Motivation and Study Habits of College Calculus Students: Does Studying Calculus in High School Make a Difference?

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ABSTRACT

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Due in part to the growing popularity of the Advanced Placement program, an increasingly large percentage of entering college students are enrolling in calculus courses having already taken calculus in high school. Many students do not score high enough on the AP calculus examination to place out of Calculus I, and many do not take the examination. These students take Calculus I in college having already seen most or all of the material. Students at two colleges were surveyed to determine whether prior calculus experience has an effect on these students' effort levels or motivation. Students who took calculus in high school did not spend as much time on their calculus coursework as those who did not take calculus, but they were just as motivated to do well in the class and they did not miss class any more frequently. Prior calculus experience was not found to have a negative effect on student motivation or effort. Colleges should work to ensure that all students with prior calculus experience receive the best possible placement, and consider making a separate course for these students, if it is practical to do so.

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To the best math teacher that I know – my father, Daniel Gibson

Chapter I

INTRODUCTION

Need

The first Advanced Placement (AP) examinations were given to high school students in 1955. In 2011, more than 18,000 schools worldwide participated in the program, with 1.9 million students taking more than 3.4 million examinations (The College Board, 2011). Some researchers have attempted to evaluate the outcomes of the program, but surprisingly little data exist on the impact of the AP program on students' future learning and success (Rhodes, 2007).

From the beginning, the purpose of the AP program was "to assist the strong secondary schools, both independent and public, in planning and teaching courses in eleven subjects conventionally taught to college freshmen in order that able school boys and girls may proceed farther than at present in the standard studies of a liberal education...Thus able young people may expect to enter college at the conventional age but with more extensive preparation than at present" (School and College Study of Admission with Advanced Standing, 1956, p. 129). Although providing students with advanced placement and college credit was the primary goal of the program, many students did not do well enough on the AP examination to receive placement or credit. Lefkowitz (1966) found that 48% of students in her study did not receive placement or credit from their colleges after taking the AP mathematics examination.

Soon after the first AP tests were given, educators began to wonder about how the program was affecting students who did not receive placement or credit after taking an AP course. Elwell (1967, p. 192) posed the question “Is the program initiated to reduce duplication of courses in school and college now contributing to that duplication? If so, is not the student who is compelled to repeat an Advanced Placement course in college likely to be bored?” Beninati (1963) interviewed eighteen chairs of college mathematics departments, and many of them suggested that students who had taken calculus in high school and repeated the course in college developed poor study habits or became bored when taking college calculus. A 1987 report by the Committee on the Undergraduate Program in Mathematics (CUPM) described this situation as the “rock and hard place” (p. 783) for these students. If they repeated Calculus I, these students may believe that they know more than they really do, and may lack willingness and motivation to learn, but they did not have the level of mastery of Calculus I topics to be successful in Calculus II.

Pocock (1974) conducted a survey of students at two colleges in New York to determine how the AP program influenced success in college mathematics. A significant proportion of students (nearly half at one of the colleges) who took AP but did not receive credit felt that they could have begun college mathematics at least a semester ahead of their actual placement.

In 1989, the National Council of Teachers of Mathematics and the Mathematical Association of America recommended that students not study calculus in high school unless they would be receiving advanced placement or credit for their work. In order to evaluate this recommendation, Skoner (1992) analyzed course grades and attitudes of 188 students enrolled in calculus classes at the Indiana University of Pennsylvania. He found that students who studied calculus in high school earned significantly higher grades in Calculus I than students who did not study calculus, but that there was no significant difference for students taking Calculus II. The difference in Calculus I grades was found to be significant even when controlling for SAT mathematics score and high school rank. Students who took calculus in high school felt that it was an advantage for them in their college calculus class, while students who had not studied calculus in high school reported that this was a disadvantage. Skoner concluded that students should take calculus in high school, even if it is likely that they would repeat the course in college.

Most of the previous research on the college achievements of students who take AP has focused on comparing college calculus course grades of students who took AP in high school with course grades of students who did not take AP. Many of these studies have included control variables like SAT mathematics scores, students' high school class rank, and students' grades' in their high school mathematics courses. Sadler and Tai (2007a) emphasize the importance of including these control variables when comparing students who take AP with those who do not. Little research has attempted to compare the study skills and work habits of these students, which is a focus of this study. Turner and Patrick (2004) found that student motivation is not a fixed characteristic - it varies depending on the classroom context. Therefore, it is reasonable to assume that students' motivation in a college mathematics course could be different than their motivation in a high school course.

Purpose

The purpose of this study was to compare the motivation and study skills of students who take calculus in high school with students who do not, in order to evaluate Beninati's claim that students who repeat calculus in college, after taking calculus in high school, develop poor study habits and become bored. The following questions were explored:

1) Are students who took calculus in high school significantly more or less likely to report seeking help in a college calculus course, as compared with those who did not take calculus in high school?

2) Do students who took calculus in high school report different study habits, levels of academic motivation, and class attendance rates in a college calculus course, as compared with those who did not take calculus in high school?

3) Do students who took calculus in high school report putting more effort or less effort into a college calculus course, as compared with those who did not take calculus in high school?

Procedures

Students at two colleges participated in this study. One is a small, private liberal arts college with an enrollment of 1,400 students. The other is a midsize public university with 14,000 students. Both colleges are located in central Michigan.

A survey was developed for this study, adapted from the Motivated Strategies for Learning Questionnaire. Surveys were distributed to students enrolled in Calculus I courses at the two colleges. A total of 133 students were surveyed in late November and early December 2012. The survey was designed so that it would take about 10 minutes to complete. A copy of the survey can be found in Appendix A.

Students were divided into two groups: those who did not take calculus in high school and those who took either an AP course or a regular calculus course. A Chi square test for independence was used to determine if differences between the two groups were statistically significant.

Organization of this Report

This report consists of five chapters. The first chapter is an introduction, and includes a description of the need for the study, research questions, and the study procedures. The second chapter is a review of relevant literature. It includes literature on the AP program, student motivation, and the problem of articulation between high school and college calculus. The third chapter presents the methodology of this study, including selection of participants, instrumentation, data collection, and data analysis. Chapter four presents the results of the study. The complete set of student responses is described first, followed by the responses for each individual college. The fifth chapter contains a summary of the findings, conclusions, and recommendations.

Chapter II

REVIEW OF LITERATURE

Introduction

The chapter reviews literature in four areas related to the motivation of college students who have taken AP coursework in high school. The first section examines the motivation for the AP program's inception and how the program has evolved, as well as research evaluating future academic outcomes of students who have taken AP courses. Several of these studies have compared college grades and graduation rates of students who take AP courses with students who do not. Some of this research has been sponsored by The College Board, which oversees the Advanced Placement program, while other studies have been conducted independently. Studies that have examined the number of students who receive advanced placement or credit from their Advanced Placement coursework are also discussed. The second section discusses efforts to reform calculus courses in the 1990s. The third section describes factors that affect student motivation. The fourth section describes problems that students face during the transition between high school and college calculus courses, and some proposed solutions to these problems, including changes implemented at Duke University and the United States Military Academy.

The AP Program

The History of the AP Program

In the 1950's, many students, parents, high school teachers, and college faculty were concerned that students were not adequately prepared for college-level mathematics courses (Beninati, 1963). Gradual changes in school populations and curriculum throughout the first half of the twentieth century created a situation where many high school graduates did not even take algebra (Angus & Mirel, 1999). The number of students attending high school increased rapidly, and many of these new students were immigrants, or otherwise disadvantaged. Due to the creation of vocational training and "life skills" tracks for the students who were not going to attend college, high schools gradually became less and less rigorous for many of their students (Angus & Mirel, 1999). The percentage of high school students enrolled in an algebra course declined from 56 percent in 1900 to 24 percent in 1953, and the percentage of students enrolled in geometry declined from 27 percent to 12 percent during that time (Brown, 1956). By the time of the launch of Sputnik in 1957, educators and non-educators alike had become concerned about the state of mathematics education, and several committees and study groups received funding to examine issues in education and make recommendations (Beninati, 1963; Elwell, 1967).

The Advanced Placement program originated from the work of two committees: the Committee on General Education in School and College and the Committee on Admission with Advanced Standing. The Committee on General Education in School and College consisted of representatives from three private secondary schools and three universities: Phillips Academy, Andover, The Phillips Exeter Academy, The Lawrenceville School, Harvard University, Princeton University, and Yale University. In 1952, the committee issued *The School and College Study of General Education*, funded by the Ford Foundation. They felt that many students were wasting their time by repeating in college courses they had taken in secondary school. Their report included a proposal for an experimental program in advanced placement. The program had two purposes: "to attack wasteful duplication of work between school and college, wherever it occurs, and to provide a stimulus to superior students to progress in fields of strength at a rate commensurate with their ability" (The Committee on General Education in School and College, 1952).

