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
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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.

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

Kevin Wayne Trutna

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ii

APPROVAL

of a thesis submitted by

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.

April 22, 1992
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Chairperson, Graduate Committee

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Date  April 22, 1992
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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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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.
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.
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,
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 & Ardaiole, 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 not meet the prerequisites 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 & Ardaio, 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
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 & Ardaioio, 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,
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.
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 than what you expected?
e. How would you describe your calculus course?
f. Was taking math different than 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.
Second, the personal characteristics of adult students enrolled in an introductory calculus course were studied. Through personal interviews, several factors that contributed towards the calculus grades of older students were discovered. Several areas were discussed by the adult students. They usually returned to school immediately after some major change in their lives. In addition, adults were very independent persons and they tended not to seek out help regarding placement material. The lack of time to devote to school was mentioned as a significant factor in an adult's collegiate career. The applicability of the course was the biggest change that adults mentioned should be made to introductory calculus. Furthermore, they felt that they needed better algebra skills than what they had acquired in the Tutor Assisted Courses (TAC) developmental program in order to successfully complete calculus.

Statistical Findings

The quantitative component consisted of a discriminant analysis procedure as well as three independent $t$-tests. All computations were calculated using the Statistical Package for the Social Sciences (SPSS/PC+ version 2.0). There were 277 adult students who took Math 181 during the 3 years under consideration. Their average age was 32 years, and they
ranged from 25 to 51 years of age. Out of the 277 adults, only 46 took the mathematics placement examination, and 11 of these did not follow the recommendation given from this test. As a group, the adults averaged 2.17 TAC developmental classes and had earned an average of 44.15 credits at Montana State University (MSU) prior to enrolling in calculus. Their grade point average (GPA) ranged from 0.40 to 4.00 with an average of 3.01 on a 4.00 scale. These adults were enrolled in calculus courses where the passing rate ranged from 25% to 75% with an average success rate of 55% per teacher.

A multivariate discriminant analysis procedure was used to statistically distinguish between those adult students who either passed or failed introductory calculus. In other words, biographical variables were used to determine if a combination existed which could be used to predict inclusion into either the "pass calculus" or "fail calculus" group. The grouping variable was based on the student's grade in calculus. Seven discriminating variables were taken from each student's biographical records. They were the age of the student \((x_1)\), whether the student followed the recommendation from the placement examination \((x_2)\), previous mathematical achievement \((x_3)\), number of TAC courses \((x_4)\), number of college credits \((x_5)\), grade point average \((x_6)\), and the teacher's success rate \((x_7)\). The correlation
coefficients for the strength of the relationship between the corresponding pair of variables within the two groups of passing calculus and failing is provided in Table 1. All correlations in the matrix are below .5. Out of the possible 21 correlations, only 2 are between .40 to .49, and 3 are between .30 to .39. There are 3 correlations between .10 to .19. All others range from .01 to .09. Thus, the variables within the groups used for the discriminant analysis were independent of each other and did not share any common variance.

Table 1. Pooled within-groups correlation matrix

\[
\begin{array}{cccccccc}
\text{X}_1 & \text{X}_2 & \text{X}_3 & \text{X}_4 & \text{X}_5 & \text{X}_6 & \text{X}_7 \\
\text{X}_1 & 1.00 & & & & & & \\
\text{X}_2 & -.13 & 1.00 & & & & & \\
\text{X}_3 & -.07 & .12 & 1.00 & & & & \\
\text{X}_4 & .19 & -.09 & -.35 & 1.00 & & & \\
\text{X}_5 & -.06 & .13 & -.09 & .39 & 1.00 & & \\
\text{X}_6 & .08 & .05 & .43 & -.38 & -.46 & 1.00 & \\
\text{X}_7 & -.08 & .08 & .08 & .07 & .08 & .01 & 1.00 \\
\end{array}
\]

Age (X_1), Placement Advice (X_2), Previous Mathematical Achievement (X_3), Number of TAC Courses (X_4), Number of Credits at MSU (X_5), GPA (X_6), Teacher Pass Rate (X_7)

A stepwise inclusion of variables was utilized because it statistically eliminated weak or redundant variables based upon their relative contribution to the discriminant equation. Thus, the stepwise procedure searched for an "optimal set of discriminating variables" (Klecka, 1980, p.
A Wilks' lambda provided a measure of discrimination which either included or did not include a given variable. The Wilks' lambda "is a statistic which takes into consideration both the differences between groups and the cohesiveness or homogeneity within groups" (Klecka, 1980, p. 54). Because Wilks' lambda is an inverse statistic, variables were selected based upon their small value. Furthermore, a variable needed an F value of 1.0 or greater to be included in the discriminant stepwise procedure. The F statistic took into account how much additional discrimination was added by the variable under consideration after the contribution of the other included variables were taken into account (Klecka, 1980, p. 57). Therefore, the stepwise selection searched for a subset of biographical variables that discriminated between successful and unsuccessful students better than the entire set of variables.

In order to determine the relative importance each biographical factor may contribute to the discriminant equation, the standardized coefficients were used (Klecka, 1980, p. 29). This allowed for differences in the numerical range of values between each of the biographical variables. By using standardized coefficients, a greater magnitude corresponds to a greater contribution by that variable.
Thus, standardized coefficients determined which variables contributed the most relative importance in discriminating between the two groups.

In order to determine the similarity between each variable and the overall discriminant function, structure coefficients were examined (Klecka, 1980, p. 31). In this study, a criterion level of .3 was used as the lowest level that was judged acceptable for a variable contributing to a meaningful description of the overall discriminant function. Five of the biographical factors were correlated with the discriminant function above the given criterion level (see Table 2). The strongest correlation came from the number of developmental TAC mathematics credits. This was negatively correlated with passing calculus. That is, the more developmental courses that an adult student took, the more likely they were to be included in the group failing calculus. The second strongest was a student's GPA at Montana State University. This was positively correlated with the discriminant function. The teacher's pass rate also had a positive correlation. Thus, an adult student had a better chance of placement in the passing group if their instructor had a higher success rate for their students. Previous mathematical achievement was similarly positively related to success. That is, those adults who have had
higher mathematical achievement in the past had a better chance of being in the successful group for passing calculus. Finally, the number of credits taken at MSU previous to Math 181 was negatively correlated with the discriminating function. Thus, students who waited to take calculus until later in their collegiate career were more likely to be in the group failing calculus. Neither age nor placement recommendation contributed meaningful results to the discriminant function.

