Characteristics of adult students in introductory calculus
by Kevin Wayne Trutna

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University

Abstract:
The characteristics of adult students enrolled in Math 181, Calculus & Analytic Geometry I, at Montana State University were studied. All students over 25 years of age who took Math 181 between the fall quarter of 1988 and the spring quarter of 1991 were included. The purpose of this study was to identify selected factors that combined to influence achievement in calculus. The effectiveness of the placement examination and developmental courses was also studied.

Seven biographical variables were gathered from the school records of the 277 adults included in this study. A discriminant analysis searched for a combination of these factors that could discriminate between successful and unsuccessful students in introductory calculus. Interviews were also conducted to determine what other factors also influenced an adult's calculus grade.

Three variables combined to discriminate between successful and unsuccessful calculus students. These were the number of developmental mathematics courses, the student's grade point average, and the percentage of students that an instructor passed during the quarter. Students who did not take developmental courses passed calculus at a significantly higher rate than those students who enrolled in the developmental program. Interviews indicated that adults felt that they lacked significant algebra skills. They usually returned to college after a major life change such as a divorce, birth of a child, or loss of a job. They do not have a significant amount of time to devote to their studies. In addition, adults rarely used the placement examination.

Because the discriminant analysis only improved group prediction by about 10%, it is concluded that other factors should be included in advising adults when they enroll in college. Academic records should not serve as the sole placement criteria for an adult's course load. In addition, the algebra courses should have similar objectives as the calculus sequence. The placement procedure should be redesigned so it is useful for adults and so that it does not discriminate against students . who have been out of school for a number of years.

CHARACTERISTICS OF ADULT STUDENTS IN INTRODUCTORY CALCULUS

by

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APPROVAL

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Kevin Wayne Trutna

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

The characteristics of adult students enrolled in Math 181, Calculus & Analytic Geometry I, at Montana State University were studied. All students over 25 years of age who took Math 181 between the fall quarter of 1988 and the spring quarter of 1991 were included. The purpose of this study was to identify selected factors that combined to influence achievement in calculus. The effectiveness of the placement examination and developmental courses was also studied.

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CHAPTER 1

INTRODUCTION

Introduction

The student population in American universities has undergone a significant change over the past 20 years. Older, nontraditional aged students over the age of 25 have increased faster than the other segments of the student population. In 1974, older students made up about 25% of the undergraduate population, and this number jumped to one-third by 1980 (Elliot, 1990, p. 160; Kasworm, 1980, p. 32). Older, adult students are expected to constitute 40% of the college population by 2000 (US Department of Education, 1990, p. viii), and there is no reason to expect a decline in this growth over the next several years (Rogers, 1981, p. 1). In the future, students ranging in ages from 17 to 24 are expected to stabilize in numbers (US Department of Education, 1991, p. 163). Thus, the proportion of older students at the college level is expected to continue to increase. In fact, older adults are the fastest growing segment of college students (Webb & Tripp, 1987, p. 3), and they now constitute 45% of the credit enrollment in colleges

and universities (Greenland, 1989, p. 13). This group of nontraditional aged students are a new subpopulation within the university that did not exist in the past. Furthermore, they are now a considerable portion of the entire population. This shift in the student population is projected to continue well into the next century (US Department of Education, 1989, p. 18). Increasing the number of opportunities for older, adult students is "the most important recent demographic change in higher education" (Williamson & Greenwood, 1989, p. 69).

Adults return to college for many reasons. Some adults may return to college because of technological obsolescence in their present job (Kasworm, 1980, p. 31). In fact, job dissatisfaction was the most common event that persuaded adults to enroll in college (Sewall, 1982, p. 28). Adult students return to college to "supplement their knowledge in regard to their current jobs or to retrain themselves to deal more effectively with changing technologies" (Hall & Langenbach, 1990, p. 10). As a result, traditional academic courses accounted for over 50% of all adult classes taken at a university while career related training covered 32% of all courses attempted (Fincher, 1983, p. 11). Thus, students may undergo a career change through a college education, or they may be involved in education for personal

fulfillment. Some have never been to college while others were unsuccessful during a previous attempt. Whatever their reason for attending, nontraditional aged students now make up a sizable subpopulation within the university as a whole.

At Montana State University (MSU), over 3,000 students are 25 years or older. This comprises approximately one-third of the entire student body. Younger and older students represent completely different backgrounds and orientations towards learning although the majority of the university's efforts have been directed towards the traditional aged student (Kasworm, 1980, p. 41). Adults may have different needs and concerns that are not present with younger students, and the traditional courses and teaching methods may not be appropriate.

Montana State University enrolls approximately 10,000 students each quarter. Of these, 20% are enrolled in the College of Engineering which comprises the largest college within the university. A sizable number of engineering students fall into the nontraditional age bracket. Mathematics 181 -- Calculus and Analytical Geometry I -- is the first part of the mathematics requirement for any engineering student, as well as physics, chemistry, computer science, or mathematics majors. The majority of students

enrolled in Math 181 during any given term are engineering students. Calculus is a prerequisite for many lower level engineering classes. Even though a student is enrolled in the College of Engineering, they must successfully complete the first term of calculus before engineering courses can be taken. Thus, Math 181 is a prominent course in the program of any engineering student.

Many adult students have difficulty fulfilling collegiate mathematics requirements (Thompson & Friske, 1983, p. 13). There are certain prerequisites that must be met before a student can attempt calculus. These can either be completed in high school or through developmental courses such as the Tutor Assisted Courses (TAC) program at MSU. Many adults in the engineering curriculum must go through developmental courses such as these because of the time lapse between high school and college or because they never have taken the required courses (Whitesitt, 1980, p. 30). Therefore, mathematics may account for a sizeable number of courses in the curriculum of an adult engineering student.

Nationwide, calculus is one of the top university courses in terms of enrollment (Steen, 1987, p.10) In general, approximately half of the students enrolled in calculus at MSU do not pass. This rate is consistent with other universities throughout the country (Cirpa, 1988, p.

1491; McDonald, 1987, p. A1). During the 1987 academic year, 300,000 students took a mainstream calculus course in America. Of these, only 140,000 finished with a passing grade for a 47% completion average (Steen, 1987, p. 11).

Adult students succeed in calculus at approximately the same rate as other students. In recent years, adults comprised 13% of all students in Math 181. The success rate of older students ranged from 50% in 1988 to 66% in 1989. This is comparable to all students who completed the first quarter of calculus. These success rates ranged from 54% in the fall quarter of 1990 to 58% in the fall quarter of 1988.

Due to the high failure rate in calculus, it has been recommended that stricter placement guidelines be followed, including an assessment of prior learning (Webb & Tripp, 1987, p. 6). However, adults are markedly different than the traditional aged college student. High school grades, the Scholastic Aptitude Test (SAT), or American College Test (ACT) scores are not reliable placement criteria for the older student due to the time gap between high school and entry into college. A placement examination that relies on memorized formulas and processes is not recommended for adults returning to college after a prolonged absence from mathematics (Lawrence, 1988, p. 5; Solmon & Gordon, 1981,

p. 53). In 1987, there were 379 colleges and universities who subscribed to the Mathematical Association of America's Placement Testing Program (Harvey, 1987, p. 136). Types of information used for placement of students at these schools and the frequency of use of these criteria are as follows:

(a) Number and kind of previous mathematics courses (62%),
(b) Grades in previous mathematics courses (58%),
(c) SAT quantitative score (39%),
(d) ACT mathematics score (37%),
(e) SAT qualitative score (17%),
(f) High school rank in class (17%),
(g) High school grade point average (14%), and
(h) ACT verbal score (8%).