The Committee on Admission with Advanced Standing (1956) had two objectives: "to help able students to proceed in their secondary and college education more nearly at their proper pace than heretofore, and by assisting strong schools to organize and conduct courses for them at the college-freshman level" (p. 1). This committee of representatives from twelve universities and twelve secondary schools was based at Kenyon College and began work in 1951.

Seven pilot schools scheduled special courses for the 1953-1954 academic year, and the Committee on Admission with Advanced Standing contracted with Educational Testing Service to administer examinations in these schools in May 1954. A total of one hundred sixty-two students took the examinations, and sixty-nine were awarded credit by the colleges and universities that they attended. In 1956 the College Entrance Examination Board assumed responsibility for the administration of the program and examinations.

Since the first year, participation in the AP program has grown exponentially. In 1960, over ten thousand students took examinations, and over five hundred colleges accepted AP scores. Elwell (1967) identifies Harvard University as a primary force behind the early growth of the program. Harvard University awarded credit and placement for scores of 3 or above, and this well-publicized policy encouraged other colleges to do the same. (Today, Harvard University generally awards credit or placement only for scores of 5 (Harvard University, 2013).) In his 1967 book, *The Comprehensive High School*, James B. Conant, the former president of Harvard University, recommended that high schools offer AP courses if they wanted to improve the quality of their programs. Since then, high schools have faced increasing pressure from parents and the general public to offer AP courses. In 1979, there were over one hundred thousand students taking examinations, and in 2002 there were over one million. In 2011, 1,973,545 students took examinations, and 4,001 colleges awarded credit and/or placement for AP scores (The College Board, 2011).

Ensuring that high school students who enroll in AP courses are able to handle the more difficult coursework has always been a major issue for the program. Gordon K. Chalmers, President of Kenyon College and one of the first members of the Commission on Advanced Placement of the College Board, estimated that about two percent of high school students were ready and willing to participate in the program. In 1956, he revised his estimate to twenty percent (Elwell, 1967). In 2010, 28.3 percent of high school students took at least one examination, up from 15.9 percent in 2000 (The College Board, 2011). Lichten (2000) argues that, as the number of underprepared students taking examinations has increased over the years, the quality of the program has decreased. He states that the percentage of exams that students receive credit for has dropped from 75% in 1960 to 35% in 2010.

In a national survey of over 14,000 students taking Calculus I courses at universities in fall 2010, Bressoud (2011) found that 61% took a calculus class in high school. Of these students, 62% took an AP Calculus AB course, 13% took an AP Calculus BC course, and 34%

scored a 3 or higher on either the AP Calculus AB or BC examination. Of all students who took a calculus class in high school, 61% reported earning an A in the course.

While AP calculus courses have become a fixture in American high schools, they have not been without critics. Beninati (1966) feared that an AP calculus course could become “a meaningless mechanical manipulation of symbols” (p. 29) if students are not adequately prepared to study calculus. Orton (1985, p. 13) argued that, when teaching calculus, “We should not be happy with blind manipulation of a notation or the mechanical application of rules.” Rather, the emphasis should be on intuition, using graphs and tables to develop an understanding of the processes of calculus. In a 1960 interview, Professor J. Laurie Snell of Dartmouth College said that students who had studied some calculus “tend to think they know it all, up to a certain point; then suddenly they realize they don’t and, as a result, do not do as well as they should” (Beninati, 1963, p. 67).

More recently, David M. Bressoud, president of the Mathematical Association of America and a Professor of Mathematics at Macalester College, wrote “Many students who retake Calculus I in college think they already know the material, but then get slammed midsemester when the level of sophistication required turns out to be higher than expected. Few of those students recover to complete the course or continue studies in mathematics” (Bressoud, 2010). Bressoud found evidence of student overconfidence in Calculus I courses in his national survey. While 58% of students enrolled in Calculus I courses at colleges expected to earn an A and 94% expected to earn at least a B, only 22% of students actually earned an A and 50% earned at least a B.

College Board Studies on Academic Achievement and AP Coursework

The College Board has sponsored several research studies on the college outcomes of students who take AP courses. Casserly (1986) was one of the earliest College Board researchers to evaluate AP outcomes. The study was conducted at 8 universities, and the differences between mean grades of AP and non-AP students in advanced courses for each subject were calculated. For most subjects, students who took AP examinations had higher grades than students who did not. College students who had taken AP courses were also interviewed. Most of the students interviewed indicated that they found the AP courses valuable, and that it was a great advantage to enter college with some credit already. Students did report having problems when choosing courses for their first year because of their AP coursework, and those that repeated in college courses that they had taken as AP courses in high school were bored by them. Casserly recommended that universities designate an “AP Coordinator” to address these issues and ensure that students entering with Advanced Placement receive proper placement and credit for their work.

Willingham and Morris (1986) followed 4,814 college freshmen, 1,115 of whom had submitted an AP grade, at nine universities. They found that students who had taken an AP course were more likely to have come from a high school that emphasized college preparation, more likely to have parents who were highly educated, more likely to be interested in a scientific or scholarly career, and more likely to be involved in leadership and extracurricular activities. They created matched pairs of students who had taken AP examinations and students who had not. The pairs were based on six measures known to predict success in college: SAT scores, school rank, academic honors earned, involvement in extracurricular activities, and the strength of written personal statements and recommendations from their high school. Students who had taken AP courses outperformed their matches significantly in terms of college grades and leadership activities.

Morgan and Ramist (1998) surveyed 66,125 students at 21 colleges. They compared average grades for upper-level courses of students who received AP credit for a previous college course and students who took the previous course at the college. Generally, they found that students with the AP credit had better grades than those who did not have AP credit. The effect was much larger for students who had scored a 5 on the AP examination than it was for students who had scored a 3. For example, students who scored a 5 on the AP Calculus AB examination and then took a Calculus II course earned an average grade of 3.04 in the course, while students who scored a 4 earned an average of 2.75, students who scored a 3 earned an average of 2.70, and students who took Calculus I at the college earned an average of 2.62. The Morgan and Ramist study did not attempt to control for any other variables, like SAT score.

Keng and Dodd (2008) used matched pairs to compare college grades of students who received AP credit with grades of students who did not take AP courses. They matched students based on SAT scores and class rank, and found that students who earned AP credit significantly outperformed students who did not take AP courses. Students who took AP examinations but did not score well enough to receive credit performed significantly worse than students who did not take an AP course at all. According to Keng and Dodd, this can be explained by the fact that the group of students who did not take AP courses was chosen to match with the students who received AP credit, so they had higher SAT scores and class ranks than the students who took an AP course but did not receive credit.

Mattern, Shaw, and Xiong (2009) compared first-year college grade-point-average, selectivity of college attended, and second-year retention rates for three groups of students:

students who did not take the AP examination, students who received a score of 1 or 2 on the AP examination, and students who received a score of 3, 4, or 5 of the AP examination. After calculating paired contrasts for all possible comparisons, they found that students who scored 3, 4, or 5 on the examination had significantly higher first-year grade-point-averages, attended more selective colleges, and were more likely to return for a second year of college. These results were still significant when controlling for SAT score and high school grade-point-average, although effect sizes were far smaller.

The most recent College Board study, by Patterson, Packman, and Kobrin (2011), found that students who scored a 2 or above on a mathematics AP examination had higher grades in college mathematics courses than students who did not take an AP examination in mathematics. This study included over 100,000 students, and the effect was found after controlling for gender, racial or ethnic identity, highest parental education level, high school grade point average, and SAT scores.

As one might expect, research studies sponsored by the College Board have found that students who take AP courses are more successful in college than students who do not. Students who take AP courses are found to have higher college GPAs and are more likely to graduate within four years. Most early studies compare students with AP coursework and students without AP coursework, failing to account for the differences in aptitude and motivation between these two groups. Some of these studies, particularly the most recent, have included control variables such as SAT scores, high school grades, family situation, gender, and ethnicity, in an attempt to isolate the impact of AP coursework.

Non-College Board Studies on Academic Achievement and AP Coursework

Klopfenstein and Thomas (2005, 2006) argue that studies finding AP coursework to be a predictor of college success, including those sponsored by The College Board, are biased because they do not take into account students' non-AP coursework. Students who take AP courses are more likely to take other rigorous courses, particularly in mathematics and science, and these courses have a positive impact on the likelihood of college success. Their research, using a sample of over 28,000 Texas high school graduates who attended four-year public universities in Texas, found that students with AP backgrounds had significantly higher grade point averages and college retention rates, without controlling for non-AP courses. When such courses were added to model, the difference became statistically insignificant. Klopfenstein and Thomas suggest that their results are partly due to the rapid expansion of the AP program, as high schools are adding courses that are called AP courses but do not have the level of quality that AP intends.

