Deciding how to look at smaller groups of students within the classroom was somewhat difficult. There are aptitude treatment interaction studies such as that of Clute (1984), who grouped her students into three levels of anxiety as measured by the MARS survey instrument. She then taught two undergraduate classes using two instructional settings. Because I didn't find that any of the mathematics attitudes significantly contributed to the variation of the measures of achievement, this didn't work for this study. But I had seen, during the summer session, differences in performance using the Myers-Briggs Type Indicator.

After investigating what the literature calls "learning styles", I thought that this would be a good way to group students. Giving the Myers-Briggs to 170 undergraduates was quite difficult and time-consuming but it seems like it was worth the effort. This study could not only look at the "learning styles" that are successful for this Pre-Calculus course, but also show which of these skills are needed for different measures of mathematics. At the time I did this, I did not know which, if any, of the two Myers-Briggs preferences would be important. Literature on learning styles using Myers-Briggs is varied in its results. Most studies on academic performance use the E vs I and the S vs N combination to create their learning styles. For this study the E vs I and the J vs P preferences were the two best predictors for mathematics achievement. Many of the studies reviewed found a relationship between two preferences and achievement in college students. Kaksbeek (1987) found that the Introverted preference helped explain a greater amount of variation in first semester GPA than any other preference. The Judgment/Perception preference also contributed to first semester GPA, suggesting that students with structured work habits had higher GPAs. If success in college is also measured by staying in school for high -risk students, the Nisbet, Ruble and Schurr (1982) found these students like closure and teacher directed activities, certainly a Judgment preference.

Even though I feel that the results I obtained with the Myers-Briggs preferences are valid, I've got to say that there are some problems with the distributions of the preferences. The first is that if we use the scores for each preference, these should be bimodal. According to Pittenger (1993) these are not bimodal, suggesting that each preference cannot be dichotomous. The second problem is that all of these preferences, but the E vs I combination, are correlated as shown in Table 15. The E vs I is not correlated with the other preference (r = .02 to .09), but the others are more closely related to each other (r = .14 to .24). Other studies have shown that the J vs P and S vs N are correlated with one another (Myers & McCaulley, 1985).

To further back up the fact that the S vs N and the J vs P are probably correlated, I also gave the Myers-Briggs Type Indicator to a Discrete Mathematics class. Even though the class was small, the results were as follows:

| | | |
|---|---|---|
| E (30.8%) | vs | I (69.2%) |
| S (69.2%) | vs | N (30.8%) |
| T (53.8%) | vs | F (46.2%) |
| J (38.5%) | vs | P (61.5%) |

This class had nothing to do with this study, and yet these student who are good in mathematics (in fact, for the most part, they are mathematics majors) also showed preferences for the E vs I and J vs P preferences. For this class, the S vs N also showed as an important preference. So I felt that the EIJP grouping represented a legitimate way to group students in this Pre-Calculus class.

BUT no matter how interesting these student groupings were, they did not come close to the strength of high school performance as THE predictor for all measures of college mathematics achievement. I do feel that the significant predictors found for the discriminant analysis represent an excellent first step in attempting to classify students as successful or unsuccessful. These high school performance variables did predict 30% of the variation in predicting the dichotomous variable--success or lack of success. However, I was not satisfied that they alone could predict whether we should put students in this class or not. For Figure 8, I would like to see the two distributions (with $D_1$ and $D_2$) farther apart. I do believe that this can be done by adding scores on a Freshmen Entrance Mathematics Achievement Test given right before this class starts. A study by Smith, Arnkoff and Wright (1990) suggests that this might account for another 10% of the variation for mathematics achievement. Another variable that could be entered or at least considered is socioeconomic status, as it is a very good predictor of degree completion (Astin, 1993).

I do feel that the first step has been taken to determine what our students need to succeed in this Pre-Calculus class. I know that this class will change to focus more on problem solving and hopefully be more useful to a student in his or her major and career. I believe that we are starting to think about those steps. But if the entering students cannot succeed then the mathematics faculty and administration of the college need to either offer intervention or look at their entrance standards.

## Classroom Experimental Design

The 3 (class times) x 2 (instructional settings) x 2 (E vs I) x 2 (J vs P) factorial experimental design shown in Figure 2 presents the real heart of this study. It was quite eye-opening to actually be in the classroom while the study was going on. I spent a lot of time with the faculty members who were instructors and the head of the department trying to figure out what was going on as it was happening. It was pleasing to work with faculty member from my own department but it was also frustrating in trying to determine what was going on not only with the instructors but with the students. I don't think we as faculty members understand the students who are now entering our colleges. The "generation gap" between what faculty members expect and what skills students bring has become very wide. Even the news shows on TV are talking about the "generation X", the young people of today. Some of the results of this study I believe reflect those differences.

I do not see many strong experimental designs in mathematics education research. I saw no study I could review that even came close to this study. Some of my discussion might be considered more speculative than some, but this is why this study is entitled " An Exploration."

Even though the results started with the main effects, every good statistician knows that the interactions are the more important than the main effects. From the very start, the *Problem-Solving Test* became a different "critter" than the other two measures of mathematics achievement. It was not valued in student's final grade and nobody, students, or instructors, did anything but nod their head when the results were tabulated. No one was surprised that the average score was less than 60. No teachers changed the way they taught the class after it was over. No one added any word problems or writing to the Algebra Skills Final Examination. It was a test given for this study only.

The interaction that turned up significant and in fact had the largest mean square was the Time of Class x Instructional Setting for the Problem-Solving Test. The means and tested contrasts are presented in Table 19. The 8:00 Cooperative Learning class was a disaster; it was 19 to 25 points lower than every other class except the 10:00 Lecture. It was probably this one class that caused time of class to be significant for these dependent variables and possibly the reason why cooperative learning was not significant. Figure 5 shows that the other two cooperative learning classes did better than the lecture classes (though not by much). Why was this 8:00 class so bad?

Believe me, this was as surprising for me as for the instructor. In fact, in the very beginning, I was afraid this instructor was going to bias my results upward because he had used cooperative learning quite a bit and knew its importance. The other two instructors had never used cooperative learning before. So why did this happen? First, both 8:00 classes performed 11 to 13 points worse than the 10:00 and 1:00 classes, no matter the instructional setting. So 8:00 mathematics classes were not conducive to student performance nor, I might add to student presence. Many more absences were recorded at this time slot. If you are not in class, your cooperative learning class doesn't have a whole group. The 8:00 instructor spent more time in cooperative learning groups than did any other instructor, but the combination of 8:00 and cooperative learning was a poor match.

Secondly, Figure 5 shows that the same instructor's other class, the 10:00 Lecture, was the second lowest mean in performance on the Problem-Solving Test. I happened to be videotaping right before this test was given, and I do know that the other two instructors did review a lot more than the first instructor. I'm not so sure they didn't actually teach more solving word problems so their students would perform better on this test. The first instructor did not do this. This suggested a possible teacher effect which should have essentially blocked out by the layout of the experimental design. I do have more data on this effect but will not present it in this dissertation.

The most significant effects were, of course, time of class, and the Myers-Briggs Extravert vs Introvert personality preference for the Problem-Solving Test. As stated above, the 8:00 classes performed poorly whether it was cooperative learning or lecture class. The discriminant analysis showed that 75% of the students who were predicted to succeed but did not took the 8:00 classes. This left the possible question as to whether there were more students in the 8:00 who had lower Math SAT scores or high school percentiles -- who, in other words, were underprepared. Interestingly, though ff a Chi-squared analysis is performed comparing the number of predicted successful vs predicted unsuccessful for the three classes, there is no difference in preparedness for the 8:00 and 10:00 classes. There is a significant effect, but it seems that the students taken the 1:00 classes had many more predicted successful and less predicted unsuccessful. So the low scores for the 8:00 classes are not due to underpreparedness.

The Myers-Briggs variable E vs I was also significant for the Problem-Solving Test. Introverts scored 8 points higher than Extraverts. I am not surprised that the Is had higher scores, because this personality preference is linked to thinking ahead as to how one will solve a problem. Is have internalized strategies for success, while Extraverts have a tendency to leap into solving problems with little forethought, relying on trial-and-error techniques which are not an effective way of solving problems. What seems important is not why E vs I is significant but why J vs P is NOT significant, when it shows up on the other measures of college mathematics achievement. I really believe that the J vs P was not significant because students do not know how to use successful strategies to solve word problems. It seems that when it comes to solving or even teaching how to solve word problems, it is difficult to explain to a students strategy that works for all problems. Why are some of us successful and some not? Remember that many of the students pretty much gave up on this test before they started. This is a factor of mathematics learned in K-12 where word problems were always the ones at the end of practice sets and usually the hardest. Teachers don't assign them often, and when they do, they don't seem to test for them. Students learn that these are not important and probably too hard to solve anyway so they aren't worth trying. I've got to say as an instructor in a developmental algebra class, that solving word problems as class work and homework is extremely frustrating, so I feel that many teachers skip all but the simplest problems. This certainly brings up the question why are we only teaching basic skills and facts? Because it's easier, because the textbooks have de-emphasized word problems, because students can't do them.

Continuing to look at the results for the factorial experiment, we find that the *Algebra Skills Final Examination* and *course grade* can be considered together, because the Algebra Skills Final Examination certainly measures what facts and skills were valued for this Pre-Calculus course. It is important to remember that the same Algebra Skills Final Examination was given to all students and that course grade is a composite grade (having considerably less variation) that is computed somewhat differently by each instructor. Table 16 shows that even though the mean squares are considerably smaller for the course grade, the results are similar, with some exception noted on the Myers-Briggs E vs I preference.

Both the Algebra Skills Final Examination and the course grade did have a significant interaction; this was the E vs I and J vs P preference combination, or what I'll call the EIJP learning style. What's causing the significant interaction is the superiority of one learning style, the IJs, over the other three -- EP, EJ and IP. The IJs outperform all other learning styles 13 to 20 points for means on the Algebra Skills Final Examination and 11 points for the mean of the course grade. Their superiority in using a step-by-step procedure to successfully aquire the skills needed for not only the Algebra Skills Final Examination but all the course assignments, tests and quizzes is shown in the plot of means in Figure 7.

This brings up a troubling question is the way we teach mathematics only geared toward one learning style? The IJs are definitely more deliberate, thinking in a step-by-step fashion and gauging their learning by completion of tasks. Are we deliberately teaching mathematics to this type of learning style to the exclusion of the other learning styles? It would seem so. Are we so structured in mathematics that perceptive people feel "imprisoned" or stifled our classes? Are the extraverts forced to sit in a learning environment in which they cannot discuss with others facts or theories so they can have that "flash of insight" that connects the new with the old? Even though we feel we need to work in group situations so other students can judge their knowledge against others, can we build a mathematics classroom conducive for more than the IJs, who are a considerable minority (14%) in this study? What can we do to help the other 86%? Add this to the fact that many college professors are IJs (4 of the 6 professors tested in my department were IJs). Studies (Provost and Anchors, 1987) looking at outstanding professors, found only 11% were IJs. Are more mathematics professors IJ since this is a preferrred style in learning not necessarily in teaching mathematics. Certainly something to think about!