While these criteria may be useful for traditional aged college students, some of this data is not available for nontraditional aged students, and other data pertaining to high school achievement may be severely outdated and no longer appropriate. Thus, it has been difficult to place adult students into an appropriate mathematics course. Traditionally, mathematics has been viewed as an academic discipline where new ideas build upon previous concepts. Therefore, proper placement of adults is desirable because it is one step toward success in education although it is not a guarantee. By placement in the proper mathematics course, it can help eliminate possible frustration and a waste of student's time and money.

Educators tend to think of mathematical learning as a cumulative process where certain facts, procedures, and ideas must be mastered before a new topic can be successfully attempted (Lehmann, 1987, p. 10). A placement test is given to incoming students to see where they fit into the mathematics curriculum. However, this ignores adult learning factors such as learning styles, perceptions, attitudes, and expectations (Kasworm, 1980, p. 42). "Historically the process of diagnosis in mathematics has been to determine the mathematical difficulties that might be preventing students from learning new mathematics" (Behr & Bright, 1983, p. 4). Because adult students have varied backgrounds, placing them where they seem to fit in the sequence of courses does not guarantee success. Adult students tend to rely upon a wealth of past experiences in any learning situation (Knights & McDonald, 1982, p. 239; Knowles, 1980, p. 44). Because they have widely different reasons for coming to college later in life, adults in mathematics courses may have "learning histories with unusual gaps" (Lawrence, 1988, p. 3). Little attention has been given to these individual differences in nontraditional aged students at the university (Knights & McDonald, 1982, p. 237; Thompson & Friske, 1983, p. 13). Other means besides a placement examination may help students understand

their abilities and interests (Webb & Tripp, 1987, p. 6). These include an assessment of past learning, aptitude, vocational interests, and diagnostic tools. It is desirable to place every student into the most appropriate course for their individual situation and background (Lehmann, 1987, p. 10; Webb & Tripp, 1987, p. 2). Due to widely different backgrounds and reasons for returning to school, traditional methods of placement may not be appropriate for adults. Thus, an appropriate placement criteria for older students in mathematics is needed.

The literature regarding adult education generally supports the theory that adults learn best when the individual is actively involved in the learning process. A collaborative learning experience is defined as the learner sharing responsibility with the teacher in determining the educational goals and curriculum (Conti, 1982, pp. 135-136). Adults orient their learning through a wealth of past experiences (Knowles, 1980, p. 44). This can hinder or help the learning (Apps, 1981, p. 41; Brookfield, 1986, p. 31). In addition, they are self-directed in their learning, and thus they need differing amounts of assistance to reach their educational goals (Knowles, 1980, p. 40). Motivation may determine if learning will take place at all and at what rate (Kidd,

1973, p. 101). Furthermore, adults learn best in problem-centered situations in which there is an immediate application of the knowledge (Knowles, 1980, p. 48). This independent learning was found to be effective in students of all abilities (Croft, 1976, p. 29). These essential elements of a collaborative learning experience help promote effective adult learning. These elements are generally not incorporated into mathematics instruction. In fact, calculus courses have changed very little over the past few decades even though the audience has undergone a significant transformation. "Even though it is recognized that adults and pre-adults should be taught using different methods, in practice there is relatively little difference" (Gorham, 1985, p. 206). If mathematics instruction is to be effective, the characteristics of the adult learner should be taken into account, and the discrepancy between theory and practice should dissolve.

Because of the increase in the older student population, the number of adults who attempt calculus will continue to grow. Students who embark upon a career change in any engineering field will have to pass through calculus before their goals are reached. Adults are very concerned with obtainable goals from their education (Terrell, 1990, p. 242), and this includes the role of mathematics relative

to their chosen career (Thompson & Friske, 1983, p. 13). This population of adults cannot be ignored because of the mission of Montana State University, and its purpose as a land grant institution. The purpose of a state-supported land grant institution is to remain open to all people as well as promoting and developing technology and the sciences. Therefore, a college education will continue to be accessible for nontraditional aged students interested in any engineering field. The growing population of nontraditional aged students will take on a greater significance in the future in regards to recruitment, retention, and graduation requirements.

Statement of the Problem

The number of nontraditional aged students in American universities has grown and will continue to grow over the next decade. Those students who embark upon a career change into any engineering related field will have to pass calculus. Approximately one-half of the nontraditional aged students have difficulty passing calculus. Because of the growing adult student population, the number of these students who attempt calculus in the future will increase. In their school setting, adult students have unique needs and backgrounds that differ from traditional aged students.

Adults learn best utilizing different methods than what current university instruction offers. In addition, adequate counseling and placement requires a knowledge of what academic and personal factors affect the success of nontraditional aged students in calculus. Currently, since many factors influencing adults in mathematics education are unknown, the same procedures are used for evaluating and placing both nontraditional and traditional aged students. Thus, neither the placement procedure nor the calculus courses have yielded a very successful environment for adults in college.

Purpose of the Study

The purpose of this study was to identify selected factors that combined to influence achievement in calculus for nontraditional aged students at Montana State University. The discriminating variables were determined from biographical data that every student must fill out in order to apply to the university. A discriminant analysis procedure searched for a relationship between these variables and the groups of success or failure in calculus. The effectiveness of the placement examination and developmental mathematics courses regarding adult students was also investigated. Further inquiry yielded other

factors that nontraditional aged students themselves felt affected their performance in calculus. This will enable counselors and adult students to identify the factors that combine to create the best chances for success in calculus in the future.

Significance of the Study

A low success rate in calculus, combined with the prospects of increasing numbers of nontraditional aged students, warrants some attention to their particular needs. American colleges and universities usually focus their curriculum, programs, and institutional missions on the traditional aged student (Kasworm, 1980, p. 30). This is in contrast with the growing population of older students, whose numbers are projected to continue to increase for several years (US Department of Education, 1990, p. viii). These adults comprise a sizable portion of the student population and they have very different backgrounds, interests, and concerns than the traditional aged students. "In general, undergraduate higher education has not acknowledged nor incorporated the principles of adult education within its institutional mission nor in its curriculum and instruction" (Kasworm, 1980, p. 41). Given the trend towards older college students, universities

cannot continue with the business as usual approach and hope to respond to this group of students (Apps, 1981, p. 11; Hall & Langenbach, 1990, p. 8; Lauzon & Waldron, 1988, p. 12).

There is little research regarding adults in collegiate mathematics, specifically in classes that are not developmental in nature. This is in contrast to the growing numbers of adults and their difficulty with mathematics. Furthermore, adults are not comparable to traditional aged students in their backgrounds and needs (Greenland, 1989, p. 13; Kuh & Ardaiolo, 1979, p. 215). In addition, there is also a need to identify more variables which might lead to a more accurate prediction of success in college mathematics.