Dickey (1986) compared students taking the AP Calculus BC course in high school with students in second-semester college calculus classes. Students completed a 25-question multiple choice calculus achievement test. Dickey found no significant difference in the achievement levels of the two groups, even after adjusting for group differences in SAT Mathematics scores.

Ferrini-Mundy and Gaudard (1992) compared calculus course grades for first-year college students who had studied various amounts of calculus in high school. They found that first-semester college calculus students who had studied a full year of high school calculus, whether it be an AP course or not, were more successful than those who had either no calculus in high school, or only a brief introduction. After adjusting by mathematics SAT score, they found a performance difference of about one letter grade.

Wilhite (1996) examined final course grades in Calculus I and Calculus II for 404 students at the University of Arkansas. She found that completion of high school calculus was not a significant predictor of academic achievement in either a Calculus I or a Calculus II course. She also found that American College Test (ACT) mathematics scores, high school rank, age, and high school mathematics grade-point-average were significant predictors of academic achievement in Calculus I, and that high school mathematics grade-point-average was a significant predictor of academic achievement in Calculus II.

Geiser and Santelices (2004) examined high school GPA, SAT scores, and AP coursework for 81,445 students enrolled at eight University of California campuses. After controlling for parents' education, SAT scores, high school GPA, and academic performance of the high school that the student attended, the number of AP or other honors courses taken in high school was not a significant predictor of college grades or persistence through two years of college. In contrast, scores on AP examinations were found to be a significant predictor of college grades, second only to high school GPA, the most significant variable in their model.

Sadler and Tai (2007b) performed a similar study comparing course grades in science courses. They concluded that two variables correspond to substantially better performance in college science courses: increasing rigor of high school science experience and higher grades in high school science courses. Sadler and Tai emphasize that their study does not provide evidence that advanced high school coursework *contributes* to student performance in college science courses, only that it is a significant *predictor* of performance. Better performance could be the result of greater student motivation, better preparation prior to taking advanced coursework, parental education, teacher quality, or any of several other variables.

Thompson and Rust (2007) surveyed 41 high-achieving students and compared their college grade point averages. In order to restrict their sample to high-achieving students, participants were required to have a GPA of at least 3.0 or be enrolled in a university honors program. They did not find any significant differences in college grades between students who had taken AP courses and those who had not. Participants were also asked to rate the benefit of their high school coursework, and those that had taken AP courses rated the benefit of their AP courses higher than their other high school courses.

Researchers not affiliated with the College Board have found mixed results when comparing the achievements of students who took AP courses with students who did not. Some researchers found that AP students performed significantly better, while others found no significant differences.

Studies on the Awarding of Placement and Credit for AP Coursework

From the beginning, colleges and universities have been free to set their own policies regarding the granting of placement and/or credit for AP examination scores (Elwell, 1967). Some researchers have examined what percentage of students received placement and/or credit for their AP examination scores as a measure of the effectiveness of the program. Three such studies (Lefkowitz, 1966; Lichten, 2000; Woolcock, 1963) found that about half of the students who took AP examinations actually received college credit.

Lefkowitz (1966) surveyed all students who had taken AP mathematics during the first nine years of the AP program at one large high school in New York City. These students indicated that the program had been a positive experience, despite the fact that 48% of them received neither placement nor college credit for the course. Additionally, Lefkowitz found that, particularly during the earlier years of the program, different colleges awarded different amounts of placement and credit. Cyril W. Woolcock (1963) surveyed 312 students who had taken Advanced Placement courses at Hunter College High School in New York City. He reported that 47 percent of students did not receive placement or credit for their work, but unlike Lefkowitz, Woolcock says that these students found the program to be “a waste of time…Many of the students in this New York group found that the colleges they attended had made little or no provision for capitalizing on their special training” (Woolcock, 1963, p. 32).

The College Board (1999) claimed that “almost two-thirds of the students achieved grades of 3 or above on AP’s 5-point scale - sufficiently high to qualify for credit and/or enrollment in advanced courses at virtually all four-year colleges and universities, including the most selective.” In reality, however, many colleges require a minimum score of 4 or even 5 to receive credit. In a representative sample of 41 colleges, Lichten (2000) found that fewer than half of the students who took the AP exam in English Literature received college credit for it.

Hill (2006) examined the high school transcripts of 2,961 students enrolled at Michigan State University in the years 1996 – 1999. He found that 491 of these students (17%) took an AP Calculus course in high school. Of these students, 31% enrolled in a Calculus I course, either because they did not take the AP examination or because they did not score well enough to receive credit, 27% received AP credit and took Calculus II or Calculus III, and 8% earned AP credit and did not take any mathematics course at Michigan State. The remaining 34% took a class below the Calculus level.

Studies on Graduation Rates

The College Board (2009) claims that "Most students take five or six years, and sometimes even longer, to earn their bachelor's degrees at public colleges and universities. Students who take AP courses and examinations are much more likely to graduate in four years." This claim is based on a study (sponsored by The College Board) by Hargrove, Godin, and Dodd (2008), which found that students who had taken AP coursework and at least one AP examination had higher college graduation rates than students who did not take any AP coursework. For example, students who had taken the AP English Literature course and examination in high school were 62 percent more likely to graduate than students who did not take the course. Students who earned a 5 on an AP examination were more likely to graduate than students who earned a lower score.

Adelman (1999) studied the effect of several variables on college graduation rates. He found that high school class rank, GPA, and test scores were much less significant in predicting college graduation than a variable called Academic Resources. Academic Resources combines the amount of high school coursework in English, mathematics, science, foreign language, and history with the amount of remedial coursework in mathematics and English and the number of AP courses taken. Students with a higher score on the Academic Resources scale were more likely to graduate from college. The strongest predictor in this study was the highest level of mathematics studied in high school. Students that took a course beyond the level of Algebra 2 were more than twice as likely to complete a bachelor's degree if they began college.

McCauley (2007) examined the records of 12,144 students in the National Education Longitudinal Study. He found that, controlling for race, gender, and socioeconomic status, students who enrolled in either an AP course or a dual enrollment course were significantly more likely to graduate from college within six years than students who did not enroll in such a course.

The Calculus Reform Movement

In the 1980s, complaints about the present methods of calculus instruction led to what came to be known as the Calculus Reform Movement (Bressoud, 2001). The goals of the movement were to decrease the large failure rates for college calculus courses (over half of students enrolled in mainstream “engineering” calculus courses were not passing them (Ferrini-Mundy & Graham, 1991)) and to increase the emphasis on problem-solving and critical thinking in these courses (and decrease the emphasis on rote algebraic manipulations) (Bressoud, 2001; Ferrini-Mundy & Gaudard, 1992). To achieve these goals, many mathematics departments have incorporated the use of graphing calculators or computer programs, cooperative group work, writing, and applied problem solving into their calculus courses (Bressoud, 2001). A 1994 survey of mathematics departments found that 22% were engaged in major calculus reform efforts, with another 46% engaged in modest efforts (Tucker & Leitzel, 1994). Among institutions where some level of reform was underway, 40% had adopted a reform textbook. The most commonly adopted textbook was the Harvard Consortium textbook, used by 45% of institutions that had adopted a reform textbook (Tucker & Leitzel, 1994).

Many institutions published the results of research studies designed to evaluate the effectiveness of their calculus reform efforts. At the University of Connecticut, Hurley, Koehn, and Ganter (1999) found that students that took a reform calculus course scored significantly better than students in traditional courses on a common final examination. They also found that students that took reform calculus were significantly more likely to take further mathematics courses, although these students' grades in these courses were not significantly better or worse than those of students that had taken traditional calculus. At Oklahoma State University, Johnson (1995) found a similar result – students taking reform calculus courses earned better grades in those courses than students taking traditional calculus, but they performed worse in subsequent mathematics courses.

Calculus reform projects have impacted high school calculus instruction also. The most notable change was the decision of the AP program to require graphing calculators for the AP calculus examinations beginning in spring 1995 (Tucker & Leitzel, 1994). Previously, calculators had not been allowed for the examinations. Many high schools adopted the same calculus reform textbooks that colleges were adopting. Tucker and Leitzel (1994) reported that the Harvard Consortium textbook was used in about 125 high schools, with another 250 high schools using a reform textbook by Thomas Dick and Charles Patton of Oregon State University.