For the two Myers-Briggs preferences, E vs I and J vs P, the E vs I preference was not significant for the Algebra Skills Final Examination and was significant for the course grade. Even though IJ is certainly a superior learning style, the Introvert preference seems to have a 5 point advantage over the Extraverts for the final course grade. This is probably due to Introverts being more the planning type and keeping up with assignments and quizzes better than Introverts. The Introverts did not perform better on the Algebra Skills Final Examination. The mean for students with the Judging preference was 11 points higher on the Algebra Skills Final Examination and almost 6 points higher for the course grade. Js are not only very structured in solving problems but superior in learning by completion of tasks.

The last main effect, time of class, was also significant for the Algebra Skills Final Examination and the course grade. Again the 8:00 classes averaged 10 to 12 points lower for the mean on the Algebra Skills Final Examination and 8 to 9 points lower on the course grade. There was no differences in means for the Algebra Skills Final Examination or the course grade between the 10:00 and 1:00 classes. This focuses us to ask ourselves, should we be teaching mathematics at 8:00?

Now that this study has been completed, it would be interesting to go back to these EIJP learning styles and gather perceptions as to what and how the students are learning. How does the way mathematics is taught affect how students learn the material? Why is there so little success in problem solving? Why do faculty and students alike not value critical thinking and problem solving over learning basic skills and facts? What happens to the EIJP learning styles when the mathematics community changes to teaching to more problem solving? Many of these questions are grounds for further research, using not the quantitative methods in this study but by using a more qualitative approach to data collection.

## Classroom Similarities and Differences

*What are the teacher similarities for two instructional methods?* Teacher B is definitely the one who can work the most problems in a class period. Even the cooperative learning class cannot slow her down much. She spends much more time lecturing than expected for a cooperative learning class. Teacher B is positive, energetic and boosts the students' self-confidence to do mathematics. She writes boldly using both boards and is constantly questioning the students for understanding. The survey results suggest that her weakest points are that she does not make changes in her class based on criticism and doesn't meet the individual needs of the students (a weak point for all the teachers). She plans to cover a certain amount of lecture material and she does. Since she only receives feedback from the 1:00 class, she doesn't realize how fast she is covering the material. Teacher C is a very patient and methodical instructor. He takes whatever time is necessary to explain a problem so that everyone understands. If it take 12 minutes to explain one problem, then this is what he does. He always involves the students by questioning and waiting for their response. He must hear a response before he continues. He seems stern and strict yet has a sense of humor that delights his students. He does value lecture as the best method for covering the material and seems to use the cooperative learning groups exclusively for higher order thinking and writing. The students don't seem to appreciate this. Teacher C also seems to know how much material the students can handle. In contrast, Teacher D uses the same approach for both classes by drawing a picture of the situation and developing the function that fits that problem. After that, it is up to the students to create the graph, including the appropriate dimensions of the viewing rectangle for their grapher. Teacher D expects them to be able to use this graph to answer the other parts to the word problem. Her style seems chaotic most of the time. Sometimes she waits for several minutes while students work on a problem and at other times she quickly gives the answer. She likes to involve the students in the learning process, and they are comfortable with going to the board to draw graphs or with reading problems from the book. There is no doubt that Teacher D spends a lot to time creating handouts that help summarize the sections and focus the student on key problems. Sometimes her assignments seems to overlap because the students don't complete the work on time. They could be working on as many as three assignments at any given time. It is quite evident that she spent most of the week I videotaped working word problems similar to those on the Problem-Solving Test.

*What are the teacher differences for two instructional methods?* Teacher B uses the same techniques for lecture as she does for cooperative learning. She still defines what problems are important and works these on the board. When the cooperative learning class does work in groups, she uses her personable style to push them to work hard and be enthusiastic about mathematics. Teacher C does value lecture as a way to understand the concepts in the book, but he is also comfortable talking to each group or individual. He makes sure that he has spend equal time with every class member, no matter what they are working on when in groups. As for lecture, students have little contact with him except to watch him lecture or answer his questions. Teacher D's philosophy on cooperative learning is similar to that of Teacher B's, namely to work in groups and talk, usually about quiz material. This is not the philosophy of cooperative learning of Teacher C. He sees groups as a platform for the students to build higher order thinking and writing skills. Teacher D found that pairs were more effective than groups of 4. The only difference in her two classes was the way the students took the quiz, either with a partner or individually.

*How does the content that each instructor is teaching show what is "valued" in that classroom?* Teacher B, by presenting so many problems in the textbook, seemed to value the students' ability to work those problems as a way to learn how to work similar problems. Seeing as many sample problems as possible focused the student on "practicing" many problems. Teacher C, on the other hand, valued that the students understand what was going on in the problem step-by-step and could explain the process. Not as many problems were necessary, as the quality of understanding of the process was foremost in the teaching style of Teacher C. Teacher D valued the student's ability to read the problem and create a graph that would best describe that function. She did have a tendency to work the first part of the problem , determining the correct function for the students. After that, the students had not only to find the correct graph for that function but use that function and graph in subsequent parts of the problem. It would be safe to say that each teacher had different goals.

*Should student evaluations determine who is the "best" teacher?* Teacher C has the best measure of classroom effectiveness as shown by the survey. Interestingly enough, this was also seen on the videotapes. His lecture style, use of patterns to illustrate logical thinking, and use of questions to probe understanding are excellent. The one reasonm, perhaps, why achievement was less in his class was because his philosophy is not to treat his students like high school students, for example, not to check for homework ,and not to summarize the material in handouts. He did not review for tests because he feels his students are college students and should develop more independent ways of handling study habits. Teacher D, on the other hand, has the lowest measures on the student evaluations, yet her classes performed that best of any for both cooperative learning and lecture. Students seem to pick the teacher that explain the material the best and has a good personality as their "best" teacher. Teacher D gives a quiz every class period, taking 15 to 20 minutes. The students are the most alert in this class because they are panicking about the quiz and because the teacher is involving them in every question. One point that bothers me is how much time is taken away by these quizzes for each class. According to the results of the two tests that measured college achievement, making a grade is more motivating for the students than the ability of the teacher to explain the material. Isn't the teacher that "best" engages the students in active learning the most "effective" teacher? In this study, this seems to be the case.

*Did the student evaluations accurately validate what the videotapes showed?* Teacher C is very well liked by his students, Table 25, the student evaluations shows. He is enthusiastic in the classroom in his commitment to mathematics and to sharing his knowledge with his students. The students see no flaws in his performance. Actually he might seem so good at doing mathematics that he seems intimidating to his students. This might suggest why his students show more negative self-confidence in doing mathematics. His enthusiasm for mathematics is considerable different than the enthusiasm that Teacher B exhibits. His weakest score was in the same area as all the teachers, and that is to make changes based on criticism. No lecture class in mathematics does this; few instructor does this. Still, he scored the highest on this question compared to the other two teachers. Even though Teacher's B scores are not as high on the survey as Teacher C's for some questions, she definitely is a good instructor in communicating excitement in the classroom. The survey suggests that her weaknesses are in making changes and providing for the individual needs of the students. The survey does seem to validate what was observed in the classroom. Teacher B is such an upbeat and energetic person that most of us, including the students in her classes, can't keep up with her. She is moving faster than the rest of us. Contrasting, Teacher D is not well liked by her students. Her teaching style is not methodical or predictable . One reason is that she is giving them so many overlapping options for making grades. Using handouts and problems from the textbook appears to the casual viewer difficult to follow. But on the contrary, Teacher D is focused on what she expects her students to learn and gives them many opportunities to do so. If her teaching style lacks a distinct structure, she makes up for it in her patience to wait for her student to complete the graph, to teach them graphing terminology and to make them fit the range of the graph to that of the problem, all of which are higher order skills, valued on the two measures of mathematics achievement.

*How does the teacher's EIJP teaching style affect the way he or she teaches in the classroom and is evaluated by the students?*

Teacher B has an EP teaching style which is characterized by energy and enthusiasm. There is no doubt that this teacher is upbeat, lively filled with movement, action and talk. Based on her Perceptive preference, she would be considered free-wheeling and flexible. I think that she is ready to "jump" into her mathematics classes and see what happens. It would seem that she would feel "imprisoned" in the structured environment of mathematics, but she seems to handle the challenge well.

Teacher D has an IJ teaching style. Her style would suggest that she might not be comfortable being the center of attention, as she must to teach mathematics. It is easy to see that she, too, like the outstanding IJ professor quoted on page 30, has an ability to assemble resources to help the students summarize each section from the textbook. Her handouts keep the students focused on the key points and problems they need to study to succeed. Like the outstanding IJ students, the IJ teacher like to complete tasks. This is probably why she likes to give quizzes each day. She wants to see the students working on keeping up their grades as much as possible. Just as in the study about high-risk students (Nisbet, Ruble & Schurr, 1987), this constant completion of tasks in the form of quizzes and extra credit for homework keeps her students focused on completing tasks to help their grade. This might be the very reason why none of her students dropped out after midterm. In fact, the data setmakes clear that the two students who dropped out before midterm just didn't show up.

Teacher C has that special EJ teaching style that 10 of the 18 outstanding professors possessed. It is probable that this teaching style has the best of both the IJ and the EP teacher. This teacher puts a lot of effort into communicating the correct way to do mathematics in a thoughtful, clear, detailed manner. The EJ teaching style has a little bit of "ham," yet the EP teacher yet is still focused on completion of tasks. He sets his own objectives and follows them. Several of the class periods ended a few minutes early, but instead of leaving early, he thought of problems that would interest students anxious to leave. These were not spontaneous; these were planned and executed in a attentive manner.

Do these three teachers follow the expected personality preferencesof the Myers-Briggs combination of two preference to create a teaching style? You bet -- these three teacher fit the profile almost exactly. But to go back to the student evaluations, one should also consider whether students prefer and "like" teachers with a certain teaching style. They much prefer the extroverted teacher who is outgoing, polite, talkative and positive. The IJ teaching style is difficult for the students to handle because the teacher is creating resources or devising a plan to teach the students what to learn. It is not so obvious and at times can be painful for the Introverted teacher. This is especially true when this teacher who has worked so hard gets such poor evaluations, even though her class performs as well or better than other clases in the same subject.