Adult students have specific goals when they return to college (Apps, 1981, p. 47; Thompson & Friske, 1983, p. 13). Those enrolled in the College of Engineering want to obtain a degree which can lead to a job. They also have time constraints because their lives are being put on hold for several years (Campbell, 1983, p. 28; Mercer, 1989, p. 58). Thus, adult engineering students are very concerned with passing Math 181 because it is the first step towards their degree. There is a need to identify the most efficient and best route which will help a student succeed in calculus.

Many problems stem from the low success rate in calculus. The university must offer many "trailer sections" of calculus. Calculus is designed as a 2-year sequence of courses, and trailer sections are one term behind the usual sequencing of calculus courses. The majority of students enroll in calculus at the beginning of the fall quarter. These trailer sections place a demand on the number of faculty and the budget of the Mathematics Department. Furthermore, the College of Engineering must offer "trailer sections" of their introductory courses to which calculus is a prerequisite. Additionally, students must take the same course more than once which is a financial burden on them. Therefore, there is little benefit from a low success rate in Math 181. If the retention of adult students is one goal of the university, then the factors that identify successful students in calculus is valuable.

There has been much discussion regarding the calculus curriculum, what topics should be covered, and what is the best way to teach the course. The present curriculum does not take into account the nontraditional aged student. The course material and presentation methods can benefit from an analysis of the students who enroll in the course, including their backgrounds and needs. Mathematics instruction for adults should be presented in a context

which draws upon their prior life experiences (Behr & Bright, 1983, p. 1). The needs of the participating students may help determine a more relevant calculus curriculum and effective teaching methodology.

It would be beneficial to identify a successful path that leads through calculus as well as the factors that combine to create success. This is particularly true with nontraditional aged students who may not take the SAT, ACT, or other standardized examinations which have been used in the past to predict success (Dwinell, 1985, p. 12; Schiff, 1989, p. 25). The only other placement criteria comes from peer counseling. Since the mathematics placement criteria was designed for students entering college straight from high school, there is a need to evaluate this placement process when it is applied to adult students. Traditionally, universities have difficulties in placing students in their first mathematics course (Edge & Friedberg, 1984, p. 136). This problem is compounded by adult students who do not have homogeneous backgrounds. Adults differ from traditional freshman regarding many personal variables (Kuh & Ardaiolo, 1979, p. 215). They form a different composite group and they should be studied separately (Casserly, 1982, p. 6).

Many adult students must make up deficiencies before they can enroll in Math 181. However, the proper placement and success in a developmental mathematics course does not guarantee success in higher mathematics (Lehmann, 1987, p. 10). One researcher stated that "by just enrolling in the [developmental] class, the student gave himself less than a 50/50 chance of success" (Clark, 1982a, p. 12). It was discovered that the Tutor Assisted Courses (TAC) developmental program does not insure a passing grade in calculus at MSU (Whitesitt, 1980, p. 96). The TAC program has changed since this study, and there is a need to evaluate the effectiveness of the TAC program in preparing students for calculus particularly with regard to the growing number of older students who participate in the TAC program.

Questions Answered

This study attempted to answer five major questions related to adult students enrolled in the calculus sequence at Montana State University. The first four questions dealt with knowledge that can be acquired from existing data. They are as follows:

1. Can biographical data on nontraditional aged students be used to discriminate between successful and

unsuccessful students in Math 181? This study sought a combination of selected factors that influenced the calculus grades of nontraditional aged students.

2. Is there a difference between the success rates of nontraditional aged students who participated in the TAC program compared to those who bypassed the program and started with calculus?

3. Do adult students who follow the recommendation of the departmental placement examination succeed in calculus at a different rate than those who do not follow the suggestion of what course they should initially enroll?

4. Is there a difference in the success rate of nontraditional aged students who took the mathematics placement examination compared to those who did not take the examination?

5. Many variables that influencing achievement may be missing from the biographical data available. What additional factors do nontraditional aged students feel contribute to success and failure in an introductory calculus course? This question sought data to expand the applicability of the above questions.

General Procedures

Permission was obtained from the chairman of the Department of Mathematical Sciences and the Registrar of Montana State University to search official student records. The academic terms under inquiry were from the fall quarter of 1988 through the winter quarter of 1991. A student was classified as successful or unsuccessful in calculus depending upon the grade that they received at that time in Math 181. A discriminant analysis procedure was used to see if biographical data could distinguish between these two groups.

In addition, follow-up interviews were collected with selected students to determine what other factors influenced their performance in calculus. They were asked questions regarding skills that were needed to pass calculus as well as what other factors in their life had an influence on their grade in calculus. In order to uncover the entire influence of calculus within a land grant institution, interviews were conducted with (a) students who were participating in the developmental program trying to build their skills in order to enroll in calculus, (b) students who did not persist in an engineering major after attempting calculus, and (c) those students who were successful in calculus and were still enrolled in an engineering program.

Limitations and Delimitations

The quantitative analysis in this research was limited to only seven attribute variables regarding adult calculus students. This was the only information available from existing data. The study was also limited to 66 individual courses of Math 181 that were offered during the years under investigation.

The study was delimited to Montana State University which has the largest engineering school in Montana. There were 277 older students enrolled in Math 181, an introductory calculus class, during 1988 to 1991. This course is one major obstacle in the engineering degree for adult students. The small population was similar in terms of the course textbook, course objectives, large group instructional format, and failure rates. In order to incorporate more adult students into the study, it would have been necessary to change the population characteristics so that it would no longer have a homogeneous makeup.

Definition of Terms

Adult Student - Any undergraduate student enrolled at Montana State University who is 25 years of age or older. This may include students who have attended college consecutively since high school and those who have had a

lapse in their education for a number of years (Elliot, 1990, p. 160; Hall & Langenbach, 1990, p. 8; Lyon, 1981, p. 3; Rogers, 1981, p. 1; Whitesitt, 1980, p. 75). They are also referred to as nontraditional aged students and older students.

Developmental Courses - The Tutor Assisted Courses (TAC) program is a series of self-paced courses ranging from beginning mathematics through trigonometry. They are designed to be completed in sequence; then a student is considered to possess the skills necessary for calculus. A student may enter the sequence at any place where they feel that they have mastery of the prior knowledge. Some of these courses count for college credit, but none of the TAC classes may be applied toward a university-wide core mathematics requirement.

Math 181 - Calculus and Analytical Geometry I. This is the first term of a standard 2-year calculus sequence for scientists and engineers. Topics include limits and derivatives of one variable. There are other introductory calculus classes designed for business and social science majors. However, they are not a prerequisite course that must be completed before students can take courses related to their major.

Nontraditional Aged Student - Another term for adult student.

Placement Examination - A voluntary departmental examination that can be taken by any student to suggest which mathematics course is most appropriate for their skill level. Most students entering MSU take this examination, but the advice is just a suggestion. Students may enroll in any introductory mathematics course, including Math 181. The examination consists of material from the TAC courses, and it is scored according to the individual course topics to aide in the placement recommendations. Students should score 50% or above on each topic before they are advised to enroll in the next higher mathematics course.