Table 2. Structure coefficients for discriminating variables and discriminant function

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of TAC credits (X4)</td>
<td>-.667</td>
</tr>
<tr>
<td>GPA at MSU (X6)</td>
<td>.635</td>
</tr>
<tr>
<td>Teacher's success rate (X7)</td>
<td>.588</td>
</tr>
<tr>
<td>Previous math achievement (X3)</td>
<td>.421</td>
</tr>
<tr>
<td>Number of credits at MSU (X5)</td>
<td>-.359</td>
</tr>
<tr>
<td>Age (X1)</td>
<td>-.123</td>
</tr>
<tr>
<td>Follow placement recommendation (X2)</td>
<td>.122</td>
</tr>
</tbody>
</table>

Since the structure coefficients reveal the relationships between the variables and the discriminant function, they can be used to name the function with emphasis given to the variables having the highest coefficients (Klecka, 1980, p. 31). The variables in this analysis combined to create a phenomena which can be referred to as "Previous Mathematical Competence." Thus, the successful group was characterized as those adult students who had an
intensive mathematical background and were good students overall. They did not need the services of the developmental courses, and thus they took calculus relatively early in their course work. While these factors were internal to the student, one factor was external: the teacher's success rate. This was computed as a percentage of students that a given instructor passed in Math 181 during the term under consideration. Thus, those students who were placed into the successful group tended to have a more extensive mathematical background, and they were enrolled in a calculus course where the instructor had a higher rate of passing students. In general, a student that had significant mathematical achievement in the past had the best chance of success in calculus.

A discriminant function can be calculated to predict placement in either the passing or failing group. Higher scores on the discriminant function are associated with placement in the group passing calculus, and lower scores correspond with the failing group. The only variables included in the discriminant function are: the teacher's passing rate \( (x_7) \), the number of TAC courses taken \( (x_4) \), and the student's GPA at Montana State University \( (x_6) \). Thus, by examining a student's records and retrieving scores on these three variables, the student can be placed into either the
passing or failing group by using the following discriminant formula:

\[ D = 0.05601 x_7 - 2.78999 x_4 + 0.16683 x_6 - 3.15472 \]

Thus, biographical data from a student's records can be entered into this equation to predict if they will pass or fail Math 181. However, this function does not contribute greatly to explaining the difference in these groups. The square of the canonical correlation indicates the amount of the variation in the discriminant function that is explained by the two groups (Klecka, 1980, p. 37). In this study, only 7.5% of this variation was explained. With no previous knowledge, the expected prediction would be 50% accurate because there is a choice of only two groups, pass or fail. However, based upon past data, the success rate in Math 181 ranged from 54% up to 58% for all students. This discriminant function correctly classified only 60.29% of the students (see Table 3). Thus, the selected biographical data improved upon the chance prediction of passing or failing by only about 10%. Furthermore, the discriminant function improved the prediction power based upon past data by even less than 10%. Although a clearly describable function was produced, the hypothesis that a discriminant function for predicting calculus success based upon adult student's
biographical background was rejected because the function contributes so little to accurately predicting group placement into either passing or failing calculus.

Table 3. Classification results from prediction equation

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Cases</th>
<th>Predicted Group Membership</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FAIL</td>
<td>128</td>
<td>FAIL 81</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>63.3%</td>
<td>PASS 47</td>
</tr>
<tr>
<td>PASS</td>
<td>149</td>
<td>FAIL 63</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>42.3%</td>
<td>PASS 86</td>
</tr>
</tbody>
</table>

Several univariant analysis were also conducted. An independent $t$-test procedure was used to examine the difference between the two groups as they were compared according to the variable of passing or failing calculus. A score of 1 corresponds to a passing grade while a score of 0 represents a failing grade in calculus. The first $t$-test compared students who took TAC developmental courses versus those who did not take TAC developmental courses to determine if there was a difference in the success rate in introductory calculus. There were 80 nontraditional aged students who did not participate in TAC courses and 197 adult students who participated in the program. A significant difference was found between these two groups ($t = 2.95$, $df = 275$, $p = .003$). That is, those adult students who did not take TAC developmental courses ($\mu' = .68$) passed calculus at a
statistically significant higher rate than those adults who took TAC classes ($\mu' = .48$).

Two other independent $t$-test analysis did not yield significant results. Those adult students who followed the recommendation from the mathematics placement examination were compared to the adults who did not follow this recommendation to see if there was a difference in their success rate in calculus. There were 31 students who followed the advice as compared to 11 adults who did not follow the placement advice. The results were not significant ($t = 0.52, df = 40, p = .603$). Thus, there was no statistical difference between the students who followed ($\mu' = .55$) and those who ignored ($\mu' = .45$) the mathematical placement advice from the departmental examination.