Student Motivation

Many studies have been done on students' motivational and self-regulatory processes. Research has found differences in student motivation with respect to age, gender and ethnicity. Classroom factors, including the nature of academic tasks, the reward structure of the classroom, and the instructor's methods and behavior, also play a role in student motivation (Pintrich & Zusho, 2007). Students' study habits, skills, and attitudes, in turn, have an effect on student grades (Crede & Kuncel, 2008), as does their class attendance (Crede, Roch, & Kieszczynka, 2010).

Recent research (Bonney, Kempler, Zusho, Coppola, & Pintrich, 2005; Hickey, 1996; Turner & Patrick, 2004) has determined that motivation is not simply an inherent trait of the learner, with some students being more or less motivated. Rather, motivation also depends on the instructions, tasks, and activities that students experience in the classroom. Korkmaz (2007) found that students who were motivated put forth more effort, participated more in course activities, interacted more with course instructors, and perceived that they were learning more, but that they did not have significantly higher test scores. Pintrich (1994) found that having students work together in cooperative groups leads to increased self-efficacy and interest, lower anxiety, more cognitive engagement, and better performance.

According to Pintrich and Zusho (2007), three general components affect a student's motivation: beliefs about one's ability or skill to perform the task, beliefs about the importance and value of the task, and emotional reactions to the task and their performance (for example, anxiety, pride, or shame). These three components influence the self-regulatory processes and behaviors used by students to monitor and control their behavior and motivation, as well as student outcomes including effort, persistence, and actual achievement.

Pintrich and Zusho collected data on thousands of college students, using the Motivated Strategies for Learning Questionnaire. They found that self-efficacy (defined as individuals' beliefs about their performance capabilities in a particular domain) was one of the strongest positive predictors of actual student achievement in courses, accounting for 9% to 25% of the variance in grades, depending on what control factors were included in the analysis. Self-efficacy was found to be a significant predictor of achievement even when previous knowledge and general ability were taken into consideration. They also found that college students with a high level of self-efficacy were more likely to use high-level cognitive strategies, like paraphrasing and making outlines, and more likely to be metacognitive than students with a low level of self-efficacy.

Students with mastery goals focus on “developing new skills, trying to understand their work, improving their level of competence, or achieving a sense of mastery based on self-referenced standards” (Ames, 1992, p. 262). In contrast, students with performance goals focus on surpassing others in achievements or grades and on receiving public recognition for their performance. Pintrich and Zusho found that students with mastery goals were more likely to use deeper cognitive strategies, and also more likely to be metacognitive, than students with performance goals. They also achieved at higher levels in terms of grades, although the effect was smaller. Similarly, Greene, DeBacker, Ravindran, and Krows (1999) found that students’ goals, values, and beliefs accounted for a significant amount of variance in both student achievement and effort.

Interest has been shown to determine how well students select and persist in processing different types of information (Hidi, 1990). Participating in an activity that one finds interesting leads to increases in knowledge, attention, concentration, persistence, and value. Participants are more likely to engage in an activity that they find interesting, and to rate the activity as not being too difficult (Prenzel, 1988). Schiefele and Csikszentmihalyi (1995) found some evidence of interest contributing to students’ grades in mathematics courses.

After analyzing 344 independent samples, with a total of 72,431 students, Crede and Kuncel (2008) found study habits, skills, and attitudes to be a significant predictor of collegiate academic performance. Crede et al. (2010) analyzed 68 articles and papers on the relationship between class attendance in college and college grades. They found that there was a strong relationship between class attendance and course grades, and that class attendance was a better predictor of college grades than high school grades, SAT scores, study habits, or study skills.

Help-Seeking

Karabenick and Knapp (1988) surveyed students' academic help-seeking and found that students in the C- to B+ range of performance reported the highest rates of help-seeking. They inferred that high-performing students did not seek help because it was unnecessary, while very low performing students were not motivated enough to seek it.

Karabenick and Sharma (1994) examined why college students asked questions when teachers were presenting course material. They found that the majority (60%) of student questions were motivated by the student's need to increase their understanding of course material, while 15% were motivated by curiosity, 6% were motivated by teachers not presenting information clearly or not adequately answering a previous question, and 5% by teachers going too fast. Students also asked questions to help their classmates understand the material – this motivated 7% of student questions. Karabenick and Sharma also examined why students did not ask questions, and why they thought their classmates were not asking questions. They found that 29% of students did not ask questions out of fear of appearing unintelligent and wanting to avoid embarrassment, which may be an underestimate since 45% of students thought that other students in the class were not asking questions for those same reasons. Students also did not ask a question if they did not have one to ask, or did not know enough to ask questions (28%), or because they were too busy taking notes or did not want to interrupt the lecture (15%).

The Articulation Problem

This section examines literature on the transition of students from high school calculus to college calculus. According to the Committee on the Undergraduate Program in Mathematics, "There is a widespread and growing dissatisfaction with the performance in college calculus courses of many students who had studied calculus in high school" (1987, p. 776). Hill (2006, p. 18) defines the word *articulate* as "to unite by means of a joint" and describes the joint between high schools and universities as having "arthritis." According to Hill, "It is only by the cooperation of high school and university faculty and staff, which must include university mathematicians, that improvement can be brought about" (p. 18).

John H. Jenkins (1990), Professor of Mathematics at Embry-Riddle Aeronautical University, describes two philosophies of deciding which students may enroll in calculus courses. The first philosophy is a liberal philosophy, with few barriers for entrance into the course. The failure rate for the course may be high, but a minimum number of students will be "under-placed." The second is a conservative philosophy, with high requirements, usually high cutoff scores on a placement examination or the AP examination. This approach aims to keep a low failure rate for the course, but a large number of students may be "under-placed." Alternatively, colleges could allow students to choose their placement (in his survey of 429 colleges, Jenkins found that forty-six percent of colleges viewed placement as advisory), or institute a drop-back policy so that students could transfer to a lower-level course within the first few weeks of the term.

The Committee on the Undergraduate Program in Mathematics (1987) report makes several recommendations to colleges for dealing with students who have some previous calculus experience. They recommend granting credit and placement out of Calculus I to students with a score of 4 or 5 on the Advanced Placement Calculus AB examination, and credit and placement out of Calculus II to students with a score of 4 or 5 on the Advanced Placement Calculus BC examination. Colleges should provide special treatment for students with a score of 3, like offering these students the opportunity to "upgrade" their score by taking a placement examination. They also recommend that colleges use personal interviews as well as placement test scores in determining the placement of students who have taken calculus in high school.

Another recommendation of the CUPM is that colleges design specific courses for students who have had some calculus background, but have not earned placement through the AP examination. These courses should be designed so that they provide the necessary review of Calculus I topics while being clearly different from high school calculus courses, so that students do not feel that they are essentially repeating their high school calculus course. These courses might alter the traditional lecture format or rearrange and supplement content, integrating more advanced calculus topics with those that the students would already be familiar with. Similarly, Burton (1989) proposes that colleges offer separate beginning calculus courses for students with different levels of high school calculus experience. The course for students who do not have calculus experience would be one semester longer than the course for students with prior experience, and the two course sequences would bring students to the same level in the end.

Lucas and Spivey (2011) describe how Duke University created a separate Calculus II course, called Freshman Calculus II, for students who enter the university with AP credit. This course includes several topics and applications not covered in the AP courses, as well as a careful review of integration techniques. After completing this course, students are able to take Calculus III. According to Lucas and Spivey, "Most of the material in Freshman Calculus II is not new, but the approach itself is what makes this course different…the order in which the material is presented is important in capturing the students' attention without overwhelming them completely" (p. 428). Student feedback about the new course was positive, indicating that students appreciated the emphasis on applications. Students who took Freshman Calculus II did not perform significantly better or worse in Calculus III than students who took the regular calculus sequence.

Retchless, Boucher, and Outing (2008) describe how the United States Military Academy (USMA) awards placement and credit to students who have taken AP Calculus examinations, as well as students who have some experience with calculus but did not take the AP examination. All eligible students are invited to take a 110-minute placement examination during the summer before their first semester, covering single-variable calculus topics. Decisions about awarding advanced placement and credit are based primarily on these examination scores, and AP examination scores are also taken into consideration, if they are available. Students who score well on this examination are placed into a fall semester multi-variable calculus course. After the first two weeks of this course, students take a second placement examination covering the same material as the first. At this point, some students will drop out of the class. Nearly one-third of the students who earn placement into this advanced program do not have any AP Calculus scores on file at USMA.

Bressoud (2010) makes three recommendations for the transition from high-school calculus to college mathematics. More research needs to be done on the difficulties faced by students undergoing this transition. (To this end, a large national study of the factors that contribute to student success in Calculus I is currently being conducted by Carlson et al. (2011).) Guidelines for high school calculus programs need to be established and enforced. Finally, colleges need to re-examine first-year college calculus sequences. He recommends that Calculus I provide a “general overview of the themes and tools of calculus” and a sense of why calculus is important and how it can be used outside the classroom (Bressoud, 2010). He also suggests that high school students could take a course such as statistics, linear algebra, geometry, or discrete mathematics, instead of calculus.