*What are student differences for two instructional methods?* There is no comparison between the students at 8:00 and 1:00 for Teacher B. The 8:00 students are tired and late many times. They lean on their hands, yawn and rub their eyes. The 1:00 students are alert, sitting up much straighter. The 1:00 students will initiate questions to the teacher, and several will answer most of the questions. At 8:00 in the morning, the students are just sitting in their seats, inattentively waiting for the class to be over. The 8:00 cooperative learning class is somewhat more awake than the 8:00 lecture but not by much. Students stare at the problem they are working but at least they have to talk. One or two in each group seem to be able to work on the problem; the rest seem dazed. They are still yawning, and with so many skipping it seems almost as if there is a rotation of students gone , that the group composition is never as originally assigned. The 10:00 class is definitely more alert, and most will use their graphers. Several will answer questions. There is no doubt that students are more engaged in the cooperative learning groups, no matter the time. Unlike Teacher B's and C's classes, Teacher D had both a 10:00 and the 1:00 class which were awake and working. Students are open about talking to classmates as well as the teacher when they have problems. To any observer, they appear rather undisciplined and noisy. But they are actively participating in the problems being worked in the classroom.

*How do outside-classroom activities affect students' academic performance?* Students will continue to argue that their social habits do not affect their academic performance, but there is no doubt that the students are more alert at 1:00 and less tired. At 8:00 they are more tired on Monday and Friday than on Wednesday. Students stay up late at night many times not finishing their homework until 2 or 3 in the morning. The students at 10:00 seem as alert as those at 1:00. In comparing Teacher C's 8:00 and 10:00 classes, the students are more tired on Friday and very eager to get out of class early. Because Teacher D had later classes, there was not as noticeable a difference in whether her students appeared tired or not. On Friday Teacher's D classes were not as eager for the class to end. They continued to work as long as it took to complete the quiz.

*What is the importance of the textbook in this class?* This course is taught page by page from the textbook. There is no doubt that the student must learn the material succeed in this class. So, in a way, the textbook drives what is valued in this mathematics classroom more than any information that a teacher would provide. This might be why students feel they can miss class so much. It was also interesting to note which teacher's students took notes. Teacher B's students took very few notes because she was working problems straight from the book. Teacher C, on the other hand, was not. His students usually did not know where his examples came from and copied down most of what he did. It was still very evident that he was covering sections in the textbook. Teacher D, along with the rest of the instructors, saw the textbook as the source of information for this class. She did help the students summarize each section by creating her handouts. But these handouts might be the reason why her classes did so well and yet consistently lost 15-20 minutes to taking a quiz each class period.

*How does the role of students as members of a college community (or not) influenced both by peers and administrative policy affect academic performance?* The students' performance for the three day's of the week, M W and F, suggests that there is a trend that affects classroom performance. On Monday they are tired from the weekend. On Wednesday they are more alert and work better in class. On Friday they are tired from either working all week or socializing on Thursday night. Students in Friday classes are eager to get out for the weekend. I am not sure how much studying goes on during the weekend. It is the administrative policy that many classes be taught at 8:00. This study has shown that this policy is detrimental to the learning of the students, especially students who have weak mathematics backgrounds to start with. It is also the policy of the school to have classes broken up into three fifty-minute segments on M W F. This,too, is detrimental to learning how to solve problems, especially in a group situation where social interaction between the students is an integral part of learning and a time-consuming activity. Socializing and leaving the college on the weekend do seem to have a negative effect on the academic performance of especially at 8:00, they are tired on Monday and on Friday. I feel that the administration needs to be aware of what faculty have know for a long time -- that students don't do well at 8:00. Why put academically weak students in 8:00 classes where they have a higher chance of failing? Not only the videotapes but also the discriminant analysis shows that more students who should have succeeded did not perhaps largely because they took 8:00 classes

## Standards of Validity for Good Classroom Research

In order to judge the quality of this research, there are certain criteria or standards need to be addressed. More literature and organizations, including a conference sponsored by the Mathematical Association of America, Charting Directions for Research in Collegiate Mathematics Education (Leitzel, 1994), are using the standards of Eisenhart and Borko (1993) as addressed in their book Designing Classroom Research: Themes, Issues, and Struggles to assess the quality of classroom research. These five standards of validity which were used to evaluate this study are as follows:

1) *Contributions of knowledge in the field.* (Potential contribution to debates about educational theory or practice.)
2) *Overall goodness of fit.* (Fit between research questions, data collection procedures and analysis techniques.)
3) *Researcher competence.* (Effective use of specific data collection and analysis techniques).

4) *External and internal value constraints.* (Addresses the worthwhileness of the study for practitioners and whether the research has been conducted in an ethical manner).

5) *Comprehensiveness.* (Holistic way to balance standards 1-4 and go beyond them).

♦ *Contributions of knowledge in the field*

Strengths:

The real strength of this study was that it was grounded in the need to know more about what is going on in our mathematics classes at our own college. We can't make changes if we don't even know what factors affect student achievement in mathematics in our classes. Even though the variables that I examined came from previous research, their importance or lack of importance was focused on our own students in our own college. The instructors teaching the classes involved in the study helped the researcher create the two measures of mathematics achievement--the Problem-Solving Test and the Algebra Skills Final Examination. The discriminant analysis came from a need to place students in the appropriate mathematics class. The ANOVA design was meant to be a comparison between how well students learn using cooperative learning versus traditional lecture. The idea for grouping the students this way came from the interest of the Academic Resource Center to use the Myers-Briggs Type Indicator to show students that while their personalities are all personalities have strengths and weakness. It is important to know how to make the best of the assets that you have.

But combining four different types of analyses to explore college mathematics achievement is the real contribution to the area of mathematics education. We now have a better idea as to what factors influence achievement and factors such as teaching and learning styles that are new areas for research. Yes, this study should add fuel to where we want to go in mathematics. There are several results that have implications in the reform movement--cooperative learning, problem solving versus basic skills, different learning styles as they relate to mathematics.

Weaknesses:

I underestimated how difficult it would be for the two instructors who had not used cooperative learning to use it in their classrooms. Even though I had handed out quite a bit of literature on the use of cooperative learning for the mathematics classroom, this didn't help in the implementation. Really when I look back on it, these two instructors hadn't decided themselves that group learning was beneficial in the classroom. Problem solving was another area which each instructor had a different idea as to its importance in the Pre-Calculus classroom. To some it meant working the word problems in the book, while to others it meant giving students new ways to solve problems and help them internalize their solutions.

- *Overall goodness of fit*

Strengths:

Since this study was "An Exploration" and no research had been conducted in this area at my college, I felt that I did a good job addressing the research questions. I collected so much data and was constantly monitoring everything that was going on in those classes. My whole Fall schedule was built around monitoring those classes. I believe my research design was strong. I have to admit that I wanted the hypotheses to be answered with the analyses techniques that I knew about. I wanted be involved in the study and have the data mean more than just a number on the page. I could do this with this study. Each analysis built on the other. The first was a general look at all the variables (quantitative) I thought would affect mathematics achievement in those seven classes. It was meant to be a "shotgun" approach. For the results from the regression analyses, I could see the feasibility of the discriminant analysis. The high school predictors were so strong that they could almost predict success in those classes by themselves. I set up the real experimental design, the ANOVA, consciously to look at the cooperative learning. I didn't even consider class time as an. For the ANOVA design, I knew that I had to look within each of the classrooms for two reasons. First, I knew there was going to be an interaction of the main effects. Adding the student grouping made the design more complex. Second, I had get the explanation of what was going on while it was going on. Nobody remembers for very long why things happen as they do. I always teach my statistics students to collect more than numerical results; ask questions, make notes, build your discussion section while you are collecting your data. What actually happened can't be explained by number in an ANOVA table or even a table of means. The classroom descriptions not only considerable enhanced the experimental design but showed the layers of complexity that occurs in the classroom.

Weaknesses:

This was a quantiative study. I could figure out what was going on with the teachers because they would talk to me and answer my questions. But I didn't know what was going on with the students in those classrooms, the units of study. I couldn't go in and ask why they did so lousy on the Problem-Solving Test. I heard the teachers' opinions but not the students'. I did a lot of analyses before I came up with the ones I used in this study. I wasn't even going to use course grade, but the differences in the dependent variables emerged as an important part of the results of this study. I had to have the measure of mathematics achievement that the college students, and instructors valued the most.

♦ *Researcher competence*

Strengths:

It's hard to evaluate you own capabilities. I know that I am a competent researcher, as I was trained for this before I ever touched this study. Having a science background has always left me suspicious of educational research. It seems too wishy-washy, too weak in experimental design. I didn't want that in this study. But a lot of what goes on with students is not in the hands of the researcher. The researcher must work arounf the head of the department deciding when the classes are taught, the dean telling the head of the department what time of the day to teach these classes, the registrar filling the classes beyond the limit for certain time slots, the students who want to know who the teacher is before taking the class, students who can't find the right classroom, the students who don't want cooperative learning, the students who don't like the teacher or the class once they get in the classroom and the students who hate mathematics and presume they are going to fail before they start. This is why educational research is so messy. Believe me I collected plenty of data, it was my goal to have it fit together to get an accurate picture on what goes on in the mathematics classroom. Because I have dealt with populations before in previous studies, I could step-by-back and get an accurate picture of what I wanted to do. I wasn't sure of the results but no one should really know what ti expect until the experiment is over, the data is analyzed, conclusions are drawn and the reflective process allows you to see what has been accomplished.

Weaknesses:

The cooperative learning classes for the two instructors who didn't have this training were scary . They looked to me for advice on how to run their classrooms. The students were very vocal in their disapproval of groups. It was hard to keep the classes going. I'm sure that my suggestions did affect the outcomes for cooperative learning. I was not prepared to do training in this area. I had done it for some of my own previous mathematics classes and hadn't like it. I have used pairing quite effectively in my statistics classes, but after two it seems more difficult. None of the teachers wanted to give up more than about fifteen minutes of their classes to group learning. When I was in the classroom, I found out that I was not a very good classroom observer. It was hard not to see that class as a teacher or as a student. When I was videotaping, I had to seek help in defining what an effective teacher was. What were the guidelines? I was never convinced that an effective teacher is the "best" teacher. I was quite panicked. I even videotaped the students in the classroom but I wasn't sure what I saw. You can't tell much about the students by looking at them and there was no way to determine what they were thinking. It was quite unsettling. I knew that I needed more qualitative research in those classes but I just didn't have the time to do it all. I had no training in "effective" teaching and I had to look hard at what I was seeing when I reviewed the videotapes. The learning styles of the students and the teaching styles of the teachers was nothing I was familiar with as a researcher. It was a result from the analyses.