Only 42 out of a total of 277 adult students took the placement examination. A $t$-test was used to determine if there was a difference in the success rate between the adults who took the placement examination versus the adults who did not take the placement examination. The results were not significant ($t = 0.20, df = 275, p = .843$). Therefore, there was not a significant difference between those students who took the mathematics placement examination ($\mu' = .52$) and the adults who did not take this test ($\mu' = .54$).
In addition to the quantitative data analysis, qualitative interviews were conducted with 25 students. They were chosen because they possessed certain desired characteristics. Of the 25 adults interviewed, 21 had taken Math 181, and 4 were in the TAC developmental program developing their skills to take Math 181. There were 5 of the 21 adults who had attempted, but not passed calculus. Thus, 16 of the adults interviewed passed calculus. However, 9 of these adults took calculus more than once before passing. Out of the 16 adults who did receive a passing grade in Math 181, only 6 persisted in an engineering major. Those students who either failed calculus or those who passed calculus but transferred into another major tended to choose teaching or business related fields. Eleven of the adults interviewed were female. The ages of the students interviewed ranged from 27 up to 46 years. The age breakdown of the adults interviewed was as follows: 4 adults were between 27 and 30 years of age, 10 were between 31 and 35 years of age, 8 adults were from 36 to 40 years of age, and 3 adults were between 41 and 47 years of age. Because the study looked at past data, most adults interviewed were well into either junior or senior level classes. Several main themes emerged from the interviews.
Trigger Event

Adults enroll in college for many reasons. The adults at MSU had similar characteristics to other adult students who were described in the literature. That is, most adults entered college to increase their earning capacity through the possibility of a better job (Kasworm, 1980, p. 31; Sewall, 1982, p. 28). They had advanced as far as possible in their present job, or they wanted the potential for another career. However, poor paying jobs were not the only reason these adults returned to school. Many adults interviewed held good paying jobs, and they voluntarily terminated their position. They needed a new challenge in life, and college provided this opportunity. "I had a really good job, but I decided that I needed to do something else." These adults were in college to achieve personal satisfaction.

Some of the older students stated that they had always wanted to go to college. However, the timing was never right, or family obligations restricted their enrollment. Most adults interviewed claimed that the right timing was one of the biggest factors in their returning to college. However, further analysis of the situation revealed that some major event in their lives may have brought about the right situation for returning to college. This usually was a
divorce, being laid-off from work, or the birth of a child. This major event provided an opportunity for a significant change which included college.

Having my daughter was the biggest thing. When you have a child you re-evaluate your life. You have to decide what you are going to do with your life because whatever you decide affects your family.

I came [to college] because after my divorce, I didn't have any skills. I could have gotten a job. But this is something that I have wanted to do for a lot of years, and I never really had the opportunity.

I had a job that was going nowhere, and I got divorced. So I decided to go to school.

This major change in the adult's life allowed them to attend college. It provided the opportunity for them to re-evaluate their priorities and goals. It also provided the right timing in which a major change could be attempted. The hardest part was deciding to go to college and taking the first step in attending college.

Mathematics Placement Procedure

Traditional college age freshman usually have a structured placement program and testing procedure that helps determine their major field of study and course load. In contrast, adults do not have this opportunity. Some seminars or programs such as the Return to Learn weekend at Montana State University are available, but these are not widely
attended because of time and money constraints. Therefore, adults must seek other placement advice such as friends, a faculty member, or the school catalogue. This self-placement procedure leads many adults to failure in college. They often do not meet certain prerequisite guidelines, and they must drop courses because they do not possess the knowledge from these prerequisite courses.

Adults enter college on their own and make their own decisions regarding what courses to take. Very few adults take the mathematics placement examination. They do not seek this advice because they are independent persons. As adults who have lived and worked on their own, older students feel they should make their own decisions. They feel that no one should tell them what to do. "They should offer the placement test and leave it up to the students. If they think they can brush up on the material on their own, then they should be allowed to start in calculus. After all, it is their money." The present calculus course enrolls students who do not meet the prerequisite guidelines; in addition, many of the adult students did not take the placement examination. They are independent learners and did not use the placement procedure offered from the mathematics department. This often leads an adult into starting in a mathematics course for which they are not prepared.
Adults are often intimidated by college, and in particular they may be "scared-to-death" by a mathematics course. They may initially enroll in low level courses to build up their academic skills. However, they may have no idea of what their mathematical abilities are, so they enroll in the lowest level course and progress on through calculus. A placement test may help prescribe a beginning course. However, most adults who went through the TAC developmental program stated that there was a large gap between the algebra course and calculus. The courses were taught differently and expectations were not similar. Mathematics intimidated adults more than any other subject. They felt they could not progress through all of the mathematics courses in sequence and know what to expect in calculus. They also felt that they were not prepared for calculus by the TAC program. This created anxiety and an attitude where failure was expected. Some adults even took the calculus course multiple times and considered that to be normal behavior. The older students were intimidated and frustrated because they did not possess the skills required by the introductory calculus course.

Some adults were not aware of the mathematics placement examination when they enrolled at Montana State University. Most students interviewed agreed that the test should be an advisory tool and not a rigid placement criteria. Because of
their independent nature and desire to make their own decisions, they felt that the placement test should help them become aware of their strengths and weaknesses without prescribing a course of study. In other words, they wanted the placement test and subsequent course placement to serve as a tool to assist adults in making decisions for themselves.

Adults typically do not know what to expect from college. Many adults spoke of being intimidated or scared about attending college. This fear was coupled with a major change in their lives that allowed them to enroll in college. Add in the fact that adults may not have used scholastic study habits in many years, and this may place them in a highly vulnerable position which can lead to failure in college. Therefore, they feel a better placement procedure other than peer advice should be readily available and known to all entering adult students. "I think having more counselors and advisors to help you to choose classes, make suggestions, and make sure you feel good about the classes you have taken; just some advice." They felt that better counseling might help make the transition to college much easier for the adult student who has been out of school for a number of years.
Time Constraints and Success

Time is a major issue for adult students. They see their time constraints as different from those of younger, traditional aged students. Besides full school loads, many adults are married, have children, and work to pay for these responsibilities. Time plays two significant roles in the lives of nontraditional aged students. First of all, they feel that they do not have many years to linger in school. Adults feel the need to decide on a major and to graduate as soon as possible so they can provide a better life for their family. "When you are 18, you think you have lots of time, and school doesn't matter that much. When you are 33 and married, you begin to wonder if you do." As a result, they have specific goals from their college education.