Summary of Related Literature

This chapter reviewed literature focusing on four major areas related to the motivation of students who have taken calculus in high school and who take calculus in college. The first area describes the AP program, including its history and some attempts to evaluate the student outcomes of the AP program, generally measuring achievement through college grades and graduation rates. Some of these studies have found that students who take AP courses perform significantly better, while others did not find any significant differences. The second area examines factors that affect student motivation. The third area describes the problem that colleges face in determining where to place students with some calculus experience, and some proposed solutions to this problem. These areas are particularly relevant to this study, as it aims to evaluate outcomes of the AP program, but rather than achievement, it attempts to measure student motivation and study skills. The purpose of this study is to compare the motivation and study skills of students who take high school calculus with students who do not, in order to evaluate the anecdotal claim that students with high school calculus experience become bored in college calculus courses.

Chapter III

METHODOLOGY

Introduction

The purpose of this study was to determine if there are differences between students who have taken calculus in high school and students who have not taken calculus in high school in help seeking behavior, study habits, levels of academic motivation, class attendance rates, and effort. A survey with items relating to motivation and study habits was used. This chapter presents the methodology used to answer the research questions presented in Chapter 1.

Selection of Participants

All students enrolled in calculus courses at two participating colleges during the fall 2012 term were eligible to participate in this study. The total number of students surveyed was 133. Both colleges are located in rural central Michigan, and many students are from towns less than an hours' drive away. There are also many students from the metro Grand Rapids and Detroit areas, as well as small rural towns across the state. Both colleges also have a small number of out-of-state and international students.

College A is a selective, private college with approximately 1,400 students. College A offers undergraduate programs only, offering 32 majors primarily in the liberal arts and sciences. Students enter College A with an average high school grade point average of 3.5 on a four-point scale and an average ACT score of 24. Thirty-four percent of students participate in intercollegiate sports, and twenty-seven percent take part in theatre, music, and dance productions. Many students who take calculus are biology or chemistry majors, and many are planning on attending a professional school that requires calculus, like medical school or dental school. About 10 students major in mathematics each year, and a few students major in physics. Many of the mathematics majors become secondary teachers, while others go to graduate school for mathematics, applied mathematics, or other fields. A total of 69 students were enrolled in three sections of Calculus I during the fall 2012 semester, with a maximum of 24 students enrolled in each section, and all courses were taught by faculty members.

University B is a public university with approximately 14,000 students. The mathematics department at University B is housed within the College of Arts and Sciences. University B offers over 180 programs ranging from associates to doctoral degrees, with a focus on career preparation and technical programs. Students enter University B with an average high school grade point average of 3.2 and an average ACT score of 22. The vast majority of students at the university enroll in courses in introductory algebra and intermediate algebra, and these courses make up a majority of the teaching load for the faculty.

The university offers a major in Mathematics, as well as a major in Applied Mathematics with six possible concentrations (Actuarial Science, Applied Mathematics, Computer Science, Industrial Mathematics, Operations Research, and Statistics). About 15 students major in one of these programs each year, with the actuarial science concentration being the most popular. Many of these students go to graduate school or find jobs in industry. Prospective mathematics teachers matriculate through the College of Education and Human Services at the University, majoring in Mathematics Education, but these students must take several courses through the mathematics department.

There were 9 sections of calculus offered at University B during the fall 2012 semester, with a total enrollment of 227 students. At University B, the mathematics department offers four different courses where Calculus I material is taught. Calculus for Business is required for students in the Construction Management programs. A course called Calculus for the Life Sciences is required for students in the university's large Pre-Pharmacy program, as well as for students minoring in Elementary Mathematics Education. Applied Calculus is a required course for students in the Welding Engineering Technology, Electrical Engineering Technology, and Automotive Engineering Technology programs. Finally, there is a traditional calculus course, Analytical Geometry – Calculus 1, for students wishing to take more mathematics courses or major in mathematics or mathematics education. Class sizes were kept small, with a maximum of 32 students in each section, and all classes were taught by faculty members.

College A and University B both award credit and/or placement for many Advanced Placement examinations. For the AP Calculus AB examination, College A awards credit for Calculus I and placement to a student with a score of 4 or 5. University B awards credit and placement to students with a score of 3 or higher.

Instrumentation

A survey was developed for this study. Because students would be completing the survey during class time, the survey was kept short to minimize the inconvenience to professors. Students were asked to indicate whether they took a calculus course in high school, whether they took the AP examination, and if so, their score on the AP examination. Students were also asked to indicate the amount of time that they spent outside of class on their college calculus course, how many times they asked for help (from the professor and from other sources), and how many times they missed class, as well as to rate themselves on a 5-point Likert scale on 11 items taken from the Motivated Strategies for Learning Questionnaire (MSLQ).

The MSLQ was developed by McKeachie and Pintrich and has been used by hundreds of researchers. The entire MSLQ consists of 81 questions, divided into six subscales measuring motivation and nine subscales measuring use of learning strategies (Artino Jr., 2005). A number of statistical tests have been performed (Pintrich, Smith, Garcia, & McKeachie, 1993) to determine the reliability and validity of the instrument. Values for Cronbach’s alpha for each of the subscales appear in Table 1.

The MSLQ was developed using a social-cognitive view of motivation and self-regulated learning, which assumes that motivation is not a static trait of the learner, but rather that students’ motivations change from course to course. MSLQ items were used for this instrument because they were designed to measure college student motivation at the course level, which is the level of this study.

Table 1. Internal reliability coefficients for motivation and learning strategy scales
Source: Pintrich, Smith, Garcia, and McKeachie (1993)

Scale	Cronbach's Alpha
Motivation Scales	
Intrinsic Goal Orientation	.74
Extrinsic Goal Orientation	.62
Task Value	.90
Control of Learning Beliefs	.68
Self-Efficacy for Learning and Performance	.93
Test Anxiety	.80
Learning Strategy Scales	
Rehearsal	.69
Elaboration	.75
Organization	.64
Critical Thinking	.80
Metacognitive Self-Regulation	.79
Time and Study Environment Management	.76
Effort Regulation	.69
Peer Learning	.76
Help-Seeking	.52

Two other widely used study skills self-assessments are the Learning and Study Strategies Inventory (LASSI) and the Survey of Study Habits and Attitudes (Crede & Kuncel, 2008). The LASSI was not used for this study because it assesses students' attitudes toward learning in general, rather than in a specific course (Artino Jr., 2005). The Survey of Study Habits and Attitudes was not used because it does not include any items on motivation (Crede & Kuncel, 2008). The Mathematics Attitude Inventory includes questions that measure students' enjoyment of mathematical activities and motivation in mathematics, but it was not used because it was designed for secondary students (Sandman, 1980).

Survey items that were most relevant to this study were chosen from seven of the MSLQ subscales. The motivation subscales measured were Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Self-Efficacy for Learning and Performance, and Control of Learning Beliefs. The learning strategies subscales measured were Effort Regulation and Help Seeking. There were two survey items from the Task Value subscale and four survey items from the Effort Regulation subscale. For the responses to this study, the Cronbach's Alpha value for the two Task Value items was .603, while for the four Effort Regulation items, it was .614.

Students self-reported their scores on the AP examination. Self-reported grades and test scores are generally considered to portray actual grades and test scores accurately, but several studies (Kuncel, Crede, & Thomas, 2005) have found significant differences between self-reported grades and actual grades, especially for students of low ability. Cassady (2001) found that students were more likely to misreport their SAT scores than they were to misreport their high school GPA, but that both were reported reasonably accurately. Because the AP examination has a much more simple scale than the SAT (the AP examination score is a single number between 1 and 5, while each section of the SAT has a score ranging from 200-800), it seems reasonable to expect that students would more easily remember their score on the AP test than their SAT score. Since the survey results were kept confidential, students did not have anything to gain by purposely misreporting their scores.

Data Collection

After obtaining IRB approval, a survey was distributed to students enrolled in calculus courses at two participating colleges. Surveys were conducted during class time. Students had the option of declining to participate. The full survey appears in Appendix A. At College A, both professors teaching Calculus I agreed to participate, and all three sections of Calculus I that were taught were surveyed. At University B, four of the nine professors teaching calculus courses agreed to participate. The following calculus courses were surveyed: one section of Calculus for the Life Sciences, one section of Applied Calculus, and two sections of Analytical Geometry - Calculus I.