♦ *External and internal value constraints*

Strengths:

Was this a worthwhile study? I believed I addressed several issues that have implications in my department. Will my department think this is a worthwhile study? I am not sure, since research has never driven any of the mathematics classes at Ferrum College (one exception is the mathematics professor who instructs future teachers). I have written this dissertation so I could take pieces out of it to give to members of my college. I feel that the implications about 8:00 classes in not just something that happens in the mathematics department but has implications across campus. The summary of findings and the next section of suggestions to my department and college are at least going to be shared with my Ferrum collegues. I did share my results with one instructor but have not have the opportunity to allow the other teachers to accept or reject my findings. It was a collaborative relationship throughout the Fall semester to help me collect the data.

The ethical concerns were addressed by asking for consent from both the students and the instructors. The researcher tried to stay out of the way of both as much as possible.

Weaknesses:

I was not an unbiased observer of these classes. I had never taught these particular classes, but I did have a tendency to side with my colleagues over some objections from the students. The students did not really know what the research study was about. I did ask for teacher change when two teachers were not ready for change, and they did their best. The study could have been strengthen by having the instructors read the descriptions and make comments. This is be a step I will take in the future.

♦ *Comprehensiveness*

Strengths:

Overall I feel that this study had good technical and theoretical quality. It should be a strong contribution, to research in mathematics education in several areas especially in comparing three measures of mathematics achievement. I believe the study to be unusually strong in this area. Even though I think the Myers-Briggs has problems with intercorrelations, I do feel that there is a need to address the different learning styles in the classes or at least individuals as different learners of mathematics. The influence of the personality of the teacher on measures of achievement was also an interesting finding. The data collection did fit the four research hypotheses. The ability to blend the results of four different types of analyses, both qualitative and quantitative, is the real strength of this study,

## Weaknesses:

The researcher expected the instructors to use cooperative learning effectively without professional development and personal commitment to the concept. Because I am application type of person, I was appalled at the lack of concern over the poor scores on the Problem-Solving Test. Because I don't value symbolic manipulations as I do real life data collection and research questions and I am not a mathematics teacher, my discussions tend to be biases toward the area of reform that stresses more real life problems and data analysis. I accept my subjectivity in this respect.

## Suggestions for my Mathematical Sciences Department

*Faculty Teaching Pre-Calculus*

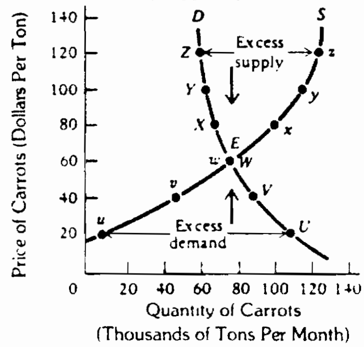
1) Value higher order skills (critical thinking and problem solving) over basic skills and facts NO MATTER how little progress you think you are making. Explore functions through algebra experiments and data analysis (we already have supplemental materials available).
2) Make students active learners recognizing that students do not learn well by traditional lectures--that mathematics cannot be learned by watching someone else doing it correctly. Start with pairing students in the classroom using the paired problem-solving method by Lockhead (1985). At other times, consider larger cooperative learning groups.
3) Help break the block of the four basic factors that impeded problem-solving performance (Hart, 1993):
   a. lack of previous experience to draw upon in understanding the problem,
   b. imposition of unstated restrictions to the problems,
   c. lack of individual monitoring or questioning, and
   d. personal student beliefs such as their own subjective opinions about what was going on with the problems.
4) Explore functions through algebra experiments and data analysis (we already have supplemental material available).
5) Value student presentations, writing projects and other assessment measures.
6) Give the students problems which are meaningful not only in their own disciplines but in the everyday lives as adults. An example of such a problem is shown on the next page (Garofalo, 1990, p. 77 & 78):

6) cont.

***Example 1:* Supply Curves, Demand Curves, and Equilibrium Prices**

Supply and demand curves are very basic and common in economics. They are used throughout the microeconomics course, starting from the very beginning. Failure to understand what these graphs represent, and how they are used to analyze economic situations and solve problems, will prevent one from being successful in the course. Below is a graph from the textbook (p. 70) that presents a demand curve for carrots, a supply curve for carrots, and an equilibrium price for carrots.

**Determination of the Equilibrium Price of Carrots**

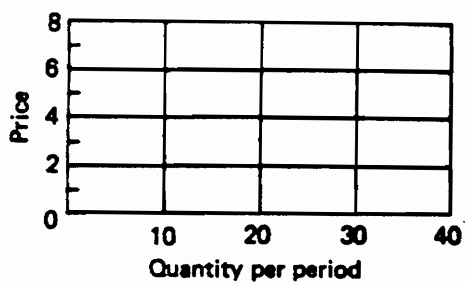



Assume the following demand and supply functions:

$Q_d = 28 - 4p \quad Q_s = 18 + p$

*(a) Determine the equilibrium price and equilibrium quantity.*

*(b) Plot the demand and supply curves on the graph and confirm your answer.*




(c) Suppose that supply shifts to $Q_s = 8 + p$, with no change in demand. Determine the new equilibrium price and quantity.

(d) Suppose that price had been held constant at its original level in (b). Predict the effects if supply shifts as in (c).

Reconsider the importance of teaching what seems to be disconnected symbolic manipulations such as these from our current text (Demana, Waits and Clemens, 1992).

6) cont.

In Exercises 27 to 42, find a complete graph of each function.

**27.** $g(x) = \dfrac{x-4}{5}$ **28.** $f(x) = x^2 - 4$

**29.** $f(x) = 2x^2 - 3x + 5$ **30.** $f(x) = x^3 - x + 1$

**31.** $g(x) = (x+3)^2 + 2x + 4$

**32.** $h(x) = 4 - x - x^3$ **33.** $h(x) = \sqrt{x+1}$

**34.** $g(x) = -1 - \sqrt{x-1}$ **35.** $k(x) = 1 + |x-2|$

**36.** $f(x) = -|2x^3|$ **37.** $g(x) = \text{INT}(x+2)$

**38.** $f(x) = (x-30)(x+20)$ **39.** $k(x) = |x^2 - 6x - 12|$

**40.** $h(x) = 2x^3 - x + 3$ **41.** $f(x) = x^3 - 8x$

**42.** $g(x) = 10x^3 - 20x^2 + 5x - 30$

7) Have math autobiographies added to problems students are solving in a group. On the left-side of the paper, have them record their feelings/thoughts as they work the problem on the right side of the paper. Have them address the questions: "What am I feeling? What does this remind me of? What is making this problem difficult for me? What could I do to make it easier for my self? (Tobias, 1991; Arem, 1993). Let these feelings be addressed by the group while they are working the problem.

8) Directly teach students within the first two weeks of class:

a. Use Facing the Myths of Mathematics (National Research Council, 1991),

b. Collect a mathematics history of the classes the student had in high school and his or her thoughts/feelings about each class. Ask what he or she expects for this class?

c. Explain to students the importance of mathematics as a "filter" to career choices.

d. Explain how to study for the class, tests and what it takes to succeed.

e. Suggest how to get the most from the textbook and other resource materials.

f. Explain how to structure study groups or tutoring teams. Realize that female students work better with only females in their group. Interaction with faculty members was found to have a negative relationship with women's math self-confidence (Sax, 1992).
g. Define failure as improving ability (Wambach, 1993). Students who are not succeeding need alternatives so they can stay in a math class.
h. Have group-building exercises such as Name Toss (Benander, Cavanaugh, Rubenzahl, 1990; Rohnke, C. 1984) to break down asocial attitude about mathematics.

9) Consider that whatever contributes to the student's grade will be what he or she values. Consider the following in the evaluation:
   a. Externally monitoring the pairs or groups.
   b. Testing for understanding and reasoning processes in word problems, and maybe even asking for qualitative problem descriptions rather than an answer (Heller & Hungate, 1985)
   c. Having students in groups check one another's homework.

*Faculty Teaching Majors*

1) Interest students in mathematics education research or in internships that link students to career opportunities.
2) Track graduating majors to identify the next step in their careers and how to ease the transition.
3) Create long term projects that link one or more faculty member to one or several students working on an unsolved mathematically oriented problem that comes situations similar to those the graduates have been facing. (National Research Council, 1991).

4) Look at innovative calculus courses from several sources such as University of Illinois or the NSF Calculus Initiative that stress the use of technology on useful topics in a lab based setting.

*Department*

1) Value faculty members who are interested in research in undergraduate education.
2) Don't teach remedial or low level mathematics classes at 8:00. In fact, any classes taught at 8:00 should be carefully reviewed.
3) Realize that the way you teach mathematics is conducive for the IJ learning style, which represents a small segment of the students (14%) being taught mathematics.
4) Limit class size to 25 students so that more group learning can take place.
5) Instead of Math 100, have a two semester course that covers Math 111 concepts at a slower pace. Let unsuccessful Math 111 students into these classes as needed.
6) Have retreats for all departmental faculty members at the end and the beginning of the academic year that make improvement of mathematics education a valued topic of conversion.
7) Set specific educational goals consistent with academic standards, the college mission statement and students' educational and career aspirations.
8) Make departmental meetings long enough so that everyone knows what is working and not working in the teaching of their classes. These issues should be resolved not left hanging.

9) Have departmental seminars that invite speakers to address certain issues in the teaching of undergraduate mathematics.

10) Consider a mandatory placement (Askt, G. & Hirsch, L. 1991) of students into mathematics classes based on research using discriminant function that successfully classifies students based on a Freshmen Placement Test, high school performance variables and motivational factors. Constantly monitor and update as needed.

11) Be aware of the changes in K-12 mathematics curriculum, pedagogy, assessment practices and their effects on entering freshmen and implications for our undergraduate mathematics curriculum.

12) Ask other departments what mathematical skills each needs for success of their majors and incorporate these into mathematics classes.

13) Use textbooks that teach heuristics (Polya, 1945) and stress problem solving and technical writing.

14) Look at every course and see what alternatives you can give struggling student so that they do not drop out of mathematics classes.

15) Consider quantitative reasoning classes in a format similar as the Science 2000. A suggested format developed by Mount Holyoke is a collection of case studies allowing students to develop an appreciation of graphical techniques, approximation methods, complex processes, developing and testing hypotheses. By using a combination of lectures, laboratory sessions and small discussion groups, students worked on case studies. Good examples for this type of class could be: Measuring and Modeling Difference: Aptitude and Achievement; and Rates of Change: Population and Resources, Predation and Disease (National Research Council, 1991, p. 15).