Secondly, older students have other responsibilities, and school may not be a top priority. The life of an adult student may be so busy that they do not have extra time to devote to studying. "Freshman may just take three or four classes and don't do anything else. That would be great, but my life doesn't end there. I have work, three kids, and their school and activities." Therefore, adults do not have time to waste, and some of them complained about a lack of social life. Time constraints and conflicting responsibilities certainly affect a student's academic
performance. "I do a lot of adding and dropping because of my family situation at the time." These pressure adults to obtain a degree as soon as possible, but at the same time they do not allow adults to concentrate entirely on their studies. Adults want to succeed in college, and they want to succeed as soon as possible. In contrast, their life situation may prevent them from dedicating the effort required to progress through college at a fast pace.

The majority of adults mentioned that evenings were reserved for family and work obligations. They try to study between classes because they may not be able to study at home or later in the evening. "When you have kids, as a mother, I feel that I have a responsibility to them. I belong with them, that is my priority." Typically, adult students spend evenings with their family or at work. As one 39-year old sophomore put it, "My 2-year old doesn't seem to realize when I have a test the next day." It may not be possible to do school work at home because of the numerous distractions. As a result, a few adults mentioned that they wanted a quiet place to study at school. In addition, adult students often mentioned the lack of outside help in the calculus course. Because of time constraints, they may not be able to make an instructor's office hours, and they complained about help in the tutoring center. They felt that quality help was not
always immediately available. Since adults do not have time to waste, they need access to quality help and places to study that can fit around their schedule.

Adults mentioned that school was a different lifestyle than working. "It stays with you 24 hours a day; you can leave work after 8 hours." This caused problems because of family and other work obligations. Older students claimed that they had problems finding time to study outside of school. "On the job, I could go home and forget about it; I can't forget about college." College studies demand a lot out of the adult students. Because of their other priorities in life, they may not be able to dedicate as much time to their studies as they would like. This time limitation was mentioned as a source of significant stress for adult students.

Adults believe that they take education more seriously than traditional aged college students. Because adults voluntarily enter college, they usually want to succeed and receive good grades.

I see too many 18-21 year olds who don't know what school means. They haven't been out to know what work is and what it means to make enough to pay the bills. As for me, I'll really appreciate what I'll get in the end.

Consequently, they are more focused and know what they want from school. However, as mentioned above, there are many
factors that vie for a student's time. "When things on the outside bother you, it makes school that much tougher." School is very important, but family responsibilities also play a significant role. Therefore, adults do not want to waste time in school. However, they do enjoy challenging courses, they want to learn, and they do not always want the easy way out. They feel that courses should be relevant and meaningful because they do not have a lot of time to devote specifically to their studies.

Nontraditional aged students want to learn useful material that has real applications to the world outside of school. This idea relates to the literature on adult education (Knowles, 1970, p. 48). The adults interviewed claimed that they wanted to really learn and understand the important material and not just to go through the motions to pass the course.

I expect to learn something from the class. I expect to get my money's worth. When I take a class, I am hoping that it will make me a better person.

I know that I really need to know the material and not just get a piece of paper that says you took the class. Now I really try to understand the material and relate it to other information.

Adults enter college for a challenge and personal advancement. However, they need to budget and use their time wisely because of the limited amount of time that they may
have to devote to their studies. "I want to do well, but so many things take my time away from studying."

In general, adults want good grades. This is true of most students, but some adults mentioned that they dropped calculus specifically because they did not want to receive a poor grade. A poor grade may signify failure, and this may enhance the lack of confidence in the mathematical abilities of many adults. This failure may reinforce their already negative attitude. "I pay my own way, and when I blow an exam I feel bad. These 18-year olds are nonchalant, like it doesn't matter."

Accomplishment and achievement were seen as significant rewards by many adults who finally passed calculus. They want challenging material, and they enter college with the intent to succeed and to reach ultimate goals.

I was devastated by my first C in calculus. But then I knew how hard I worked and how much knowledge I retained, and that C was worth it. It made my day.

I had to laugh. Calculus brought me to my knees. I was very frustrated. I felt stupid, like I'm not going to be able to handle this. Calculus will keep me from getting my degree. Then I passed, and I felt like a million bucks. I know it is hard and it is a struggle, but it is worth it.

This proud sense of accomplishment was observed in a number of adult students. Passing calculus served as a symbol. They had the feeling that if they could pass calculus then
they could succeed in college. However, the problem is that adults may quit, and calculus may deter them from obtaining their goal of a college degree. A poor grade in calculus may signify to the adult students that they are not good enough for college and should not have come back to school. Adults felt that poor grades reinforced this attitude.

Changes in the Calculus Curriculum

Every adult interviewed had some idea on how to change calculus to make it a better course. This was true for those who passed at the top of their class as well as for those adults who struggled unsuccessfully through the course multiple times.

The teacher was mentioned by many adults as having an influence on their success. Older students claimed that they need an instructor who does not expect too much. That is, the instructor should realize that the audience is diverse in terms of abilities and mathematical preparations. Adults felt that teachers should recognize these limitations and realize the "not everyone is good at math." An instructor who can translate the material into understandable terms was often mentioned as a benefit. Because nontraditional aged students feel they should make their own decisions, many students expressed the idea that they should be able to transfer into a class where the teacher seems to work best
for that particular individual. Most adults recognize that they have a preferred style of learning, and they want to transfer into a calculus class that is taught in their preferred style.

Most adults criticized the material and pace of the calculus course. They claimed that direct applications of the material would make it more meaningful and easier to understand.

I can't remember all of the class, but I use some of the material. Some of the material was esoteric, you know, things you will never use in engineering. It would be better if they would concentrate on the stuff you need to know.

Those adults who passed the course often made the statement that they could memorize the material, but they never understood what purpose or use it actually served. This thought was echoed in many students' comments regarding the pace of the calculus course. The majority felt that the course was too fast. They would like to slow down so that they could grasp and understand the concepts and not just memorize procedures. This was especially true of the material up to the first examination because it set the tone for the whole course. Wanting to actually understand calculus further supported the concept that nontraditional aged students enrolled in college to learn new material and not just solely to obtain a degree. "I like the
applications. It is important to know why in the heck do I need to know this."