Successful Student - Any student who received a grade of A, B, or C at the end of the quarter (Frerichs & Eldersveld, 1981, p. 4; Whitesitt, 1980, p. 10). This success is rated as a percentage score from a combination of examinations and homework, and it is based upon 100-90% for an A, 89-80% for a B, 79-70% for a C grade by MSU Department of Mathematics.

Unsuccessful Student - Any student registered at the end of the quarter who received a grade of D, F, WP, or WF. This includes 60-69% for a D, 59% or below for an F, a Withdraw Pass, or Withdraw Fail. An engineering student may

not progress onto the next calculus course with any of the above grades. For students who withdrew from the course before a university deadline, but there was no record of their attempting the class.

Summary

The influence of older students on the college population has become very significant as greater numbers of adult students enter college. Adults return to education mainly because of limitations in their careers. At a land grant institution, many adults enter college with the hopes of obtaining a degree in engineering. This desire often goes unfulfilled because passing introductory calculus is difficult for adult students, and they do meet the pre-requisites for the engineering courses.

This study attempted to identify the factors and situations that combined to create the best chance for success in adult calculus students at Montana State University. Future students and counselors can use this information to assess an individual's situation when they return to college and need to fulfill a mathematics requirement by passing calculus.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

Adults differ from traditional aged college students in many ways. As a distinct age group, adults have unique characteristics when they return to college. They are different in their views regarding education, as well as being different in academic backgrounds and abilities. The motivation and goals of adult students are also different from that of traditional aged college students. Factors that are considered to contribute toward success in mathematics are explored and a comparison is drawn between the characteristics of successful and unsuccessful students in mathematics.

Characteristics of Nontraditional Aged Students at Universities

The academic ability of older students has been questioned by undergraduate faculty (Apps, 1981, p. 84; Kasworm, 1980, p. 32, Kasworm, 1990b, p. 156, Williamson & Greenwood, 1989, p. 77). A traditional aged student enters

college immediately after or within a few years of completing high school. They are generally acknowledged to have the intellectual and scholastic skills needed for a college education because they graduated from high school. This is not always the case with older adults. Some may not have a high school diploma while others did not enroll in college preparatory classes. Because of the time away from formal education since high school, certain academic skills and thought processes may have declined from not being actively involved in a scholastic environment. However, "older undergraduates do perform adequately and effectively, as assessed by GPA, in competitive undergraduate environments" (Kasworm, 1980, p. 37). Adults were found to be more successful in college and had a higher grade point average than the entire student body taken as a whole (Ferguson, 1966, p. 347; Fredrick, 1985, p. 249). In fact, no significant difference could be found between most cognitive and affective variables when nontraditional and traditional aged students were compared in a developmental mathematics course (Elliot, 1990, p. 164). Thus, older students do have the intellectual capacity to obtain a college education (Knights & McDonald, 1982, p. 237). "Adults can learn most things as well as younger, more traditional students. Because of their vast experience,

they may be able to learn some things better" (Apps, 1981, p. 91).

This is not to suggest that all academic skills are possessed by adult students from the moment that they first step on campus. The advanced academic skills of returning adults is not the same as their last encounter with formal education (Fincher, 1983, p. 6; Knights & McDonald, 1982, p. 244; Suddick & Collins, 1984, p. 3) The verbal abilities of older students compares equally with younger students, but adults are at an initial disadvantage with regards to mathematics (Fredrick, Mishler, & Hogan, 1984, p. 330; Sewall, 1984, p. 2). However this disadvantage is surmountable and they can succeed in college after a period of adjustment. Through orientation, diagnostics, and remediation, adults are able to compete equally with younger college students. Most of these skills may have "grown rusty and inefficient from non-use" (Rogers, 1981, p. 2), but they do exist in some form or another. There are also those basic educational skills which adults do not possess, and these need to be learned through a developmental program. Thus, educational diagnostics and remediation do have an impact upon collegiate performance (Hudson, 1986, p. 43; Williamson & Greenwood, 1989, p. 70-71).

The backgrounds, attitudes, and beliefs, and their relative importance regarding the undergraduate environment are markedly different between younger and older students (Kasworm, 1980, p. 41; Lehmann, 1987, p. 3). These beliefs and attitudes play a significant role in the adult learning experience at college. In general, adult students are typically more mature in their thinking and outlook on life (Dwinell & Higbee, 1989, p. 4-5; Kasworm, 1980, p. 40; Kasworm, 1990b, p. 164). Adults "may reflect a more mature attitude toward school and have a higher probability of receiving good grades in college" (Sewall, 1984, p. 13). This mature thinking can be found in the specific goals and reasons adults give for enrolling in certain courses (Dahlke, 1974, p. 222; Levin & Wyckoff, 1988, p. 181). Thus, the attitudes of an adult student are believed to have an influence on their education in regards to avoidance and persistence of specific courses (Bleyer, 1980, p. 344; Elliot, 1990, p. 160). However, two researchers found that beliefs and attitudes did not contribute toward success (Bassarear, 1986, p. 11; Heher, 1988, p. 103). Attitudes interact differently depending upon the individual student's needs and goals. In general, a student's attitude is related to achievement, but this correlation may be negligible (Aiken, 1976, p. 295). It will suffice to claim

that the attitudes of adult students do impact the educational experience; it is under debate as to whether or not this yields a significant impact.

Expectations play a role in educational success, and this is particularly true with mathematics. Adult students typically underestimate their abilities in mathematics (MacDonald, 1978, p. 159). Because they draw upon a wealth of past experiences, adults who have done poorly in the past often expect themselves to fail in mathematics. This may be due to an educational history of failure which is often attributed to a lack of ability. Thus, an individual's confidence is lowered and failure is expected (Burton, 1987, p. 305; Lawrence, 1988, p. 3). The previous formal educational experience is often a barrier for adults returning to college (Apps, 1981, p. 97). In addition, adults may have unique concerns due to their nonparticipation in formal schooling for a number of years. These may include test anxiety as well as questioning their own capacity to understand a whole new body of knowledge (Terrell, 1990, p. 242).

However, adults have a strong motivation for changing their lives and returning to college. They may be willing to work the extra hours needed for mastery of the material and this can compensate for inadequate background and lack

of confidence (Apps, 1981, p. 43; Kasworm, 1990b, p. 157; MacDonald, 1978, p. 159). In fact, age was found to be positively related to persistence in a university education (Anderson & Darkenwald, 1979, p. 365). This motivation is not seen in an overwhelming number of traditional aged students. Some studies found that over 50% of participants in a developmental mathematics course were not sure why they were taking the course, or they felt that they may need the course to increase their mathematical knowledge (Eldersveld, 1983, p. 164; Frerichs & Eldersveld, 1981, p. 6). This indicates that many students do not have a compelling reason for taking a developmental mathematics course. In contrast, nontraditional aged students return to college with specific goals in mind. Many adults enroll in mathematics courses because of the loss in career and advancement options, as well as limited effectiveness in their present job. This motivation was found to be a significant factor related to students persisting in an engineering major (Foster, 1976, p. 726). One writer feels that "older students, unlike some of their traditional-college-age peers, are truly dedicated to getting an education" (Watkins, 1990, p. A12). However, the goals and needs of college students are not solely a function of the student's age. They are also affected by the life situation of the student, which in turn can provide

significant motivation for pursuing a college degree.