16) Use standards to develop good instruction. Consider the model put together by the University of Wisconsin (Newman & Wehlage, 1993). Judge each lesson by these Five Standards of Instruction:

| | | |
|---|---|---|
| | **1. Higher-Order Thinking** | |
| lower-order thinking only | 1 2 3 4 5 | higher-order thinking is central |
| | **2. Depth of Knowledge** | |
| knowledge is shallow | 1 2 3 4 5 | knowledge is deep |
| | **3. Connectedness to the World** | |
| no connection | 1 2 3 4 5 | connected |
| | **4. Substantive Conversation** | |
| no substantive conversation | 1 2 3 4 5 | high-level substantive conversation |
| | **5. Social Support for Student Achievement** | |
| negative social support | 1 2 3 4 5 | positive social support |

*College*

1) Reward extra work that faculty undertake in working with underprepared students.
2) Reward teacher productivity and excellence.
3) Diversify the faculty role to include encouraging undergraduate research and writing.
4) Create faculty development programs that enhance faculty vitality and the quality of student learning. There is a particular need to discuss difficult issues such as multiculturalism, race, gender, ethnicity, and sexual orientation. (Frederick, 1993).
5) Encourage multidisciplinary teaching and undergraduate research projects. (#1-#5, Astin, 1993)

6) Help faculty transform a course into a super course by the following means:
   a. Have more flexibility in scheduling. You can't solve problems in a fifty-minute class that meets M W F.
   b. Give faculty the right to fail when attempting to design better courses. Support faculty about student complaints (Blackburn, 1993).

7) Help each faculty member grow by:
   a. Being sensitive to negative career events. (Perhaps related to their faculty colleagues or lack of support.)
   b. Placing a premium on individual growth.
   c. Providing diverse opportunities that individuals can exploit to grow as teachers, scholars or researchers (Finkelstein, 1993).

8) Prevent faculty from being isolated from each other and from themselves by
   "--their individual interests,
   --their departments,
   --their crowded time schedule,
   --the physical distances,
   --the psychological distances,
   --the absence of a culture of conversation, and
   --the belief that their welfare depends on the work they do in isolation of one another" (Frederick, 1993).

9) Build collegiality through contact, conversations and community:
   a. Change conversations toward more collegial affirmations of the value of faculty lives and work.
   b. Connect faculty development programs to the institutional mission and culture.
   c. Do not let student evaluations can be injurious to the mission of quality learning and teaching; shift from summative sorting purposed to formative developmental purposes.
   d. Use classroom research, assessment or feedback to find out what students have learned and let this be the focus of development for faculty and students. (Frederick, 1993)

## BIBLIOGRAPHY


Arem, C. (1993). Conquering math anxiety: A self-help workbook. Pacific Grove, CA: Brooks/Cole.

Askt, G., & Hirsch, L. (1991). Selected studies in math placement. Review of Research in Developmental Education, 8 (4), 3-6.

Astin, A. (1993). What matters in college? San Francisco, CA: Jossey-Bass.

Astin, H. S. (1993). Responsive faculty or responding to student needs. In M. Weimer (Ed.), Faculty as teachers: Taking stock of what we know (pp. 5-11). Park, PA: National Center on Postsecondary Teaching, Learning and Assessment.

Benandez, L., Cavanaugh, L. & Rubenzahl, I. (1990). Ideas in practice: A new equation in developmental mathematics. Journal of Developmental Education, 14 (1), 26-28.

Betz, N. E. (1987). Use of discriminant analysis in counseling psychology research. Journal of Counseling Psychology, 34 (4), 393-403.

Blackburn, R. T. (1993). Faculty at work. In M. Weimer (Ed.), Faculty as teachers: Taking stock of what we know (pp. 25-31). Park, PA: National Center on Postsecondary Teaching, Learning and Assessment.

Clute, P. S. (1984). Mathematics anxiety, instructional method, and achievement in a survey course in college mathematics. Journal for Research on Mathematics Education, 15 (1), 50-58.

Cole, N. S. (1990). Conceptions of educational achievement. Educational Research, 19 (3), 2-7.

Davidson, N., & Kroll, D. L. (1991). An overview of research on cooperative learning related to mathematics. Journal for Research in Mathematics Education, 22 (5), 362-365.

Demana, F., Waits, B. K., & Clemens, S. R. (1992). College algebra & trigonometry. Reading, MA: Addison-Wesley Publishing Company.

Denzin, N. (1989). The research act: A theoretical introduction to sociological method (3rd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Eisenhart, M., & Borko, H. (1993). Designing classroom research: Themes. issues and struggles. Boston, MA: Allyn and Bacon.

Ethington, C.A., & Wolfle, L. M. (1986). A structural model of mathematics achievement for men and women. American Educational Research Journal, 23(1), 65-75.

Fennema, E. & Sherman, J. (1976). Fennema-Sherman mathematics attitudes scales. JSAS: Catalog of selected documents in psychology, 6(1), 31. (MS. No. 1225).

Finkelstein, M. J. (1993). The power of 'colleagues' and 'campuses' in promoting faculty development as teachers. In M. Weimer (Ed.), Faculty as teachers: Taking stock of what we know (pp. 53-55). Park, PA: National Center on Postsecondary Teaching, Learning and Assessment.

Fish, R. S. (1984). An investigation of the relationships between the four topological dimensions of the Myers-Briggs Type Indicator and achievement in selected courses at the community college level. Doctoral dissertation, Virginia Polytechnic and State University, Blacksburg.

Frederick, P. (1993). Faculty stories: Conversations for collegiality. In M. Weimer (Ed.), Faculty as teachers: Taking stock of what we know (pp.57-61). Park, PA: National Center on Postsecondary Teaching, Learning and Assessment.

Garofalo, J. (1990). What mathematical compentencies are needed for success in college. Research & Teaching in Developmental Education, 7 (1), 75-84.

Garofalo, J. & Lester, F. Jr. (1985). Metacognition, cognitive monitoring, and mathematical performance. Journal for Research in Mathematics Education, 16 (2), 163-176.

Goldman, R. D., & Hewitt, B. N. (1976). The Scholastic Aptitude Test "explains" why college men major in science more often than college women. Journal of Counseling Psychology, 23 (1), 50-54.

Gose, B. (1994). More jobs? Liberal-arts graduates still find prospects dim. The Chronicle of Higher Education, 40 (37), A28 & A 30.

Gougeon, D. (1984). CEEB SAT mathematics scores and their correlation with college performance in math. Educational Research Quarterly, 9 (2), 8-11.

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

Hart, L. C. (1993). Some factors that impede or enhance performance in mathematical problem solving. Journal for Research in Mathematics, 24 (2), 167-171.

Heller, J. I. & Hungate, H. N. ( 1985). Research on scientific problem solving. In E. A. Silver (Ed.), Teaching and learning mathematical problem-solving: Multiple research perspectives (pp. 105-110). Hillsdale, NJ: Lawrence Erlbaum Associates.

Jensen, G. H. (1987). Learning styles. In J. A. Provost & S. Anchors (Eds.), Applications of the Myers-Briggs Type Indicator in higher education (pp. 181-206). Palo Alto, CA: Consulting Psychological Press.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1991). Cooperative learning: Increasing college faculty instructional productivity. ASHE-ERIC Higher Education Report no. 91-1. Washington, DC: Association for the Study of Higher Education.

Johnson, R. A. & Wichern, D. W. (1992). Applied multivariate statistical analysis. Englewood Cliffs, NJ: Prentice Hall.

Kalsbeek, D. (1987). Campus retention: The MBTI in institutional self-studies. In J. A. Provost & S. Anchors (Eds.), Applications of the Myers-Briggs Type Indicator in higher education (pp. 31-63). Palo Alto, CA: Consulting Psychological Press.

Keirsey, D., & Bates, M. (1987). Please understand me. Del Mar, CA: Promethean Books.

Kloosterman, P., & Stage, F. K. (1992). Measuring beliefs about mathematical problem solving. School Science and Mathematics, 92, 109-115.

Kogelman, E., & Warren, J. (1978). Mind over math. New York, NY: McGraw-Hill.

Lawrence, G. (1984). A synthesis of learning style research involving the MBTI. Journal of Psychological Type, 8, 2-14.

Leitze, A. R. (1994, April). Beliefs about mathematics, mathematics teaching, and mathematics learning in manipulative-based mathematics content courses: A summary. Paper presented at the meeting of the National Council of Teachers of Mathematics, Indianapolis, IN.

Leitze, J. R. (Ed.). (1994). Charting directions for research in collegiate mathematics education. Washington, DC: Mathematical Association of America.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1986). Self-efficacy in the prediction of academic performance and perceived career options. Journal of Counseling Psychology, 33 (3), 265-269.

Lester, F. K & Charles, R. L. (1991). A framework for research on problem-solving instruction. In J. P. Ponte, J. M. Matos & D. Ferandes (Eds.). Mathematical problem solving and new information technologies (pp. 1-15). NATO ASI Series F Vol. 89. Berlin: Springer-Verlag.

Lichtenberg, J. (1994). Publishers, professors and the importance of textbooks. The Chronicle of Higher Education, 40 (37), A48.

Llabre, M. M., & Suarez, E. (1985). Predicting math anxiety and course performance in college women and men. Journal of Counseling Psychology, 32 (2), 283-287.

Lockhead, J. (1985). Teaching analytical reasoning through pair problem solving. In J. W. Segal, S. F. Chipman & R. Glaser (Eds.)., Thinking and Learning Skills, Volume 1 (pp.109-131). Hillsdale, NJ: Lawrence Erlbaum Associates.

McCaulley, M. & Natter, F. L. (1974). Psychological (Myers-Briggs) Type differences in education. Gainesville, FL: Center for Applications of Psychological Type.

McCutcheon, J.W., Schmidt, C.P., & Bolden, S. H. (1991). Relationships among selected personality variables, academic achievement and student teaching behavior. Journal of Research and Development in Education, 24 (3), 38-44.

Miller, J.D., Suchner, R. W., Hoffer, T., Brown, K., & Pifer, L. (1991). LSAY codebook: Student, parent and teacher data for cohort two for longitudinal years, one, two and three (1987-1990, Vol. 2). Dekalb, IL: Longitudinal Study of American Youth, Northern Illinois University.

Murphy, S. H. (1992). Closing the gender gap. College Board Review, 163, pp. 18-25 & 36.

Myers, I. B., & McCaulley, M. H. (1985). Manual: A guide to the development and use of the Myers-Briggs Type Indicator. Palo Alto, CA: Consulting Psychologists Press.

National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: NCTM.

National Opinion Research Center. (1983). High school and Beyond 1980 sophomore cohort first follow-up (1982) data file user's manual. Washington, DC: National Center for Statistics.

National Research Council. (1991). Moving beyond myths: Revitalizing undergraduate mathematics. Washington, DC: National Academy Press.

Newman, F. M., & Wenlage, G. G. (1993). Standards of authentic instruction, Educational Leadership, 50 (7), 8-12.

Nisbet, J. A., Ruble, V. E., & Schurr, K. T. (1982). Predictors of academic success with high risk college students. Journal of College Student Personnel, 23 (3), 227-235.