Personal situations were often mentioned as having a profound influence on a student's calculus grade. Adults mentioned that the instructors should recognize the different life situations of many of the students. Adults claim that the school should not change to accommodate their specific situation, but examinations and classes could be more flexible to allow for these differences.

I have to deal with luggage that I came in with. That is a choice I made and it is not the responsibility of the school to deal with it.

There are certain things that we have to do in college. It is like a contract when we started college. But they should acknowledge certain restrictions in our lives.

Adult students are independent and have made their own decisions in life. They want the university to understand their situation and recognize it. Because of time restrictions, many adults complained about night courses, seminars, and required laboratories if they were perceived as a waste of time. The school should recognize the situations of the adults and the time limitations that they have regarding school. "You have to keep up and that is a problem sometimes." Adult students are not asking the university to change for their specific situation, but the rules could be more flexible to serve the school's clientele.
The overwhelming majority of nontraditional aged students claimed that algebra skills were the biggest factor regarding success in calculus. Most students recommended that the mathematics curriculum be changed to include a rigorous algebra course that prepared the students for calculus. As mentioned earlier, adults felt that the TAC developmental program did not prepare them for calculus. Students said they needed a better background and base of algebra knowledge on which to build calculus. In their opinion, it was not the calculus that was the difficult part, but it was the algebra required in order to manipulate the material which caused problems.

Understanding limits was the concept which gave adults the most problems. Limits explain instantaneous behavior as compared to the average behavior of objects over time. They saw limits as the underlying principle behind all of calculus. This principle helped explain acceleration, velocity, and the rate of change of objects over time. They expressed the idea that it would have been beneficial to see limits in an intensive algebra course because of their importance to calculus. This idea also showed up when adults criticized the pace of the calculus course. They felt as if the first part of the course progressed too fast when they were studying limits. This served as the base of the whole
course, and they wanted to slow down and understand the material better. Some students mentioned that they had no problem with differentiation and integration, but understanding limits even helped them succeed in higher calculus courses. This reiterates the idea that adults enroll in college to learn new, relevant, and applicable information. They do not enter college just to obtain a degree.

Summary

A multivariate discriminant function was calculated for placing adult students into either the passing calculus or failing calculus group. These groups differed in regards to "Previous Mathematical Competence." That is, those adults were more likely to be placed into the passing calculus group if they were successful in previous mathematical courses, if they were good overall students, and if they did not require the services of several developmental mathematics courses. However, the discriminant function improved upon a 50% chance prediction for including a person into one of two classification groups up to a prediction that was accurate for about 60% of the cases. The overall success rate for Math 181 ranged from 54% to 58% based upon past data. Thus, the discriminant equation did not greatly improve upon the
prediction power based upon past data. Furthermore, only 7.5% of the variance of the function was explained by the two groups. Other univariant analysis revealed a significantly higher success rate of those adults who did not participate in the TAC developmental courses versus those adults who did take TAC courses. No significant differences were found on data regarding the placement examination.

Adults view their lives as different than that of a traditional college aged student. They have worked and lived on their own for many years. Thus, they are independent people and may not seek out all available help when returning to college. Many return to college because of some major change in their lives, and the lack of time is a significant concern for them. Adults generally were intimidated by college. Failing classes helped to reinforce this negative attitude. Insufficient algebra skills was the main factor that adults felt contributed to their poor grades in calculus.
CHAPTER 5

CONCLUSIONS

Summary of the Study

Nontraditional aged students over the age of 25 are entering American colleges and universities at a very high rate. The proportion of these adult students is growing rapidly, and they now compose a sizeable subpopulation within the university as a whole. This shift in the student population has no foreseeable decline in the immediate future (US Department of Education, 1991, p. 159). However, they are largely being ignored in regards to teaching methods, entrance requirements, and missions of the university (Kasworm, 1980, p. 41). Out of the 10,000 students at Montana State University (MSU), approximately one-third are over 25 years of age.

Adults enter college for personal achievement and to obtain better employment. They have specific goals for their education and a definite vision of what they want to do after graduation. The College of Engineering is the largest college within MSU, and it is the premiere engineering institution in the State of Montana. Thus, a sizeable number
of adult students enroll at MSU with the intent of majoring in engineering.

The mathematics requirement in college is often difficult for adult students (Thompson & Friske, 1983, p. 13). Introductory calculus, Math 181, is a prerequisite for engineering courses which may lead to a degree. Thus, calculus plays a significant role in the course work of engineering students because it is one of the first classes that must be passed before they can attempt engineering courses.

There are many problems associated with the calculus curriculum. First of all, the success rate is approximately 50% for all students. Furthermore, the mathematics placement examination may be an ineffective tool for adult students because of their prolonged absence from school. Mathematics is traditionally a discipline where new information builds upon existing knowledge. There is a hierarchy of topics, and adults may have many "learning gaps" in the knowledge that was retained since their last school experience. Thus, other placement procedures may be helpful for adults (Lawrence, 1988, p. 3; Webb & Tripp, 1987, p. 6). Other problems stem from the lack of mathematical skills which are required for calculus. These often are not acquired in lower level, developmental courses (Whitesitt, 1980, p. 96). Therefore,
this population of adult students was studied to determine their characteristics and to discover what factors combine to create an atmosphere which can influence their grades in introductory calculus.

There were 277 adult students enrolled in introductory calculus between the fall quarter of 1988 through the winter quarter of 1991. These years were chosen because of similar textbooks, objectives, and testing procedures. A census of all of the older students was taken. Adults comprised approximately 13% of all students taking the first quarter of calculus in the years under consideration. Out of all of those adults, 149 passed Math 181 for a 54% success rate. This was comparable with the overall success rate which ranged from 54% in the fall quarter of 1990 to 58% in the fall quarter of 1988. A discriminant analysis procedure was used to determine if seven biographical factors could help classify adult students as successful or unsuccessful in calculus. These variables were obtained from the student's records. Although it was possible to produce a discriminant function using these known and readily accessible variables, this function was only 10% above a chance prediction for this grouping. Therefore, qualitative interviews were used to uncover other factors that influenced the adult student's performance in calculus. This case study approach avoided
preconceived hypothesis and consequently allowed for uncovering unknown factors regarding adult engineering students.