There are many other factors related to a successful or unsuccessful experience for the adult learner on a college campus. Many academic variables were found to be related to a student's achievement. One variable was reading ability (Bauer, 1984, p. 70). The instructor was mentioned by many adults as having an influence on their education (Foster, 1976, p. 726; Goolsby, Dwinell, Higbee, & Bretscher, 1988, p. 21; Himaya, 1973, p. 3; MacDonald, 1978, p. 161). This includes a review of pertinent material at the beginning of the course, availability for extra assistance, and frequent feedback. However, in one study the quality of teaching and subject material did not discriminate between those students who persisted or withdrew from a major in engineering (Foster, 1976, p. 727). Furthermore, younger and older students do agree about the characteristics of good and bad teachers (Apps, 1981, p. 114). Other factors related to success include: time spent studying, the places available to study, ability to get to school, and the choice of obtaining desired courses and a good schedule (Frankel, 1985, p. 6; Williamson & Greenwood, 1989, p. 73).

Other, nonacademic factors also influence an adult's educational experience. In fact, most dropouts are not in

academic jeopardy, and they are four times as likely to drop out for nonacademic reasons (Jones, 1986, p. 15). A combination of personal and academic situations may combine to create problems for the adult returning to college (Apps, 1981, p. 169; Williamson & Greenwood, 1989, p. 71). These nonacademic factors include cognitive traits as well as personal and family situations. Thus, other variables besides academic reasons influence an adult's education. First of all, an adult's attitude influences their scholastic experience. Adults were found to be different than younger students with respect to attitudes (Bleyer, 1980, p. 345; Sewall, 1984, p. 13) and maturity level (Kasworm, 1980, p. 40). Confidence in one's ability, attitude towards a particular subject, and fear of intimidation were also found to be related to success (Bauer, 1984, p. 70). An adult's self-confidence, time management skills, available time for school, and financial resources are different than their younger counterparts (Lehmann, 1987, p. 4).

The financial situation of adult students is different than that of traditional aged students. They may have family obligations, they may leave a source of income while returning to school, and they may not have parents to help out with the financial problems. The ability to pay for an

education, family support, and time spent at work also contribute to an adult's educational experience. However, there is disagreement about the relationship between age and employment. Some researchers claim that there is no relationship (Hale & Wattenbarger, 1990, p. 205; Konvalina, Stephens, & Wileman, 1983, p. 110), while others found a significant correlation (Lauzon & Waldron, 1988, p. 19; Puh & Ardaiolo, 1978, p. 211) with older students working more than their younger counterparts. Furthermore, an adult's status as a part-time student, permanent residency, and long term goals are also variables related to the success of nontraditional aged students (Hall & Langenbach, 1990, p. 9; Kasworm, 1980, p. 31). Because many adults are successful at college, it can be concluded that the family and job commitments of adult students do not necessarily undermine their college education.

Many of the variables that influence adults in college are not present in younger, traditional aged students due to their different backgrounds, present situation, and personal needs. Thus, many unique factors, both academic and nonacademic, influence the educational experience for nontraditional aged students. "Adult's needs and goals are as diverse as their ages, level of education, level of mathematics education, and occupations" (Mathison, 1979, p.

1). They do not make up a homogeneous group and they differ widely from the traditional aged college student.

Nontraditional Versus Traditional Aged Students in Mathematics

When adults return to college, they have an initial disadvantage with regards to their mathematical abilities. There is a significant difference between younger and older students on standardized mathematics scores (Fincher, 1983, p. 44; Fredrick, Mishler, & Hogan, 1984, p. 330; Lyon, 1981, p. 6; Sewall, 1984, p. 12). Some of this may be explained by the lack of recent exposure to mathematics and by having forgotten formulas (Sewall, 1984, p. 14; Solmon & Gordon, 1981, p. 53). However, the number of semesters since last enrolling in a mathematics course was not significant in predicting calculus grades (Edge & Friedberg, 1984, p. 140). Additionally, Lyon (1981) found that recency of mathematics did not affect mathematical competency (p. 8), and that adults tended to score higher on mathematical reasoning, problem solving, and graphical interpretations than the younger students (p. 9). He concluded that "adult students have a knowledge of mathematical competencies which is equal to, or superior to, the knowledge of high school students" (p. 10). However, adults tend to rate below their younger counterparts in regards to definitions, formulas, and

algorithms. Since these skills can be learned and reviewed through remediation, adults can expect to perform well in collegiate mathematics.

The mathematical backgrounds of younger and older students are markedly different. Younger students have significantly more mathematical courses in their academic histories (Sewall, 1984, p. 8; Solmon & Gordon, 1981, p. 53). The high school grade point average (GPA) of adults returning to college was found to be lower than the high school GPA of traditional aged college students (Fincher, 1983, p. 8; Kuh & Ardaiolo, 1979, p. 211). This may suggest that many adults did not enroll in college immediately after high school because of unsatisfactory preparation. However, many adults in college have had some previous college experience. In the literature, this number ranges from 25% up to 89% (Fincher, 1983, p. 2; Hall & Langenbach, 1990, p. 9; Mercer, 1989, p. 57; Sewall, 1982, p. 10). Therefore, adults enter mathematical courses with many different backgrounds, and their prior history does have an impact on their success in the future.

There is also a significant difference between the mathematical backgrounds of successful and unsuccessful students (Lyon, 1981, p. 7; Stones, Beckmann, & Stephens, 1980, p. 35). In fact, Suddick and Collins (1984) called

the mathematics course backgrounds the "single best predictor of success" of students in college mathematics courses (p. 9). This suggests long term competitiveness and perserverence (Edge & Friedberg, 1984, p. 140). This prediction power could not be expanded by including such variables as age, recency of mathematics, or number of previous credit hours in college. Likewise, Whitesitt (1980) found success in mathematics to be independent of age (p. 91). However, an exception was found by Frerichs and Eldersveld (1981) in one study in which the most successful group was an average of two years older than their unsuccessful counterparts (p. 6). Thus, adults are not predestined to failure in mathematics. Moreover, most universities offer developmental courses to offset poor mathematical backgrounds.

Characteristics of Successful Students in College Mathematics

There are many other factors that characterize a successful student in mathematics besides a person's previous background. One possible factor is the gender of the student. This was not found to be a significant contributor to mathematical success in a number of studies (Lyon, 1981, p. 6; McCammon, Golden, & Weunsch, 1988, p. 507; Siegel, Galassi, & Ware, 1985, p. 536; Suddick &

Collins, 1985, p. 9; Ware & Chastain, 1989, p. 7; Whitesitt, 1980, p. 72). In contrast, the sexes should be analyzed separately because of their differences (Aiken, 1976, p. 302), with women more predictable than men (Bean, 1980, p. 93; Gussett, 1974, p. 953). The differences in mathematical achievement between the sexes may be explained by societal influences (Behr & Bright, 1983, p. 2), with women enrolling in mathematics courses in smaller numbers than that of men.