Noddings, N. (1985). Small groups as a setting for research on mathematical problem solving. In E. A. Silver (Ed.), Teaching and learning mathematical problem-solving: Multiple research perspectives (pp. 83-112). Hillsdale, NJ: Lawrence Erlbaum Associates.

Pittenger, D. J. (1993). The utility of the Myers-Briggs Type Indicator. Review of Educational Research, 63 (4), 467-488.

Polya, G. (1945). How to solve it. Princeton, NJ: Princeton University Press.

Provost, J. A., Carson, B. H., & Beidler, P. G. (1987). Effective teaching and type: The words of outstanding professors. In J. A. Provost & S. Anchors (Eds.), Applications of the Myers-Briggs Type Indicator in higher education (pp.221-245). Palo Alto, CA: Consulting Psychological Press.

Reckinger, N. R. (1980). Joining hands: Using learning and teaching styles. Speech given at Indiana's University Alternative Schools Conference. (Eric Document Service N. ED 285 275).

Resnick, L. B. (1987). Learning in school and out. Educational Researcher, 16 (9), 13-20.

Reynolds, A. J., & Walberg, H. J. (1992). A process model of mathematics achievement and attitude. Journal for Research in Mathematics Education, 23 (4), 306-328.

Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. Journal of Counseling Psychology, 19, 551-554.

Rohnke, C. (1984). Silver bullets: A guide to initiative problems, adventure games, stunts and trust activities. Hamilton, MA: Project Adventure, Inc.

Sax, L. J. (1992). Self-confidence in math: How and why do men and women differ during the college years? Paper presented at the Annual Meeting of the Association for the Study of Higher Education, Minneapolis, MN. (Eric Document Reproduction Service No. ED. 352 899).

Saxe, G. B. (1988). Candy selling and math learning. Educational Researcher, 17 (6), 14-21.

Secada, W. G., & Byrd, L. (1993). School -level reform and the teaching/learning of mathematics. NCRMSE Research Review, 2 (2), 5-7 & 12.

Siegal, R. G., Galassi, J. P., & Ware, W. B. (1985). A comparison of two models for predicting mathematics performance: Social learning versus math aptitude-anxiety. Journal of Counseling Psychology, 32 (4), 531-538.

Smith, R. J., Arnkoff, D. B. & Wright, T. L. (1990). Test anxiety and academic competence: A comparison of alternative models. Journal of Counseling Psychology, 37 (3), 313-321.

Stenmark, J. K. (Ed.) (1991). Mathematics assessment: Myths, models, good questions and practical suggestions. Reston, VA: National Council of Teachers of Mathematics.

Swafford, J. O., & Kepner, H. S. (1980). The evaluation of an application-oriented first-year algebra program. Journal for Research in Mathematics Education, 11 (2), 190-206.

Thorndike-Christ, T. (1991). Attitudes toward mathematics: Relationships to mathematics achievement, gender, mathematics course-taking plans and career interest. WA: Western Washington University. (ERIC Document Reproduction Services No. ED 347 066).

Tobias, S. (1982). When do instructional methods make a difference? Educational Researcher, 11 (4), 4-9.

Tobias, S. (1991). Math mental health: Going beyond math anxiety. College Teaching, 39 (3), 91-96.

Turner, J. (1994, May 20). Girls: better grades, fewer scholarships. Roanoke Times & World-News, pp. B1 & B3.

Wambach, C. A. (1993). Motivational themes and academic success of at-risk freshmen. Journal of Development Education, 16 (3), 8-12.

Whittlesy, E. (1991). Sierra College Algebra Student Survey results. Rocklin, CA: Sierra Community College. (ERIC Document Reproduction Service No. ED 332 765).

# APPENDIX A

Initial Mathematics Student Survey

## CONSENT FORM

You are invited to participate in a study about factors that affect college mathematics achievement. This study involves learning more about what happens in the Math 111 classroom. All students taking Math 111 (approximately 170) will be involved in this study.

This project involves collecting the following information:

1. A survey measuring math attitudes, self reported information about math classes taken in high school and college and demographic information to be given the first day of class.
2. Six classroom observations of each Math 111 class taken on the weeks of Sept 20, Sept 27, Oct 4, Oct 25, Nov 1 and Nov 8.
3. Two of the above observations for each class will be videotaped.
4. Myers-Briggs Type Test which measures learning styles will be given to each student the last two weeks of class.

Your participation in the project will provide information about students taking Math 111 and help future students be successful in this class. The Myers-Briggs Test will allow you to learn more about your own learning style, useful for all your classes. After the tests have scored, the researcher and a career services officer will explain how the results affect you personally.

The results of this study will be kept strictly confidential. The information you provide will have your name removed, and only a subject number will identify you during analyses and any written reports of the research.

You are free to withdraw from this study at any time without penalty. If you wish to withdraw, your grade for Math 111 will not be affected in any way. To withdraw, contact Margaret Jamison in Garber 106 or tell your instructor.

This research project has been approved, as required, by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University, by the Department of Curriculum and Instruction and Educational Research and Evaluation. If you have any questions or comments, please call or visit Dr. Margaret Jamison (Garber 106 or Ext 384) or Dr. Jimmie Fortune at Virginia Tech (703-231-6960).

I hereby agree to voluntarily participate in the research project desribed above and under the conditions represented.

______________________________
Signature

______________________________
ID Number

**Thank you for participating!!**

______________________________
Date

*Ferrum College*
*Initial Math Student Survey*

## I. ATTITUDES ABOUT MATHEMATICS

**Circle the response that bests descibes your attitudes about mathematics.**

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| 1. Math doesn't scare me at all. | 1 | 2 | 3 | 4 |
| 2. It wouldn't bother me at all to take more math courses. | 1 | 2 | 3 | 4 |
| 3. I haven't usually worried about being able to solve math problems. | 1 | 2 | 3 | 4 |
| 4. I almost never have gotten shook up during a math test. | 1 | 2 | 3 | 4 |
| 5. I usually have been at ease during math tests. | 1 | 2 | 3 | 4 |
| 6. I usually have been at ease in math classes. | 1 | 2 | 3 | 4 |
| 7. Mathematics usually makes me feel uncomfortable and nervous. | 1 | 2 | 3 | 4 |
| 8. Mathematics makes me feel uncomfortable, restless, irritable, and impatient. | 1 | 2 | 3 | 4 |
| 9. I get a sinking feeling when I think of trying hard math problems. | 1 | 2 | 3 | 4 |
| 10. My mind goes blank and I an unable to think clearly when working mathematics. | 1 | 2 | 3 | 4 |
| 11. A math test would scare me. | 1 | 2 | 3 | 4 |
| 12. Mathematics makes me feel uneasy and confused. | 1 | 2 | 3 | 4 |
| 13. Generally I have felt secure about attempting mathematics. | 1 | 2 | 3 | 4 |

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| 14. I am sure I could do advanced work in mathematics. | 1 | 2 | 3 | 4 |
| 15. I am sure that I can learn mathematics. | 1 | 2 | 3 | 4 |
| 16. I think I could handle more difficult mathematics. | 1 | 2 | 3 | 4 |
| 17. I can get good grades in mathematics. | 1 | 2 | 3 | 4 |
| 18. I have a lot of self-confidence when it comes to math. | 1 | 2 | 3 | 4 |
| 19. I'm no good at math. | 1 | 2 | 3 | 4 |
| 20. I don't think I could do advanced mathematics. | 1 | 2 | 3 | 4 |
| 21. I'm not the type to do well in math. | 1 | 2 | 3 | 4 |
| 22. For some reason even though I study, math seems unusually hard for me. | 1 | 2 | 3 | 4 |
| 23. Most subjects I can handle OK, but I have a knack for flubbing up math. | 1 | 2 | 3 | 4 |
| 24. Math has been my worst subject. | 1 | 2 | 3 | 4 |
| 25. I like math puzzles. | 1 | 2 | 3 | 4 |
| 26. Mathematics is enjoyable and stimulating to me. | 1 | 2 | 3 | 4 |
| 27. When a math problem arises that I can't immediately solve, I stick with it until I have the solution. | 1 | 2 | 3 | 4 |
| 28. Once I start trying to work on a math puzzle, I find it hard to stop. | 1 | 2 | 3 | 4 |
| 29. When a question is left unanswered in math class, I continue to thing about it afterward. | 1 | 2 | 3 | 4 |
| 30. I am challenged by math problems I can't understand immediately. | 1 | 2 | 3 | 4 |
| 31. Figuring out mathematical problems does not appeal to me. | 1 | 2 | 3 | 4 |
| 32. The challenge of math problems does not appeal to me. | 1 | 2 | 3 | 4 |

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| 33. Math puzzles are boring. | 1 | 2 | 3 | 4 |
| 34. I don't understand how some people can spend so much time on math and seem to enjoy it. | 1 | 2 | 3 | 4 |
| 35. I would rather have someone give me the solution to a difficult math problem than to have to work it out for myself. | 1 | 2 | 3 | 4 |
| 36. I do as little work in math as possible. | 1 | 2 | 3 | 4 |

## II. MATH PREPAREDNESS

**We need to gather information about previous classes you have taken in high school and college. Please answer the following questions.**

1. How did you do in your math classes in high school? *(check the appropriate box)*

| | A | B | C | D | F | Didn't take |
|---|---|---|---|---|---|---|
| Pre-Algebra | | | | | | |
| Algebra I | | | | | | |
| Geometry | | | | | | |
| Algebra II | | | | | | |
| Consumer Math | | | | | | |
| Math Analysis | | | | | | |
| Algebra III | | | | | | |
| Advanced Math | | | | | | |
| Trigonometry | | | | | | |
| Calculus | | | | | | |
| Other *(list)* ______________ | | | | | | |

2. Did you take a math class in your senior year? Yes ______ No ______

3. Have you taken any math classes in college? Yes ______ No ______

If you answered yes to question 3, then please answer questions 4-8. If you answered no, then skip questions 4-8 and answer the questions requesting background information.