The average age of all adults enrolled in calculus was 32 years. On the average, they had a mathematical background prior to Math 181 roughly equivalent to passing advanced algebra or trigonometry and to attempting but not passing calculus. These adults students took approximately 44 credits at MSU before calculus and earned a grade point average of 3.01 on a 4.00 scale. Only 42 of the 277 adults took the placement examination. Although demographic factors can be isolated and described in statistical terms, it is difficult to portray the average adult student. Those adults in both the passing and failing group differed greatly in regards to backgrounds and academic preparations.

The major statistical finding of this study did not greatly improve upon a chance prediction into one of the two groups. The three variables of teacher success rate, number of TAC developmental courses, and student's grade point average at MSU were used to discriminate between the two groups of students. This combination of interacting variables was termed "Previous Mathematical Competence" because the function described those adults who had performed well in mathematics courses in the past and did not require
the services of the TAC developmental courses as the most successful students in calculus. Given no previous knowledge, a successful chance prediction could be made 50% of the time when placing adults into the passing calculus or failing calculus group. The discriminant analysis only increased this prediction power by about 10%. Thus, the discriminant equation correctly identified approximately 60% of the adult students as passing or failing Math 181. Based upon previous data, the overall success rate of students enrolled in Math 181 was between 54% and 58%. Thus, the discriminant equation did not greatly improve upon the prediction power based upon past data.

In addition, an independent t-test found that there was a significant difference between those adult students who participated in the TAC program versus those who did not take any TAC developmental courses. Adults who bypassed this program tended to pass calculus at a higher rate. Furthermore, no significant difference was found in a comparison between adult students who took the placement test versus those who bypassed this test. Likewise, there was no significant difference in the success rates of the adult students who followed the recommendation of the placement examination when compared to the students who ignored the placement advice.
The qualitative interviews were designed to search for further information that was related to an adult student's grade in calculus. It was discovered that adults were particularly vulnerable when they returned to college because some major event or change in their lives usually precipitated their returning to school. Typically, this was a divorce, birth of a child, or loss of a job. Thus, besides the major change of coming back to school, adults may also have a significant life event to deal with as they start college.

Adults may not have been aware of the mathematics placement examination when they returned. However, adults are highly independent, and they resent being told what to do. Having lived and worked in the world, older students feel as if they should make their own decisions in life. They may have perceived the placement examination as such a tool for making decisions rather than pointing out their strengths and weaknesses. Thus, very few adults took the placement test.

The lack of time to attend to all of their life tasks was mentioned as a significant factor in the lives of almost of all of the adults interviewed. This posed a significant problem because adults enter college to obtain specific goals as quickly as possible. Many have a family to support and
raise, and thus they want to graduate as soon as possible. On the other hand, their family and work obligations take away precious time that can be devoted to studying. Thus, even though adults want to learn in college and graduate quickly, they have other priorities and may not be able to spend a significant amount of time exclusively on their school work. Time pressured adults to obtain a degree, but it also prevented them from dedicating the needed hours for this goal.

There were many changes that were suggested by the adults regarding the calculus curriculum. The pace of the course was criticized because it did not allow enough time to understand the material as compared to just memorizing procedures. Adults wanted a course that was more applicable, and they wanted to know the practical significance of the material being studied. Algebra skills were mentioned as being the biggest factor contributing to success or failure in calculus. The TAC developmental courses did not provide a significant background, nor did adults feel that they possessed the skills needed to manipulate the calculus material.
Conclusions and Recommendations

There are several conclusions that can be drawn from this study. First of all, adults are not predestined to failure in a college calculus course even if they have a particularly poor mathematics background. Given the present information it is not possible to predict inclusion into either passing group or failing group with a high degree of accuracy. The prediction equation correctly classified only 60% of the students. This is a small gain of 10% over the chance inclusion into either the passing or failing calculus groups (Klecka, 1980, p. 50). Even though the function termed "Previous Mathematical Competence" was used to discriminate between successful and unsuccessful calculus students, it did not greatly improve the chance prediction power. Thus, there are many other factors which contribute toward success in calculus. Because of the low predictive ability of the discriminant function, other variables should be taken into account when an adult enrolls in a calculus course. These other factors are not readily available from the current records.

Five biographical variables were correlated with the discriminant function. The number of TAC courses had a highly negative correlation. This indicates that good mathematics students do not need the services of the TAC
program. This theme follows with the negative correlation of the variable related to the number of credits at MSU. The good students take calculus courses relatively early in their undergraduate program because they enter college with a good preparation for taking calculus. Thus, they have higher previous mathematical achievement. In general, a successful student was enrolled in a course where the teacher passes a higher number of students. There was no way to represent a variable that reflected a "good calculus teacher," so the success rate was used. Therefore, a successful calculus student does not have to fight for a relatively small number of passing grades that were given by the instructor.

There were two variables which were not related to the discriminant equation. First of all, age was not related. Thus, it did matter how old a student was in regards to passing calculus. This can be interpreted to mean that older students are not predestined to failure in calculus. Secondly, information about a student's willingness to follow the placement recommendation was not correlated with the discriminant function. It was discovered that only 42 out of 277 adults took this placement test, and this low number of students may have affected the correlation. Therefore, the variable related to the placement examination may not be very useful in interpreting the results. Any conclusion drawn
from such a low percentage of the population should be viewed with skepticism.

Other factors were significant elements in the lives of adult students besides the biographical variables that were used in this study. Adult students felt that they did not have enough time to dedicate to school. The number of hours worked, the number of dependent children, and the number of credits taken during the quarter the student attempted calculus could be used to measure the amount of time that adults had to specifically devote to their studies. Advice from the placement examination could be studied in more depth. This score could be broken down based upon individual topic areas to determine which specific skills an adult possesses. Furthermore, the goals and expectations that adults have regarding college could be looked at to discover how devoted they are to their studies or to match their course work with their future goals. Appropriate instruments and subsequent data on this information might improve the prediction power of the discriminant function.