The age of a student may be one factor that is related to mathematical success. Nonetheless, age did not help predict success on a mathematical skills test (Suddick & Collins, 1985, p. 9) nor did it help predict a student's aptitude (Konvalina, Stephens, & Wileman, 1983, p. 110). However, some studies found that age may contribute towards achievement (Dahlke, 1974, p. 219; Eldersveld, 1983, p. 164; Konvalina, Stephens, & Wileman, 1983, p. 110), and differences in mathematical test scores can be found between different age groups (ERIC Digest, 1984, p. 1; Frerichs & Eldersveld, 1981, p. 8; Lyon, 1981, p. 6). These differences in mathematical abilities may be influenced by the amount of everyday experience with mathematics during an adult's educational hiatus, so they are a function of the student's experience and background. Other studies found that there were no significant differences among the time

intervals away from math with regard to the scores on a mathematical competency test (Edge & Friedberg, 1984, p. 140; Lyon, 1981, p. 8). Thus, there are mixed results when age and time away from mathematics were used as factors related to mathematical success.

The role of a placement examination is one variable used to predict success in mathematics. Many entering adults are not required to take traditional placement tests such as the Scholastic Aptitude Test (SAT) or American College Test (ACT). Therefore, the only placement criteria for adults in mathematics comes from an individual placement examination which is offered by the mathematics department. An individual's score and subsequent course placement from the placement examination were found to be related to success in mathematics (Ahrens, 1980, p. 9; Clark, 1982a, p. 28; Clark, 1982b, p. 12; Crooks, 1980, p. 7; Heher, 1988, p. 104; Schiff, 1989, p. 25). However, placement examinations and procedures are more reliable in selective colleges where the student body is more homogeneous in their abilities than in liberal colleges with an open admission policy (Noble & Sawyer, 1989, p. 350).

Scores from the SAT or ACT examinations have widespread use in placing students and predicting student success in collegiate mathematics. This score was found to be related

to success (Clark, 1981, p. 3; Croft, 1976, p. 35; Gussett, 1974, p. 954; Troutman, 1977, p. 17), but this was contradicted by other studies (Clark, 1982a, p. 1; Goolsby, Dwinell, Higbee, & Bretscher, 1988, p. 24; Siegel, Galassi, & Ware, 1985, p. 536). However, much of this information may not be available for adult students at MSU. This is so because they may transfer from another college, and thus they are not required to submit information pertaining to high school academic records or standardized tests. Even when it is available, this information is several years old for adult students, and it may no longer be pertinent to their educational situation. Nevertheless, it is generally not disputed that the past academic history of a person has a profound influence on their future achievement.

The best predictors of success in mathematics are a student's previous grades and academic records (Carmichael, 1986, p. 13; Elliot, 1990, p. 163; Fincher, 1983, p. 44; Konvalina, Stephens, & Wileman, 1983, p. 111). A related variable is the general academic ability of a student (Troutman, 1977, p. 17; Ware & Chastain, 1989, p. 10). Therefore, students who have done well in the past in regards to academic success have the best chance to succeed in the future. Background and previous achievements are important predictor variables in college mathematics. This

includes a student's high school GPA (Ahrens, 1980, p. 9; Croft, 1976, p. 35; Shoemaker, 1986, p. 16; Wollman & Lawrenz, 1984, p. 386), their GPA in high school mathematics courses (Clark, 1981, p. 3; Troutman, 1978, p. 403), and the number of mathematics courses taken (Clark, 1982, p. 3; ERIC Digest, 1984, p. 2; Konvalina, Stephens, & Wileman, 1983, p. 110; Stones, Beckmann, & Stephens, 1980, p. 32). Thus, those students who have done well academically in the past, and those students who have extensive course work in mathematics have the best chance to succeed in future mathematics courses.

The recency of mathematics and general academic ability of older students had an effect upon their grades in higher level mathematics courses. These factors included previous college GPA as well as the number of college credits passed prior to enrolling in higher level mathematics (Clark, 1981, p. 3; Clark, 1982a, p. 17; Clark, 1982b, p. 13; VanDruff, 1973, p. 86). Therefore, if a student recently succeeds in lower level developmental courses they may have a better chance of success in calculus than other students who enroll in calculus straight from an extended absence from formal education. The recent achievement in all college courses is also related towards present success in mathematics.

Several distinctions exist between successful and unsuccessful students in mathematics. In general, successful students enroll in a mathematics course because of an interest in the subject or to improve their skills, they do not enroll in a mathematics course to fulfill a prerequisite or because it is a necessary step in obtaining a job (ERIC Digest, 1984, p. 2; Dahlke, 1974, p. 217; Foster, 1976, 727). Successful students had better numerical skills (Dahlke, 1974, p. 217; Frerichs & Eldersveld, 1981, p. 8), rated themselves as having a higher mathematical ability (ERIC Digest, 1984, p. 2; Foster, 1976, p. 726; Frerichs & Eldersveld, 1981, p. 8), and had a higher reading ability (Edwards, 1972, p. 159). Students are also more successful when attending a traditional lecture course than when involved in a self-paced tutorial program (Frerichs & Eldersveld. 1981, p. 8). The experience in past mathematics courses tends to be more extensive for successful students. They also had better overall grades and had an enjoyment for the subject.

"It would appear that there are a number of inconsistencies in the findings pertaining to affective variables and gender, as related to mathematics performance and/or achievement of college students" (Goolsby, Dwinell, Higbee, & Bretscher, 1988, p. 20). This is due to the

unique needs of adults returning to college and their widely different backgrounds. In conclusion, students who have had a recent successful experience with formal mathematics training, and who have a high interest level in mathematics, have the best chances to succeed in collegiate mathematics.

CHAPTER 3

PROCEDURES

Introduction

The purpose of this study was to discover what variables had an effect upon success in calculus for the nontraditional aged student. In order to achieve this, a case study approach was utilized. This approach allowed for a thorough examination of the specific characteristics within a known bounded system (Meriam, 1988, p. 9). Montana State University (MSU) is a state supported land grant school that is accessible to Montana residents. As a result, it has the largest engineering program in the Montana University System. Only the Montana College of Mineral Science and Technology has a similar program, albeit much smaller in numbers. The College of Engineering enrolls approximately one-fifth of the students at MSU with many of these students over the traditional college age. It is within this framework that the study was conducted.

Data related to predictor variables was gathered from two sources. First, biographical data was gathered since this information is available to counselors to assist in the

placement of future adult students. A discriminant analysis procedure was used. This discriminated between two or more groups on the basis of similar, shared factors (Kerlinger, 1986, p. 562). In this study, a student was classified as unsuccessful or successful in calculus and the biographical traits that were similar between each group were explored. However, since the data was limited, it was not assumed that this biographical data contributed 100% accurate results. Other variables may have been present which affected a student's performance.