Data Analysis

Student responses were separated into two groups: those who did not take calculus in high school and those who did take calculus in high school. For the survey items on amount of time spent outside of class, attending office hours, seeking help, and missing class, frequencies were compared using a Chi square test for the two groups to determine if differences were statistically significant. For each item that used a Likert scale, frequencies were compared using a Chi square test for the groups to determine if differences were statistically significant, and the mean and standard deviation of the responses were calculated. An alpha level of .05 was used for all statistical tests.

The results were separated by college, and for each survey item, a Chi square test was performed for the two groups at each college. At University B, there were three different calculus course types, so the results for University B were separated by course type and a Chi square test was performed for each.

Chapter IV

RESULTS

Introduction

The purpose of this study was to compare the motivation and study habits in college calculus courses for students who took calculus in high school and students who did not. A total of 133 students were surveyed, 58 students at College A (a small, private liberal arts college) and 75 students at University B (a midsize public university). The survey asked students how much time they spent outside of class on calculus work, how often they sought help from their professor and others, and how often they missed class. They were also asked to rate themselves on 11 items taken from the Motivated Strategies for Learning Questionnaire, assessing their motivation, effort regulation, and help seeking. This chapter contains an analysis of student responses to each survey item. The first section considers responses for the group as a whole, the second section considers each of the two colleges individually, and the third section considers the three different types of calculus courses offered at University B.

Student Responses to Survey Items

Of the students surveyed, 61% reported having taken a calculus course while in high school. Of the students who took a calculus course, only 33% (27 students) reported having taken the Advanced Placement AB calculus examination. Their scores appear in Table 2.

Table 2. Advanced Placement AB calculus examination scores for students surveyed

Score	Number of Students
1	9
2	6
3	8
4	2
5	0
I don’t remember	2
Total	27

Table 3 shows the amount of time that students reported spending per week, outside of class time, working on calculus. Students who had not taken calculus in high school spent more time outside of class working on problems and studying than students who had taken calculus. The majority (84%) of students who had taken calculus spent less than four hours a week working on calculus, while only 46% percent of students who had not taken calculus spent less than four hours a week. None of the six students who reported spending more than six hours a week working on calculus had taken calculus in high school. The differences were significant, X^2 (3, N = 129) = 24.14, p <.001.

Table 3. Amount of time spent per week on calculus (outside of class time)

Amount of Time	No Calculus in High School	Calculus in High School	Total
0-2 hours	7	28	35
2-4 hours	16	38	54
4-6 hours	21	13	34
more than 6 hours	6	0	6
Total	50	79	129

The majority of students (83%) reported that they never went to their professor's office hours, or went only once or twice during the semester. Students who had not taken calculus in high school, however, were more likely to go office hours than students who had. Over half (52%) of the students who had taken calculus reported never going to office hours, while only 27% of students who had not taken calculus said the same. Table 4 shows all student responses. These differences were significant, X^2 (3, N = 133) = 9.96, p =.019. Of the students who had visited their professor during office hours, 37% of students who had not taken calculus reported that the reason they went was to ask a question about a mathematics problem, while only 28% of students who had taken calculus said that was the reason for going.

Table 4. Frequency of seeking help from course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	14	42	56
1-2 times	25	30	55
3-4 times	8	7	15
more than 4 times	5	2	7
Total	52	81	133

Students were more likely to seek help from someone other than their professor (for example, a friend). Seventy-two percent of students reported seeking this type of help at least once. All student responses to this question appear in Table 5. There was no statistically significant difference between students who had taken calculus in high school and those who had not, X^2 (3, N = 133) = 5.28, p =.15, although 33% of students who had not taken calculus reported seeking help more than four times, while only 17% of those who had taken calculus did so.

Table 5. Frequency of seeking help from someone other than course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	15	22	37
1-2 times	13	27	40
3-4 times	7	18	25
more than 4 times	17	14	31
Total	52	81	133

The majority (85%) of students reported that they never attended a tutoring or extra-help session outside of class. Student responses appear in Table 6. Of the students who had not taken calculus in high school, 25% reported attending a tutoring session at least once, while only 9% of the students who had taken calculus said the same. The differences between students who had taken calculus and those who had not were significant, X^2 (3, N = 133) = 12.06, p =.007.

Table 6. Frequency of attending tutoring or extra-help session

Frequency	No Calculus in High School	Calculus in High School	Total
Never	39	74	113
1-2 times	4	6	10
3-4 times	3	0	3
more than 4 times	6	1	7
Total	52	81	133

Thirty-five percent of students reported never missing class, while another 38% reported that they missed class only once or twice. Students' absence rates appear in Table 7. There was no significant difference between students who had taken calculus and those who had not, X^2 (3, N = 133) = 1.25, p =.741.

Table 7. Frequency of missing class

Frequency	No Calculus in High School	Calculus in High School	Total
Never	18	29	47
1-2 times	18	33	51
3-4 times	9	9	18
more than 4 times	7	10	17
Total	52	81	133

Intrinsic Goal Orientation was measured with the survey item “In this course, I prefer course material that really challenges me so I can learn new things.” Student responses to this statement appear in Table 8. The mean response for students who took calculus was nearly identical to the mean response for students who did not, and there was not a statistically significant difference between the two groups, X^2 (4, N = 133) = 3.72, p =.445.

Extrinsic Goal Orientation was measured with the survey item “Getting a good grade in this class is the most satisfying thing for me right now.” Overall, students reported being highly motivated by getting good grades, and mean scores for both groups of students were much higher for this item than for the intrinsic motivation item. Student responses for this statement appear in Table 9. Students who had not taken calculus had a higher mean response, indicating that they were more likely to be motivated by grades than the students who had taken calculus. These differences, however, were not significant, X^2 (4, N = 133) = 2.86, p =.582.

Table 8. Intrinsic Goal Orientation: "I prefer course material that really challenges me so I can learn new things" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	2	2	4
2	5	9	14
3	21	27	48
4	19	40	59
5	5	3	8
Total	52	81	133
Mean Response	3.38	3.41	3.40
Standard Deviation	0.932	0.833	0.870

Table 9. Extrinsic Goal Orientation: "Getting a good grade in this class is the most satisfying thing for me right now" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	1	5	6
3	4	11	15
4	21	32	53
5	26	33	59
Total	52	81	133
Mean Response	4.38	4.15	4.24
Standard Deviation	0.718	0.882	0.827

Task Value was measured with two survey items: “I like the subject matter of this course” and “Understanding the subject matter of this course is very important to me.” Student responses to the first statement appear in Table 10. While the mean response for students who took calculus in high school was higher than the mean response for students who did not, the difference was not statistically significant, X^2 (4, N = 133) = 8.98, p =.062.

Table 10. Task Value: “I like the subject matter of this course”
(1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	4	2	6
2	10	5	15
3	11	21	32
4	19	31	50
5	8	22	30
Total	52	81	133
Mean Response	3.33	3.81	3.62
Standard Deviation	1.184	0.989	1.091

Student responses to the second statement appear in Table 11. The mean responses for the two groups of students were virtually identical, and the difference was not significant, X^2 (4, N = 133) = 0.51, p =.973. Overall the mean student response was higher for this statement than for the first, implying that students found the subject of calculus to be important for their education even if they did not personally enjoy it.

Table 11. Task Value: "Understanding the subject matter of this course is very important to me" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	1	3	4
3	8	13	21
4	20	29	49
5	22	35	57
Total	52	81	133
Mean Response	4.17	4.16	4.17
Standard Deviation	0.901	0.915	0.906

Self-Efficacy for Learning and Performance was measured with the statement "I expect to do well in this class." Student responses to this statement appear in Table 12. The mean response for students who had taken calculus in high school was slightly higher than for students who had not taken calculus, although it was not statistically significant, X^2 (4, N = 133) = 2.97, p =.562. Overall, a majority of the students (75%) responded with 4 or 5, indicating that students had a high level of confidence, and possibly overconfidence, in their calculus abilities, as Bressoud suggested.

Table 12. Self-Efficacy for Learning and Performance: "I expect to do well in this class" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	3	5	8
3	14	12	26
4	15	27	42
5	20	37	57
Total	52	81	133
Mean Response	4.00	4.19	4.11
Standard Deviation	0.950	0.910	0.926

Control of Learning Beliefs was measured with the statement "If I try hard enough, then I will understand the course material." Student responses appear in Table 13. The mean response for students who had taken calculus was slightly higher than for those who had not, but the difference was not statistically significant, X^2 (4, N = 133) = 3.49, p =.479. Eighty-nine percent of students responded with a 4 or 5, indicating that they believe they have a great deal of control over their learning in calculus.