Adults enter college to obtain a degree or training which can lead to better employment opportunities. Furthermore, many adults interviewed stated that they needed a new challenge in life. Proper counseling could help adults enroll in courses that would meet these goals. Adults may
need many "survey type" courses which could introduce them to new disciplines. The adults interviewed claimed that they may have taken courses because they "just looked interesting." Counseling and testing might help illuminate some of the interests that adults may have toward different subject areas. In addition, they could be made aware of what courses would be appropriate to start with in an area where they may not have any experience. This might eliminate starting in a course that is too difficult, or conversely, beginning in a low level course which stifles the adult's curiosity and motivation. Thus, advisors need training to be aware of other nonacademic factors that influence a student's ability to perform well in the classroom. In addition, the advisors need to be aware of the skill and time requirements needed for particular courses.

Adults tend to enroll in college after a major change in their lives. Because they are particularly vulnerable at the time they begin college, adults need extensive orientation and counseling advice when they return to college. Due to this major change in their lives, adults need reinforcement to help alleviate an attitude that may be negative toward mathematics as well as feelings of inadequacy in their new environment. Thus, proper counseling may help eliminate adult students being overwhelmed as they return to college.
There are many aspects that should be explored when an adult decides upon a course load. First of all, an advisor should take a careful look at the previous academic record of an adult student. These should be looked at in light of the number of years elapsed since the last enrollment in school. Previous academic records may be useful in determining the academic abilities that a student possesses. However, the life of the adult may have changed dramatically since high school, and these records may no longer be applicable. Careful attention should be paid to the skills that were used in the years away from school. Objectives, expectations, and prerequisites can be discussed so that adults know what knowledge and skills they are required to possess when they enroll in a particular course.

Furthermore, a network may be formed so adults have a support group. Adults need good advice when returning to school, and they need to know that other people are experiencing the same problems. Since many adults have typically had a recent major change in their lives that afforded them the opportunity to enter college, they need to be treated as individuals because of their vulnerability and new lifestyle as a college student. Advisors need to be trained to become aware of these nonacademic factors that influence the lives of adult students.
A diagnostic procedure should be established for adults rather than the existing placement examination. This could incorporate some type of placement test as well as meeting with an advisor to discuss the adult's personal situation. Even though there was no statistical difference between those adults who took the placement examination and the students who did not take this test, the numbers were small. Only 42 out of 277 adults took the placement test. Thus, students do not appear to take the placement examination very seriously, and any conclusions drawn from such a small sample should be viewed with skepticism.

It is recommended that all students take some type of diagnostic test to discover their strengths and weaknesses rather than to prescribe a required sequence of courses. Adults either are not aware of the present placement examination, or they do not perceive it as being useful. Therefore, the diagnostic examination and subsequent advice could be restructured so that adults do not see the test as a waste of time. The results should be meaningful, and they should point out particular weaknesses and strengths of an adult's mathematical ability. Then adults can correct these deficiencies prior to enrolling in calculus. This can be accomplished either by learning the material on their own or by enrolling in a developmental course that addresses the
adult's particular needs regarding mathematical abilities. That is, instead of repeating a whole year of algebra to acquire a few specific skills, an adult may enroll in a few short, module type of courses. These can address specific weaknesses that a student may have regarding certain mathematical topics. Thus, the diagnostic advice should not prescribe a series of courses, but it can help adults discover their needs and retain their independent nature. Furthermore, adults could make their own decisions on how to obtain the needed skills before they enroll in calculus.

Adults thought of themselves as being independent and solving problems for themselves. They want to make their own decisions. However, this lack of placement advice caused many students to repeat calculus. Adults should be aware of the services that are designed to help them, especially regarding placement advice. Adults need advice that is relevant and meaningful. They do not have time to waste so results should be worth the effort of seeking diagnostic advice. They should know what is expected for each particular course in terms of the skills needed and where the course fits into a student's program. Programs such as the Return to Learn weekend could significantly help adults. The cost and time requirements should be kept to a minimum in order to encourage adult participation.
Consideration should be given to redesigning the material on the present placement test so that it does not discriminate against adult students who have been out of school for many years. It should not be based on remembered formulas. Rather it should measure if an individual possesses the knowledge needed for each mathematics course. That is, instead of requiring the recall of specific information, it should determine if a student can comprehend and manipulate given material. Problems should not start out with the recall of specific information. This may bias one's score because the adult student may not even be able to get started with solving the particular problem. By presenting certain formulas and types of problems, it can be discovered if adults possess the skills to manipulate the given material. Furthermore, the results should be scored for each individual subject area so adults can directly locate their strengths and weaknesses. The examination should not be random choice. Rather, all work should be displayed so that an instructor can determine where the adult encounters problems with the mathematics. Adult students may be motivated to take this type of placement test. As it is, adults claim they often feel stupid because they do not recall all of the information that they may have studied a number of years earlier. They feel that their mathematical
skills are poor, and by performing poorly on a placement examination, their feelings of inadequacy are reinforced. The placement examination could also be given at a latter date after adults have had a period of time in which to brush up on forgotten skills and mathematical formulas. In addition, a criteria for the required material could be made available so adults could know specifically what skills are needed for each course. This may help adult students set obtainable goals instead of promoting negative attitudes.

The TAC program is not adequately preparing adult students to success in calculus. Algebra skills were mentioned as having the biggest impact upon a student's calculus grade. The TAC program provides all of the algebra preparation at Montana State University. However, it was not originally designed to prepare students for a rigorous calculus course. It was designed to provide developmental mathematical skills for those students who did not take 3 years of high school mathematics. Therefore, the TAC program is being misused as the sole preparatory course for Math 181.