Second, in order to uncover some of these missing variables, interviews were used to determine what other factors influenced an adult's performance in introductory calculus. In this case study approach, the data collection from interviews and subsequent analysis were simultaneous events in order to give new direction, confirm, and extend the data collection (Owens, 1982, p. 11). The emergent plan helped uncover missing variables because there were no preconceived theories going into the qualitative component. By using a dual-design, the adults in the study became real people within their own environment, and they were not completely reduced to a few descriptive traits without individual needs, problems, or personalities.

Population

This study took place on the campus of Montana State University (MSU), a land grant institution that was established in 1893. It is located in Bozeman, Montana, a town with a population of approximately 30,000. The university is the major employer. Farming and agriculture are the principle businesses in the surrounding region. In the spring quarter of 1991, there were 9,333 students enrolled at MSU. This consisted of 6,347 undergraduate students, 767 graduate students, and 2,219 various nondegree students. Since MSU is a land grant institution, the mission of the university focuses on scientific and technical training. As a result, approximately 20% of all students are enrolled in the College of Engineering, the largest college within MSU.

The Department of Mathematical Sciences had 24 full-time professors, 6 part-time instructors, and 44 graduate teaching assistants during the fall quarter of 1990. During this quarter, there were 3,822 students enrolled in undergraduate mathematics courses. Of these students, 1,664 were associated with the TAC developmental program, and the other 2,158 students were in higher level courses, including upper division classes. One nondevelopmental course, Math 181, had 417 students finish the quarter. This course alone

accounted for about 19% of all of the enrollment for nondevelopmental courses.

The population in this study was all adult students enrolled in Math 181 at Montana State University from the fall quarter of 1988 through the winter quarter of 1991. During this time, all sections of Math 181 used the same textbook (Boyce & DiPrima, 1988) which is a standard mainstream first-year calculus text. During these years, there were 66 individual sections of Math 181 offered. A total of 277 adult students were enrolled in Math 181 during the years under consideration. This number represented 13% of all students taking the first quarter of calculus. The average age of these adults students was 32 years. However, the ages ranged from 25 to 51 years. They had completed about 44 credits at MSU prior to enrolling in calculus and their average grade point average was 3.01 out of 4.0 for these efforts. Some students took calculus in their first quarter at MSU while others earned 161 credits prior to Math 181.

Validity

There were many possible threats to the validity of this study which may have prevented it from actually investigating the given problem (Campbell & Stanley, 1966,

p. 5). Some were inherent in the limited design while other problems may have occurred because of the population of students and unique characteristics of Montana State University. However, this design was not violated by the threats of historical change, instrumentation, or selection.

Historical changes did not affect the results of the proposed study. Beginning with the fall quarter of 1990, Montana State University changed from an open admission policy to adopting admission standards. However, this did not affect older students because at the time of application, if more than 3 years had passed since high school graduation, no additional admission requirements were placed on any MSU students. Another historical change that may have affected success in Math 181 was the change from three common hour exams to two exams in 1990. Past data indicates that the failure rates, the textbook (Boyce & DiPrima, 1988), and the course objectives were identical (Fredenberg, 1991). Furthermore, the scores from different years were comparable because a percentage score was used to define success.

The course material, examinations, and results were comparable over the 3 years under investigation. The exams were written by a course supervisor. Every student took the same examination at the same time. The Mathematics

Department rules remained constant regarding the use of calculators and the time allowed for each examination. The material was identical from year to year, and the overall success rates ranged from 54% in the fall quarter of 1990 to 58% in the fall quarter of 1988.

Furthermore, the placement examination did not change for incoming students. The mathematics placement examination was developed by all math department heads from schools within the Montana University System. It is recommended that all entering students take the examination which has two parts. Students take the appropriate subtest depending upon their mathematical background. The examination is scored in each individual subject area, and students should correctly answer at least half of the questions on each subject before they are advised to enroll in the next higher course. The same placement examination was used during all 3 years included in the study.

A census of every adult student finishing a quarter in Math 181 was used in the study to eliminate selection bias. Students who dropped the course prior to a university deadline were not considered in the study since records on their performance were incomplete. It is also impossible to determine if such students were passing or failing the course at the time that they dropped.

The results of this study will be applicable in the future. Entrance requirements to MSU will continue to become more stringent, but older students will be exempt from such requirements. MSU changed from a quarter system to semesters in the fall of 1991. This affected Math 181 because it incorporated part of Math 182 (Calculus & Analytic Geometry II) which was split in half due to the semester conversion. However, the material in the new Math 181 is identical for the first part of the course. The text (Ellis & Gullick, 1990) changed, but the topics covered are virtually identical.

There may be extraneous variables which contribute to success in calculus. These pose a threat to the predictive validity of the results of the study since these factors are not included in the statistical analysis. However, they were examined through interviews with selected adults. According to related literature, personal variables that were found to contribute towards achievement include: (a) number of hours worked (Frankel, 1985, p. 7; Konvalina, Stephens, & Wileman, 1983, p. 110; Lehmann, 1987, p. 4; Lyon, 1981, p. 3); (b) attitude of the student (Bauer, 1984, p. 70; Lawrence, 1988, p. 5); (c) motivation of the student (Dahlke, 1974, p. 216; Wollman & Lawrenz, 1984, p. 386); and (d) the reasons for taking mathematics (Dahlke, 1974, p.

221; Frerichs & Eldersveld, 1981 p. 3; Levin & Wyckoff, 1988, p. 181). Family atmosphere was also found to influence achievement (Knights & McDonald, 1982, p. 239; Rogers, 1981, p. 3). Instructional method (Frerichs & Eldersveld, 1981, p. 3) and the number of study hours (Levin & Wyckoff, 1988, p. 180) also contribute towards success in collegiate mathematics. However, there are no records of these variables from available past data so they cannot be included in discriminating between successful and unsuccessful calculus students. The interviews with adult students were used to examine these and other variables that may have influenced a student's calculus grade.

Methods of Data Collection

All biographical data was obtained from official records on file at the Office of the Registrar and the Department of Mathematics. These are legal records and they are regarded as valid. Permission was obtained from the Registrar to examine student's personal files. It was explained that the information was to be used for educational purposes only, and the names will not be revealed.

In order to uncover further variables related to success in calculus, interviews were conducted with 25

selected individuals. These consisted of 4 adults who were in the TAC developmental program working toward calculus and the 21 adults who had taken calculus. Eleven of the participants were female. The information became saturated so no more interviews were conducted. The participants were selected for an interview based upon their passing or failing calculus.