4. What college math classes have you taken?
math 101 ____ math 102 ____math 100 ____ math 111 ____
other *(list)* ____________________

5. What grade did you receive in this math class?
math 101 ____ math 102 ____math 100 ____ math 111 ____
other *(list)* ____________________

6. Have you skipped any semesters since taking your last math class? Yes ____ No ____

7. If so, how many semesters have you skipped? _______

8. If you have skipped any semester, why have you done so?

## III. BACKGROUND INFORMATION

**Choose only one answer for each of the following questions.**

1. In which area do you think your strongest interest lie?
   - Humanities/Fine Arts/English ________
   - Liberal Arts ________
   - Social Sciences/History ________
   - Business/Management/Accounting ________
   - Biology/Environmental Sci/Pre-Prof Sci ________
   - Computer Sci/Math/Engineering ________

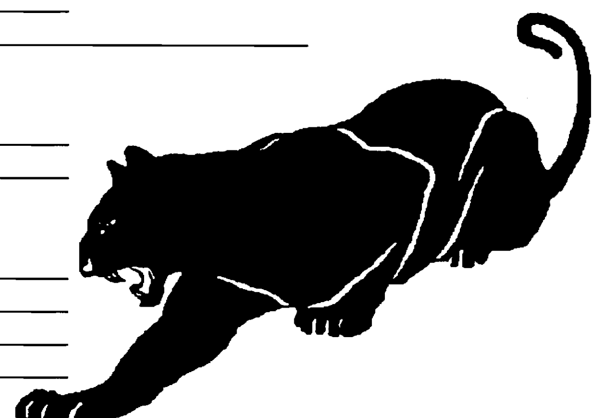
2. If you have declared a major, what is it?
________________________

________________________

3. What is your ethnic heritage?
   - American Indian ________
   - Asian or Pacific Islander ________
   - African American ________
   - Caucasian ________
   - Hispanic ________
   - Other (list) ________________________

4. What is your gender?
   - male ________
   - female ________

5. What is your student classification?
   - Freshmen ________
   - Sophomore ________
   - Junior ________
   - Senior ________



*Thank you for your time and cooperation!*
*Best of Luck for the Fall Semester!*

# APPENDIX B

Sample Report Form for Myers-Briggs TI

# REPORT FORM

Name: ____________________

Gender: ☐ Male ☐ Female Date: ____________

The MBTI* reports your preferences on four scales. There are two opposite preferences on each scale. The four scales deal with where you like to focus your attention (E or I), the way you like to look at things (S or N), the way you like to go about deciding things (T or F), and how you deal with the outer world (J or P). Short descriptions of each scale are shown below.

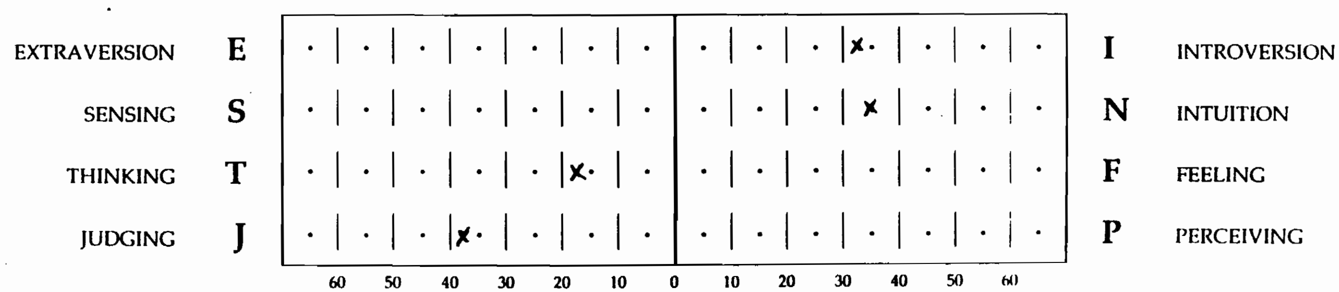
| | | | | |
|---|---|---|---|---|
| E | You prefer to focus on the outer world of people and things | or | I | You prefer to focus on the inner world of ideas and impressions |
| S | You tend to focus on the present and on concrete information gained from your senses | or | N | You tend to focus on the future, with a view toward patterns and possibilities |
| T | You tend to base your decisions on logic and on objective analysis of cause and effect | or | F | You tend to base your decisions primarily on values and on subjective evaluation of person-centered concerns |
| J | You like a planned and organized approach to life and prefer to have things settled | or | P | You like a flexible and spontaneous approach to life and prefer to keep your options open |

The four letters show your Reported Type, which is the combination of the four preferences you chose. There are sixteen possible types.

REPORTED TYPE: I N T J

PREFERENCE SCORES: 33 35 17 37

Preference scores show how consistently you chose one preference over the other; high scores usually mean a clear preference. Preference scores do *not* measure abilities or development.




Each type tends to have different interests and different values. On the back of this page are very brief descriptions of each of the sixteen types. Find the one that matches the four letters of your Reported Type and see whether it fits you. If it doesn't, try to find one that does. For a more complete description of the types and their implications for career choice, relationships, and work behavior, see *Introduction to Type* by Isabel Briggs Myers. Remember that everyone uses each of the preferences at different times; your Reported Type shows which you are likely to prefer the most and probably use most often.

CPP Consulting Psychologists Press, Inc. ■ 3803 E. Bayshore Road ■ Palo Alto, California 94303

6834

## Characteristics frequently associated with each type

| | Sensing Types | | Intuitive Types | |
|---|---|---|---|---|
| Introverts | **ISTJ**<br>Serious, quiet, earn success by concentration and thoroughness. Practical, orderly, matter-of-fact, logical, realistic, and dependable. See to it that everything is well organized. Take responsibility. Make up their own minds as to what should be accomplished and work toward it steadily, regardless of protests or distraction. | **ISFJ**<br>Quiet, friendly, responsible, and conscientious. Work devotedly to meet their obligations. Lend stability to any project or group. Thorough, painstaking, accurate. Their interests are usually not technical. Can be patient with necessary details. Loyal, considerate, and concerned with how other people feel. | **INFJ**<br>Succeed by perseverance, originality, and desire to do whatever is needed or wanted. Put their best efforts into their work. Quietly forceful, conscientious, concerned for others. Respected for their firm principles. Likely to be honored and followed for their clear convictions as to how best to serve the common good. | **INTJ**<br>Usually have original minds and great drive for their own ideas and purposes. In fields that appeal to them, they have a fine power to organize a job and carry it through with or without help. Skeptical, critical, independent, determined, and sometimes stubborn. Must learn to yield less important points in order to win the most important. |
| Introverts | **ISTP**<br>Cool onlookers—quiet, reserved, observing and analyzing life with detached curiosity and unexpected flashes of original humor. Usually interested in cause and effect, how and why mechanical things work, and in organizing facts using logical principles. | **ISFP**<br>Retiring, quietly friendly, sensitive, kind, modest about their abilities. Shun disagreements and do not force their opinions or values on others. Usually do not care to lead but are often loyal followers. Often relaxed about getting things done, because they enjoy the present moment and do not want to spoil it by undue haste or exertion. | **INFP**<br>Full of enthusiasms and loyalties, but seldom talk of these until they know you well. Care about learning, ideas, language, and independent projects of their own. Tend to undertake too much, then somehow get it done. Friendly, but often too absorbed in what they are doing to be sociable. Little concerned with possessions or physical surroundings. | **INTP**<br>Quiet and reserved. Especially enjoy theoretical or scientific pursuits. Like solving problems with logic and analysis. Usually interested mainly in ideas, with little liking for parties or small talk. Tend to have sharply defined interests. Need careers where some strong interest can be used and be useful. |
| Extraverts | **ESTP**<br>Good at on-the-spot problem solving. Do not worry, enjoy whatever comes along. Tend to like mechanical things and sports, with friends on the side. Adaptable, tolerant, generally conservative in values. Dislike long explanations. Are best with real things that can be worked, handled, taken apart, or put together. | **ESFP**<br>Outgoing, easygoing, accepting, friendly, enjoy everything and make things more fun for others by their enjoyment. Like sports and making things happen. Know what's going on and join in eagerly. Find remembering facts easier than mastering theories. Are best in situations that need sound common sense and practical ability with people as well as with things. | **ENFP**<br>Warmly enthusiastic, high-spirited, ingenious, and imaginative. Able to do almost anything that interests them. Quick with a solution for any difficulty and ready to help anyone with a problem. Often rely on their ability to improvise instead of preparing in advance. Can usually find compelling reasons for whatever they want. | **ENTP**<br>Quick, ingenious, good at many things. Stimulating company, alert, and outspoken. May argue for fun on either side of a question. Resourceful in solving new and challenging problems, but may neglect routine assignments. Apt to turn to one new interest after another. Skillful in finding logical reasons for what they want. |
| Extraverts | **ESTJ**<br>Practical, realistic, matter-of-fact, with a natural head for business or mechanics. Not interested in subjects they see no use for, but can apply themselves when necessary. Like to organize and run activities. May make good administrators, especially if they remember to consider others' feelings and points of view. | **ESFJ**<br>Warm-hearted, talkative, popular, conscientious, born cooperators, and active committee members. Need harmony and may be good at creating it. Always doing something nice for someone. Work best with encouragement and praise. Main interest is in things that directly and visibly affect people's lives. | **ENFJ**<br>Responsive and responsible. Generally feel real concern for what others think or want, and try to handle things with due regard for other people's feelings. Can present a proposal or lead a group discussion with ease and tact. Sociable, popular, and sympathetic. Responsive to praise and criticism. | **ENTJ**<br>Hearty, frank, decisive, leaders in activities. Usually good at anything that requires reasoning and informed talk, such as public speaking. Are usually well informed and enjoy adding to their fund of knowledge. May sometimes appear more positive and confident than their experience in an area warrants. |

Copyright © 1988 by Peter B. Myers and Katharine D. Myers. All rights reserved. No portion of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the Publisher. Printed in the United States of America.

Twenty-third printing, 1993.

*Myers-Briggs Type Indicator* and MBTI are registered trademarks of Consulting Psychologists Press, Inc.

INTJ
Introvert, Intuitive, Thinking, Judging

*Brief Personality Description*

INTJs are perfectionists. Their fierce independence and strong need for personal competence, as well as their unshakeable faith in their own original ideas, drives them to achieve their goals. Logical, critical, and ingenious, INTJs can see the consequences of the application of new ideas and live to see systems translated into reality. They are demanding with themselves and others, and are not particularly bothered by indifference or criticism. INTJs are usually skeptical, decisive, and determined in the face of opposition.

With original minds, and great insight and vision, INTJs are good brainstormers and work well with global concepts. They are good strategic thinkers and can usually see with clarity the benefits and flaws of any situation. In subjects that interest them, they are fine organizers and can invest incredible concentration, energy, and drive. They will persevere through a minutia of details to reach or exceed their high standrds.

INTJs represent approximately 1% of the American population.

*Possible Blindspots*

Because INTJs value their own visions and ideas for the future so highly, they are vulnerable to missing some important realities of the present moment. They may fail to recognize practical weaknesses in their ideas, which may make their execution more difficult. INTJs may need to simplify their often theoretical and complicated ideas so they can communicate them to others.

INTJs may lack understanding of how their behavior affects others and can be critical and blunt, often not encouraging others to challenge their views or express any personal feelings. Because INTJs have a rather impersonal style, they may erroneously assume others wish to be treated in the same manner. They need to learn to accept the seemingly "illogical" feelings of others as valid. This will help them from alienating and offending those around them.