In addition, there was a negative correlation between being placed into the successful group of calculus students and the number of TAC courses that a student took. Furthermore, the adults who did not take TAC courses passed calculus at a significantly higher rate than those adults who
participated in the TAC program. Therefore, the current algebra course should be improved to prepare all students for calculus. One recommendation is to determine specific objectives that should be met before entering calculus. This will determine what expectations are required for Math 181. Because the TAC courses are designed to prepare a student for calculus, the objectives, goals, and required material should be similar for both the TAC courses and the calculus course. At the present time, the TAC courses are all self-paced, and examinations are multiple choice. They are almost identical to the practice tests within the textbook. However, students in the calculus sequence must keep up with the pace set by the instructor. They are required to show all of their work and to justify each step involved in solving a problem. Furthermore, the examinations may require students to apply the knowledge they have obtained from the book. These problem-solving skills are not being developed in the TAC program. In addition, the examinations are not taken from the text, and students must comprehend and translate different information. It is recommended that the TAC courses and calculus have similar objectives and teaching methodologies.

Adult students like the personal attention that they receive in the TAC program. A tutor is available to help
them with their specific needs. However, because adults may
don not have been associated with formal mathematical training
for a number of years, there should be some more structure to
the TAC courses. They could be designed in a manner that
would incorporate some classroom instruction in addition to
the tutoring. This may help ease the transition into a
calculus course where the students are expected to keep up
with daily assignments.

In addition, adult students were not content with the
material in the calculus course. Presently, they are not
adequately being taught the fundamental knowledge that they
will need to build upon and to succeed in calculus. Algebra
courses could be redesigned to preliminarily introduce the
important topics that will be covered in calculus such as
rate of change, acceleration, and instantaneous velocity.
Adults claim that these should not be "new discoveries" in
calculus because they are central ideas to higher
mathematics. It would help in the understanding of the
material if students were at least introduced to these ideas
previous to calculus.

Applications and relevant problems should be an integral
part of algebra and calculus. Furthermore, adults mentioned
that they did not develop enough problem-solving skills from
the algebra course. While there should be a significant
emphasis on algebraic manipulation, students also need to incorporate these skills as they apply to situations in the real world. Word problems and applications should not be an after-thought where a few examples are appended at the end of each section. Rather, real-world applications and interesting examples could serve as a starting point for studying the material. This could provide motivation as well as pointing out the usefulness of the mathematics. Mathematics should not be divorced from the real-world applications.

Adults realize that they enrolled in college to better themselves, and they claim that they really want to learn and understand calculus because it will be useful in further engineering courses. Therefore, course objectives could be constructed which teach calculus at a higher level of understanding and requires a student to demonstrate that they know more than just repeating procedures. Typical calculus examinations are based upon the lower levels of Bloom's taxonomy. Students are asked to recall information, recite theorems, and calculate certain answers. The course may be improved if students were required to demonstrate higher levels of knowledge such as applying and extending certain knowledge to new situations. They should be asked to synthesize new material with the knowledge that they possess.
They should be required to demonstrate a thorough knowledge of calculus and its relevance to further subjects. They also need to apply the material to physical problems. This is especially true with adults who want relevant material that has immediate applications. These could be built upon some of the past experiences that adults have encountered in their lives. The wealth of past experiences which adults possess should not be ignored regarding the topics covered in the calculus curriculum.

Adults feel that their time constraints, goals from college, and dedication to learning are all different than the average traditional aged college student. However, these are largely being ignored by the instructors. The faculty should be made aware of the needs and unique situations of adult students. This may be accomplished through professional development seminars. Adults are a different composite group than the traditional 18-22 year old college students. It is not requested that changes and exceptions should be made for every adult student, but institutional demands can be more flexible to allow for the adult's time restrictions. Adults are goal oriented, and they need specific objectives which can be achieved. Attendance requirements, class meeting times, and surprise quizzes seem to penalize adult students because they may have other
priorities which can prevent them from attending every class. However, the material should not be watered-down. Adults must be accountable for thorough knowledge of the subject matter, but testing and other evaluation procedures could incorporate the goal-oriented nature of adult students. Group projects, demonstrations, and presentations could replace examinations. This would not penalize an adult for missing a class period due to circumstances beyond the control of the individual. Furthermore, these evaluation methods could promote higher levels of understanding within the calculus curriculum. Adults represent a sizeable subpopulation within the university, and they should not be ignored. This is particularly true in the area of mathematics which causes much anxiety and negative feelings from adult students.

The course expectations could be modified in many ways. Adult students experience many time pressures because of their family, work schedule, and school load. Instructors could take this into account and not penalize a student for missing a class if a sufficient reason is given and students demonstrate they know the material. Furthermore, the assignments, tests, and laboratories should be constructed so that students receive maximum benefit and not just waste their time to get in the required number of hours for a
particular course. Because evenings are often devoted to family and work demands, a significant amount of time should be given to complete assignments. Adults may not be able to work on the assignment the night it is handed out. Rather, they need to budget their schedule and have a significant amount of time to complete the task.

Recommendations for Further Study

There are several studies which may build upon this study and could help further the knowledge of students in collegiate mathematics. First of all, this study could be replicated on traditional aged college students to determine which specific differences exist between them and older students. Further inquiry is needed on the cognitive aspects of adults in college mathematics, including the use of an appropriate diagnostic examination. This study only looked at certain factors that were related to success in introductory calculus, and it did not take into account adult learning theory as it specifically applies to mathematics. Furthermore, an instrument could be developed to measure the factors that were uncovered during the interviews. This information could then be collected to determine if it is helpful in discriminating between adults who either pass or fail calculus. Such an instrument could assist advisors in
placing older students into an appropriate mathematics course.

The effects of a calculus course that was specifically designed to meet the needs and circumstances of adult college students could be explored. This could draw upon past experiences that the adults possess. Furthermore, adults could be required to demonstrate material and apply calculus principles to real-world applications. They might solve problems in cooperative groups with each group determining what needs and objectives they want from the course. Then adults could participate in the learning process, and they could attach personal meaning to the topics covered.