Investigative Categories

Seven attribute variables that may have contributed toward success in first quarter calculus were investigated. These were obtained from the student's records on file in the Office of the Registrar and the Department of Mathematics. The individual variables are:

x_1: Age. This was taken from each student's personal file.

x_2: Willingness to follow the recommendation from the Math Department placement examination. Each student's score on different components of the placement exam gives a recommendation as to what mathematics course they should begin with. From the student records, it can be determined if each student enrolled in the suggested course or bypassed this suggestion.

x_3: Previous mathematical achievement. This variable was constructed because of the inconsistency of available records for adults. The data coding was as follows: 5 for students who passed calculus, trigonometry, analytic geometry, advanced mathematical topics, or pre-calculus; 4 for those who attempted but did not pass any of the courses for a 5; 3 for those who passed geometry, advanced algebra, or beginning algebra; 2 for those who attempted but did not pass any of the

courses for a 3; and 1 for those who attempted general mathematics or consumer mathematics.

x_4: Number of TAC mathematics courses taken at MSU.

x_5: Number of college quarter credits passed at MSU at the time that they enrolled in Math 181.

x_6: Overall GPA at MSU at the time they enrolled in Math 181.

x_7: Success rate of the student's instructor during the quarter for which they were enrolled in calculus. This score was obtained from the percentage of students who passed Math 181 from a given instructor when compared to all of the students who finished the quarter with that particular instructor.

Success in Math 181 was based upon a percentage score taken from a combination of common hour exams and a final exam. Percentage points were used because the grading format changed in the fall of 1990. From the fall quarter of 1988 to the spring quarter of 1990, the grading was based on three common hour exams (100 points each), one final (200 points), and an in-class grade (100 points). Thus, a total of 600 points were possible. However, in the fall quarter of 1990, only two common hour exams (100 points each) were used, along with a final and an in-class grade, which combined for a total of 500 possible points.

A common hour examination was an identical examination taken by all students in Math 181 at the same time. One instructor graded the same problem from every student's exam. Therefore, the variability in grading from class to class was

minimal. Final exams were graded similarly. However, the 100 in-class points were left up to the individual instructor, and these varied widely. For this reason, the in-class points were not used in computing a student's percentage score. The total score was based upon an average of common hour exams and the final. This equated the different methods that were used for grading. Thus, from the fall quarter of 1988 to the spring quarter of 1990, there were 400 total points possible, and in the fall quarter of 1990 and the winter quarter of 1991, there were 300 points possible. However, the dependent variable was based upon a common score ranging from 0% to 100% for all students enrolled in Math 181.

Statistical Hypothesis

In one part of this study, biographical data was used to statistically analyze the 277 adult students under investigation. Four major null hypothesis were tested:

1. The biographical data of adult students did not discriminate between successful and unsuccessful students in Math 181.

2. There was no difference in the success rate in Math 181 of those adult students who participated in the TAC program at MSU versus nonparticipating adult students.

3. There was no difference in the success rate in Math 181 of those adult students who followed the recommendation from the Department of Mathematics placement examination versus those adult students who did not follow the recommendation.

4. There was no difference in the success rate in Math 181 of the adult students who took the placement examination when compared to the success rate of the adult students who did not take the placement examination.

Various criteria were used for evaluating the statistical testing. Two different criteria were used for judging the discriminant analysis. First, the discriminant function produced by the analysis had to be describable using structure coefficients with a value of .3 or greater. Secondly, the descriptive function had to correctly classify at least 75% of the students in order to reject the null hypothesis. This is a 25% increase over the chance inclusion into one of two groups (Klecka, 1980, p. 50). The univariant t-tests were tested at the .05 level of significance. Each result was analyzed separately.

Interview Procedure

The naturalistic component of this research project was chosen to discover new variables that might influence

achievement in calculus. Because of its elusive nature, this open discovery could not take place with questionnaires, surveys, or fixed tests. The aim of the research was to understand human behavior in its own setting (Owens, 1982, p. 5). This included reactions, behaviors, tones, and expressions. The data collection was an ongoing iterative process where each interview suggested new information to be explored.

The interviews were not structured so as to allow the students to expand in their own style. It was explained that the interview would be kept confidential, and the results were to be used for educational purposes only. Names were not revealed. The use of a tape recorder was requested in order to achieve a more accurate record. This allowed the interviewer to observe behavior, expressions, and body language.

Interview Design

Each student interviewed was asked several questions. These were not predetermined, and more were added as new ideas and theories emerged. An outline of representative questions is presented below. These elicited similar information through different questions. The interviews flowed through a conversation format. The students felt at

ease after they knew their opinions were valued, and they voluntarily answered these and many more questions.

1. Introductory questions

a. When did you take calculus?
b. How well did you do in calculus?
c. Why did you take calculus?
d. When did you return to school?
e. Why did you return to school?
f. Did you go to college before now?
g. Did you have enough time to study during the quarter you took calculus?
h. Did you work during the quarter you took calculus?
i. What is your major?
j. Are you married? Do you have children?

2. Life situation of the student

a. What changes have happened in your life since you returned to school?
b. In your words, what has been the most difficult part of your life since returning to school?
c. Why did you take calculus?
d. Where does calculus fit into your major?
e. Describe your life at the time you took calculus.
f. What other things were going on when you took calculus?
g. What needs do you have that are different than the traditional freshman?
h. How is school different for you than the traditional student?
i. How has your absence from school effected you?
j. What could MSU do to help your transition back to college?
k. How does your family affect your school work?
l. What does your family feel about you returning to school?
m. What changes have happened at your house because of you going to college?

3. Calculus instructor

a. What do you think about your Math 181 instructor?
b. How would you rate your instructor?
c. What could your instructor have done to improve the course?

d. How would you describe your instructor?
e. Describe how your instructor helped/hindered you in Math 181.

4. Background and readiness for calculus

a. What background do you think is needed for taking calculus?
b. If I were to take calculus, what advice would you give me?
c. What would have helped you do better in calculus?
d. Describe your ability in mathematics.
e. Some people say that most people are not ready for calculus. How would you respond to that?
f. At the time you took calculus, describe your readiness.
g. What factors would you describe that are needed to pass calculus?
h. What one thing helped you the most in calculus?
i. What do you believe is needed by a student in order to pass calculus?
j. What do you believe helped (or hindered) you in Math 181?
k. Would you describe yourself as a good student?
l. Did you take the placement examination?
m. How did you know what math course to start with?
n. Did you begin in the appropriate math course?

5. Problems associated with calculus

a. What is your opinion of Math 181?
b. How would you change Math 181 to make it a better course?
c. What would you like to see happen with calculus?
d. Was taking calculus different that what you expected?
e. How would you describe your calculus course?
f. Was taking math different that what you expected?
g. If you were in charge, what improvements would you make to the calculus course?
h. What are some of the problems with calculus at MSU?
i. Do you feel that you started in the appropriate math class?
j. How should the math department decide to place students?
k. What changes are needed to help you learn more in calculus?
l. How would you describe the pace of Math 181?
m. What topics need to be omitted from Math 181?

CHAPTER 4

RESULTS

Introduction

Adult students who are enrolled in college form a very diverse group. They cannot be stereotyped because there is no "typical adult student" in terms of academic background, preparation for college, or scholastic skills which were retained during the layoff from formal education. This study attempted to discover and measure some of the characteristics of adult students that were related to success in calculus. These can help identify what factors should be examined when an older student enrolls in college with the intent to major in engineering.

This study consisted of two major parts. First, qualitative research techniques were utilized to determine statistical facts about the population of adult engineering students. A discriminant analysis was used to determine if the adults could be categorized as passing or failing calculus based upon their biographical data. Further, *t*-tests were used to compare specific groups of adult students.