*Popular Occupations*

Some occupations that offer potential for satisfaction include (but are not limited to) the following:

| | | |
|---|---|---|
| Scientist/scientific researcher | Manager | Astronomer |
| Computer systems analyst | Judge | Computer |
| Computer programmer | News writer | News analyst |
| Technician: electrical/electronic | Psychologist | Design Engineer |
| Environmental planner | Psychiatrist | Administrator |
| Teacher: university | Neurologist | Architect |
| Investment/business analyst | Cardiologist | Engineer |
| Biomedical engineer | Pharmacologist | Writer/editor |
| Attorney: litigator/commercial | Inventor | Artist |
| Management consultant | Strategic planner | Designer |

*Recommendations for the Job Search*

Pathways to success for INTJs include using their abilities to:

* Anticipate trends, forecast future needs
* Synthesize complicated information
* Create their own career options; design their own job
* Develop an innovative career plan
* Make logical decisions and be persistent

## APPENDIX C

Problem-Solving Test

## Problem-Solving Test

1. Circle J Ranch wants to enclose a rectangular paddock using 600 feet of fence.
   a) Draw a picture of this paddock label both sides with one side being x.

   b) Write an algebraic expression for the area of the paddock.

   c) Graph the expression from part b) and place below includidng the grapher's range.

   d) What are the dimensions of the paddock that will have the maximum area?

2. The senior class wants to sell screen-printed T-shirts to make money for spring fling. They have $84.00 fixed costs (gasoline, cost of printing etc). They can buy each T-shirt for $4.75 and are going to sell them for $12.00 each.
   a) If Profits = Revenues - Costs, write an algebraic expression for profits where x is the number of t-shirts sold.

   b) Graph the expression for profits and place below including the grapher's range.

c) How many T-shirts must be sold to break even?

d) How many T-shirts must be sold to make at least $200 profit?

e) Write your solutions for a-d in paragraph form communicating clearly and completely the steps you took.

3. The Jones have $22,000 to invest. They have chosen two types of investments, one at 7% interest (which has a penalty for early withdrawal) and another at 3% (no penalty).
   a) Write an algebraic expression to describe the total interest the Jones would receive at the end of one year with x represented the amount invested at 7%.

   b) Draw a graph for part a) and place below.

c) If the Jones received $990 interest after one year, how much was invested at each rate?

4. Northwest Manufacturing Company frequently has an out-of-town visitor who needs a car for getting around town. Northwest obtains a car for the visitor by making use of one of two rental agencies. Cheap Car Rental Company charges an initial $32 and ~~the~~ $.27/mi. Rent-a-Lemon charges $28 and ~~the~~ $.30/mi. The company is trying to come up with a policy to decide when it would be cheaper to use one agency and when it would be cheaper to use the other.

   a) Write an algebraic expression that relates cost to x the number of miles that the rental car will be driven.

   b) Draw a graph for each rental agency on the same axes. Include the grapher's range.

   c) At what distance would the charges be equal?

   d) What should be the rental policy for Northwest Manufacturing Company? Write clearly so employees of the company can understand your policy.

# APPENDIX D

## Algebra Skills Final Examination

ALGEBRA SKILLS FINAL EXAMINATION

CARRY OUT THE INDICATED OPERATIONS AND/OR SIMPLIFY.

$\frac{25-10x+x^2}{x^2 - 25}$ $(x^{-4}y^{-6})^{-1/2}$ $(2x - 3)(-3x + 4)$ $(27)^{2/3}$ $4^{-3/2}$

$\frac{x^2}{x-3} - \frac{9}{x-3}$ $\frac{x^2 - 4}{5xy+10y} \cdot \frac{5x^2y}{3x^2-6x}$ $\frac{1}{x-2} + \frac{2}{x+2} - \frac{3}{x^2-4}$ $\frac{x^3}{x^{-5}} -2$

SOLVE

$3x - 4 = 8$ $x^2 - 8 = 0$ $x^2 - 3x + 2 = 0$

$2(x - 3) < 5x - 9$ $|x - 3| < 5$ $|2x + 1| \geq 7$

Find the slope-intercept equation of the line:

| | | |
|---|---|---|
| thru $(-3,2)$ & $(1,10)$; | thru $(2,-3)$ parallel; to $3x + y = 17$ | thru $(1,0)$ perpendicular. to $y = (1/4)x + 1993$ |

Find the distance between $(-3,-1)$ and $(2,-13)$. Find the midpoint of the line segment joining these points.

Write a function which results from applying a vertical shrink by a factor of 1/2, a horizontal shift of -3, and a vertical shift of 4, in that order, to the function $y = x^2$.

Find, to two decimal places, the only real solution to the equation: $x^3 - x - 1 = 0$.

Let $f(x) = 2x - 3$ and $g(x) = x^2 + 1$. Find:

$f(-1)$ $\quad$ $g(-3)$ $\quad$ $f(g(2))$ $\quad$ $g(f(3))$ $\quad$ $f(g(x))$

Sketch the graph. Label all intercepts, local minimums, and local maximums.

$y = |x + 2|$

$y = \sqrt{3 - x} + 2$

$y = x^2 - 3x - 10$

$y = x^3 - 3x + 2$

## APPENDIX E

Final Mathematics Student Evaluation

# *Final Mathematics Student Evaluation*

(Please remember that the pledge of confidenciality is still in effect. None of your responses will be shared with anyone without your permission. Used for research purposes only.)

Name ______________________ Teacher ______________________

Social Sec # ______________________ Class Time ______________________

**Circle the response that best describes your answer to the following statements.**

**I. TEACHER EVALUATION**

| *About your math teacher:* | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| 1. Communicates enthusiasm for subject matter and teaching. | 1 | 2 | 3 | 4 |
| 2. Uses instructional time effectively. | 1 | 2 | 3 | 4 |
| 3. Implements learning activities in a logical sequence. | 1 | 2 | 3 | 4 |
| 4. Uses examples to clarify difficult concepts or content. | 1 | 2 | 3 | 4 |
| 5. Makes changes based on criticism. | 1 | 2 | 3 | 4 |
| 6. Senses when students do not understand material. | 1 | 2 | 3 | 4 |
| 7. Tailors instruction to students with varying interests. | 1 | 2 | 3 | 4 |

**II. SELF-CONFIDENCE IN MATHEMATICS**

| *About yourself as a math student:* | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| 1. Generally I have felt secure about attempting mathematics. | 1 | 2 | 3 | 4 |
| 2. I am sure I could do advanced work in mathematics. | 1 | 2 | 3 | 4 |
| 3. I am sure that I can learn mathematics. | 1 | 2 | 3 | 4 |
| 4. I think I could handle more difficult mathematics. | 1 | 2 | 3 | 4 |
| 5. I can get good grades in mathematics. | 1 | 2 | 3 | 4 |

(OVER)

| | | | | |
|---|---|---|---|---|
| 6. I have a lot of self-confidence when it comes to math. | 1 | 2 | 3 | 4 |
| 7. I'm no good at math. | 1 | 2 | 3 | 4 |
| 8. I don't think I could do advanced mathematics. | 1 | 2 | 3 | 4 |
| 9. I'm not the type to do well in math. | 1 | 2 | 3 | 4 |
| 10. For some reason even though I study, math seems unusually hard for me. | 1 | 2 | 3 | 4 |
| 11. Most subjects I can handle OK, but I have a knack for flubbing up math. | 1 | 2 | 3 | 4 |
| 12. Math has been my worst subject. | 1 | 2 | 3 | 4 |

## III. YOUR OWN STUDY HABITS

| *About yourself as a math student:* | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| 1. I keep up with my homework. | 1 | 2 | 3 | 4 |
| 2. When studying for a test, I wait till the night before to start studying. | 1 | 2 | 3 | 4 |
| 3. I read each assigned section in my math book. | 1 | 2 | 3 | 4 |
| 4. If I can't work a problem, I wait for the teacher to work it for me. | 1 | 2 | 3 | 4 |

5. How many average hours do you study before coming to each math class? ________________

6. How many times have you been absent this semester in math class? ____________________

7. If you have missed math class, what are your reasons? ___________________________________

_______________________________________________________________________________

## IV. PERSONAL STATEMENT

Have you been satisfied with your Math 111 class? Why or Why not?

# VITA

*Margaret Godwin Jamison* was born February 29, 1948, in Lake Charles, Louisiana. She attended schools in Calcasieu parish until she was thirteen when she moved to Florida with her family. She graduated with honors from Boca Ciega High School in St. Petersburg, Florida in 1966. In 1968, Margaret received an Associate of Arts degree with honors from St. Petersburg Junior College. In 1970, she received a Bachelor of Science in Laboratory Animal and in 1972, she received a Master of Science in Animal Breeding from the University of Florida at Gainesville. Margaret continued her schooling by moving to Blacksburg, Virginia to work on a Ph. D in an Interdepartmental Genetics program and completed this degree in 1976 publishing a dissertation on the Genetic Architecture of Reproduction and Growth Traits in Laboratory Mice.

She was married in 1973 to Jerry Wayne Jamison, who completed a Master's degree in Dairy Science that same year. After graduation in 1976, she and Jerry started a dairy business. In 1977, their first child, Judith, was born and in 1979, their second child, Jeffrey, was born. January 1979, the couple, their two children, and dairy herd moved back to Franklin county, Virginia, the birthplace of Jerry Jamison and bought a dairy farm in Glade Hill, Virginia.

In 1986, Margaret Jamison returned to Virginia Tech part-time to complete the classes necessary to be certified in secondary education in mathematics and biology. After completing the courses in 1989, Margaret was hired in the Mathematical and Computer Sciences department at Ferrum College. She has worked hard in implementing the use of the graphics calculator into the mathematics and statistics classrooms. In her computer literacy classes, she has stressed use of hands-on activities. During 1989 through 1991, she was a part-time Institutional Research officer with an emphasis on statistical computing. In 1991, Margaret received a National Science Foundation planning grant on "Shaping 7th grade Mathematics in an Information Society." After NSF reviewers suggested that her degree was not appropriate for educational grants, in 1992 she entered the doctoral program at Virginia Tech in the area of Educational Research and Evaluation. In 1994, she completed her Ph.D. and continues as an assistant professor of mathematics at Ferrum College.

Margaret has published an article in NASSP on a "Generic Model for School Effectiveness." She is active member in AERA, ISTE and AACE. In the summer of 1993, Margaret won honorable mention in the 1993 SIG/Tel Telecomputing contest. Her academic interests are teaching of statistics as applied data analysis, teaching integrated software useful for students in both academics and their careers, teaching telecommunications as an information service to college students and implementing reform into the college mathematics classroom.

Margaret G. Jamison

Margaret G. Jamison