Table 13. Control of Learning Beliefs: "If I try hard enough, then I will understand the course material" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	0	1
2	2	1	3
3	3	8	11
4	21	29	50
5	25	43	68
Total	52	81	133
Mean Response	4.29	4.41	4.36
Standard Deviation	0.893	0.721	0.791

Four statements measured Effort Regulation. The first was "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do." This statement was reverse coded due to the way the question was worded. Students with a higher level of effort regulation would respond with a lower number on the scale, unlike the other statements, where responding with a higher number means that the student has a higher level of that particular characteristic. Student responses to this statement appear in Table 14. The difference between the two groups was not statistically significant, X^2 (4, N = 133) = 4.43, p =.351. Interestingly, the mean for students who had not taken calculus before was higher than then mean for students who had, indicating that students who had taken calculus before were actually less likely to be bored (or to allow their boredom to affect their studying).

Table 14. Effort Regulation: "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	13	19	32
2	12	29	41
3	15	14	29
4	7	14	21
5	5	5	10
Total	52	81	133
Mean Response	2.60	2.47	2.52
Standard Deviation	1.272	1.205	1.228

The second statement to measure Effort Regulation was "I work hard to do well in this class even if I don't like what we are doing." Student responses to this statement appear in Table 15. The mean response for the two groups of students was nearly identical, and the difference between them was not statistically significant, X^2 (4, N = 132) = 2.60, p =.626.

Table 15. Effort Regulation: "I work hard to do well in this class even if I don't like what we are doing" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	4	8	12
3	16	18	34
4	16	35	51
5	14	19	33
Total	51	81	132
Mean Response	3.75	3.78	3.77
Standard Deviation	1.017	0.962	0.980

The statement "I work on practice exercises even when I don't have to" also measured Effort Regulation. Student responses to this statement appear in Table 16. The vast majority of the students who responded with a 1 on the scale (meaning that they definitely did not work on practice exercises if they did not have to) were students who had taken calculus in high school. Twenty-three percent of students who had taken calculus in high school responded with a 1, while only 4% of students who had not taken calculus said the same. The difference between the two groups was statistically significant, X^2 (4, N = 133) = 11.10, p =.025, with students who had taken calculus being significantly less likely to work on practice exercises.

Table 16. Effort Regulation: "I work on practice exercises even when I don't have to" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	2	19	21
2	22	26	48
3	15	19	34
4	6	12	18
5	7	5	12
Total	52	81	133
Mean Response	2.88	2.48	2.64
Standard Deviation	1.114	1.184	1.170

The final statement to measure Effort Regulation was "When course work is difficult, I either give up or only study the easy parts." This statement was also reverse coded. Student responses appear in Table 17. While students who had not taken calculus were slightly more likely to agree with this statement than students who had, there was no statistically significant difference between the two groups, X^2 (4, N = 133) = 2.07, p =.723. The majority (74%) of students responded with a 1 or 2, indicating that students were very willing to work hard even when coursework was difficult.

Table 17. Effort Regulation: "When course work is difficult, I either give up or only study the easy parts" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	18	34	52
2	18	28	46
3	10	11	21
4	4	7	11
5	2	1	3
Total	52	81	133
Mean Response	2.12	1.93	2.00
Standard Deviation	1.096	1.010	1.044

The final statement of the survey measured Help Seeking (from the instructor only). Student responses appear in Table 18. This statement did not specify when or how the student would ask the instructor – it could have referred to questions asked during lectures, in front of the whole class, or it could have referred to questions asked during the instructor's office hours. Interestingly, all of the students that said that they would definitely not ask the instructor to clarify concepts were students who had taken calculus before. Students who had taken calculus before had a lower mean response than those who had not, indicating that they were less likely to ask the instructor for help. The difference between the responses of the two groups was statistically significant, X^2 (4, N = 133) = 9.92, p =.042. This was consistent with student responses to the survey item about visiting their professor during office hours, as students who had taken calculus before were significantly less likely to do so than those who had not.

Table 18. Help Seeking: "I ask the instructor to clarify concepts I don't understand well"
(1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	10	10
2	11	12	23
3	13	28	41
4	17	20	37
5	11	11	22
Total	52	81	133
Mean Response	3.54	3.12	3.29
Standard Deviation	1.056	1.198	1.158

In summary, students who had taken calculus in high school spent significantly less time outside of class on their college calculus course and were significantly less likely to see their professor during office hours or attend a tutoring or extra-help session than students who had not taken calculus. Students who had taken calculus were less likely to work on practice exercises and less likely to ask the instructor to clarify concepts. There was no significant difference between the groups on any of the other items.

Comparing the Two Colleges

A total of 58 students were surveyed at College A and 75 students at University B. The total numbers of students at each college who had and had not taken calculus in high school appear in Table 19. There was a significant difference between the two colleges. At College A, 72% of students reported that they had taken calculus in high school, while at University B, only 52% of students said the same. This difference was statistically significant, X^2 (1, N = 133) = 5.72, p =.017.

Table 19. Number of calculus students and non-calculus students, by college

	No Calculus in High School	Calculus in High School	Total
College A	16	42	58
University B	36	39	75
Total	52	81	133

Table 20 shows the number of students at each college who reported that they had taken the AP Calculus AB examination after their high school calculus course. Of the students who reported having taken a calculus course in high school, 45% of students at College A had taken the AP Calculus AB examination, compared with only 21% of students at University B. This difference was statistically significant, X^2 (1, N = 81) = 5.56, p =.018.

Table 20. Number of calculus students who took the AP Calculus AB examination, by college

	Did Take	Did Not Take	Total
College A	19	23	42
University B	8	31	39
Total	27	54	81

The AP Calculus AB examination scores for students at both colleges appear in Table 21. The distribution of scores for students enrolled in calculus courses at College A and University B are very similar. There was no significant difference in scores between the two colleges, X^2 (4, N = 27) = 6.22, p =.184. At each college, there were two students who scored high enough that they should have received credit for Calculus I (a score of 4 at College A and 3 at University B). The reasons for this are unclear. These students may have simply misremembered or misreported their scores on this survey, or they may have made a conscious choice to take a Calculus I course to strengthen their calculus skills.

Student responses to the items on time spent per week, visiting the professor during office hours, seeking help from someone other than the professor, attending tutoring sessions, and class attendance were analyzed for each college. Complete results appear in Appendix B. At College A, significant differences were found between students who had taken calculus in high school and students who had not for time spent per week and frequency of visiting the professor during office hours, while no significant differences were found between the two groups of students for frequency of seeking help from someone other than the professor, frequency of attending tutoring sessions, or class attendance. These results were the same as for the responses as a whole for all items except frequency of attending tutoring sessions.

Table 21. Advanced Placement Calculus AB examination scores for students surveyed, by college

Score	College A	University B	Total
1	6	3	9
2	5	1	6
3	6	2	8
4	2	0	2
5	0	0	0
I don’t remember	0	2	2
Total	19	8	27

At University B, two results were the same as they were for the responses taken as a whole, and the same as they were for College A: significant differences were found between the two groups for time spent per week, while no significant differences were found for class attendance. On the other items, however, University B students were different: there was no significant difference among the two groups for frequency of visiting the professor during office hours or attending tutoring sessions, but there were significant differences for seeking help from someone other than the professor. Students who had not taken calculus in high school were somewhat more likely than those who had to visit their professor during office hours and attend tutoring sessions, but not enough to be statistically significant. Student responses to the item on seeking help from someone other than the professor at University B appear in Table 22.

Table 22. Frequency of seeking help from someone other than course professor – University B

Frequency	No Calculus in High School	Calculus in High School	Total
Never	12	9	21
1-2 times	6	16	22
3-4 times	5	8	13
more than 4 times	13	6	19
Total	36	39	75

Significant, X^2 (3, N = 75) = 8.14, p =.043

There were only three students at College A who had not taken calculus in high school and who never sought help from someone other than the course professor, while this was true of 12 students at University B. All three of these students at College A sought help from the course professor at least once, while at University B, there were 5 students who had not taken calculus in high school that said that they never sought help from the course professor nor anyone else.

When student responses were considered as a whole, there were significant differences between students who took calculus and those who did not for two statements: "I work on practice exercises even when I don't have to" and "I ask the instructor to clarify concepts I don't understand well."

For the statement "I work on practice exercises even when I don't have to," the difference between the two groups was not significant at either College A or University B, even though it was significant when the two groups were combined. Student responses for the two colleges are shown in Tables 23 and 24. The twelve students at College A who said that they definitely did not work on practice exercises were all students who had taken calculus in high school. Of the students who had not taken calculus in high school, 44% responded with a 1 or 2, indicating that they did not work on practice exercises, while 64% of students who had taken calculus said the same. At University B, this response was given by 47% of students who had not taken calculus and 46% of students who had.

Table 23. "I work on practice exercises even when I don't have to" – College A
(1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	12	12
2	7	15	22
3	7	9	16
4	1	4	5
5	1	2	3
Total	16	42	58
Mean Response	2.75	2.26	2.40
Standard Deviation	0.856	1.127	1.075

Not Significant, X^2 (4, N = 58) = 7.05, p =.133

Table 24. "I work on practice exercises even when I don't have to" – University B
(1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	2	7	9
2	15	11	26
3	8	10	18
4	5	8	13
5	6	3	9
Total	36	39	75
Mean Response	2.94	2.72	2.83
Standard Deviation	1.218	1.213	1.212

Not Significant, X^2 (4, N = 75) = 5.20, p =.268

Student responses to the statement "I ask the instructor to clarify concepts I don't understand well" appear in Table 25 (College A) and Table 26 (University B). A chi-square analysis shows that the difference is not significant for the students attending College A, but it is significant for the students attending University B, although the difference in mean response for the two groups is greater at College A than it is at University B. Among students who had not taken calculus, those at College A were more likely to ask for clarification than those at University B, while for students who had taken calculus, those at University B were more likely to ask for clarification than their College A counterparts.

Table 25. "I ask the instructor to clarify concepts I don't understand well" – College A
(1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	4	4
2	2	10	12
3	5	15	50
4	5	11	16
5	4	2	6
Total	16	42	133
Mean Response	3.69	2.93	3.14
Standard Deviation	1.014	1.045	1.083

Not Significant, X^2 (4, N = 58) = 7.00, p =.136

Table 26. "I ask the instructor to clarify concepts I don't understand well" – University B
(1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	6	6
2	9	2	11
3	8	13	21
4	12	9	21
5	7	9	16
Total	36	39	75
Mean Response	3.47	3.33	3.40
Standard Deviation	1.082	1.325	1.208

Significant, X^2 (4, N = 75) = 12.22, p =.016

In summary, student responses for the two institutions surveyed were similar for many, but not all, of the survey items. Students attending College A were more likely to have taken calculus in high school than those attending University B, and of those who took calculus in high school, students attending College A were more likely to have taken the AP Calculus AB examination than those attending University B. There was a difference between the two colleges in the statistical significance of survey items involving help seeking.

Comparing Courses

At College A, all students needing calculus took the same Calculus I course, regardless of their intended program. At University B, however, four different courses covering Calculus I material were offered to students in different programs. It is reasonable to think that the students enrolled in different courses would have different levels of motivation for doing well in calculus. For example, one might expect that a student majoring in mathematics who was enrolled in Analytical Geometry – Calculus I might have put more effort into the course than a Welding Engineering Technology major enrolled in Applied Calculus, because the mathematics major would know that they would be taking more calculus courses in the future. A mathematics major might also simply enjoy mathematics courses more than a student in a different program. Additionally, course material is presented slightly differently in the different courses, and this may have an effect on student motivation. Applied Calculus, Calculus for the Life Sciences, and Calculus for Business tend to focus more on real-world problems and less on theory than the Analytical Geometry – Calculus I course.

In this study, one section of Calculus for the Life Sciences (14 students), one section of Applied Calculus (17 students), and two sections of Analytical Geometry – Calculus I (23 students and 21 students) were surveyed. Complete results for each course type appear in Appendix C. In the Calculus for the Life Sciences course, there was only one item on the survey for which students who took calculus in high school and those who did not were significantly different – frequency of seeking help from someone other than the course professor, X^2 (3, N = 14) = 7.88, p =.049. On all other survey items, there was no significant difference between the two groups. In the Applied Calculus course, there were no significant differences between students who took calculus in high school and those who did not for any of the survey items. In the Analytical Geometry – Calculus I courses, there were two items for which there was a significant difference between students who took calculus in high school and those who did not – amount of time spent outside of class on calculus coursework, X^2 (3, N = 41) = 7.91, p =.048, and frequency of seeking help from someone other than the course professor, X^2 (3, N = 44) = 8.01, p =.046.

Chapter V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Study

The purpose of this study was to compare the motivation and study skills of students who take calculus in high school with students who do not, in order to evaluate the claim that students who repeat calculus in college, after taking calculus in high school, develop poor study habits and become bored. There has been a rapid growth in the percentage of college freshmen who took a calculus course in high school, particularly with the growth of the Advanced Placement program. Many of these students do not take the AP examination, or they do not score well enough to place out of Calculus I, so they must essentially repeat the information in a college calculus course.

Students in calculus courses at two colleges in Michigan completed a pencil-and-paper survey. Students were first asked to indicate their calculus experience in high school: whether or not they took calculus, whether or not they took the AP Calculus AB examination, and if so, their score on the examination. They were then asked to indicate how much time they spent outside of class on calculus coursework, how often they sought help from their professor and others, how often they attended tutoring sessions, and how often they missed class. They were also asked to rate themselves on a 5-point on scale on 11 items taken from the Motivated Strategies for Learning Questionnaire (MSLQ). These items were designed to measure intrinsic goal orientation, extrinsic goal orientation, task value, self-efficacy for learning and performance, control of learning beliefs, effort regulation and help seeking.

Conclusions

A statistically significant difference was found between students who had taken calculus and those who had not in the amount of time spent outside of class, frequency of seeking help from their professor, and frequency of attending tutoring sessions. There was also a statistically significant difference between the two groups on one of the four statements measuring effort regulation ("I work on practice exercises even when I don't have to") and the one statement to measure help seeking ("I ask the instructor to clarify concepts I don't understand well").

When responses were separated by college, some differences between the two colleges emerged. At College A, a statistically significant difference was found between students who had taken calculus and those who had not in the amount of time spent outside of class and frequency of seeking help from their professor. At University B, a statistically significant difference was found in the amount of time spent outside of class, frequency of seeking help from someone other than their professor, and in responses to the statement measuring help seeking ("I ask the instructor to clarify concepts I don't understand well").

The first research question was "Are students who took calculus in high school significantly more or less likely to report seeking help in a college calculus course, as compared with those who did not take calculus in high school?" For the entire group of students surveyed, students who did not take calculus in high school were more likely to report seeking help than students who did not. Students who had not taken calculus were more likely to report seeking help from their professor, more likely to attend a tutoring or extra-help session, and more likely to agree with the statement "I ask the instructor to clarify concepts I don't understand well" than students who had.

There are differences between the two institutions. At College A, students who had not taken calculus were more likely to report seeking help from their professor. Students from the two groups were equally likely to seek help from someone else, equally likely to attend a tutoring or extra-help session, and equally likely to agree with the statement "I ask the instructor to clarify concepts I don't understand well." This suggests that at least some of the students who had taken calculus in high school were asking their professor questions during class time, but did not go to office hours to ask questions. Perhaps their pre-existing knowledge of calculus meant that they were better able to formulate questions during class time than students who were taking calculus for the first time, who were processing new information during class time.

At University B, the results were quite different. Students who had not taken calculus and students who had were equally likely to seek help from their professor or attend a tutoring or extra-help session. On the other hand, students who had not taken calculus were significantly more likely to agree with the statement "I ask the instructor to clarify concepts I don't understand well." The question of seeking help from someone other than the course professor produced an interesting result. The most frequent response for students who had not taken calculus was "more than 4 times", while the second-most frequent response was "never" – these students were seeking help either frequently or not at all. This seems to suggest that many of these students were able to find someone, perhaps a classmate, with whom they would often work on calculus, while many were either unable to find such a person, or did not want to do so. In contrast, the most frequent response for students who had taken calculus was “1-2 times”.

The help-seeking behaviors for the two groups of students are quite different at the two different institutions. This seems to suggest that help-seeking behavior depends more on the institution than on whether the student has prior experience with calculus. For example, while instructors at both institutions were required to hold posted office hours, at College A, the instructors’ offices are located across the hall from the classrooms, while at University B, they are in a different building. This difference in accessibility may have an effect on how likely students are to go to their instructor’s office to ask for help. Another difference is in the student population – at College A, a large percentage of students have taken or are currently taking calculus, while at University B, the majority of the students are enrolled in introductory and intermediate algebra courses, and the percentage of students who take calculus is much smaller.

The second research question was “Do students who took calculus in high school report different study habits, levels of academic motivation, and class attendance rates in a college calculus course, as compared with those who did not take calculus in high school?” Students who took calculus in high school spent significantly less time outside of class on calculus than those who did not. An obvious explanation for this is that students who had already taken calculus were simply able to do homework more quickly, and that their prior exposure to calculus meant that they did not need to spend as much time studying in order to feel prepared for examinations. On the other hand, it is possible that students who had already taken calculus were making a conscious choice to spend less time on it, possibly so that they could spend more time on other courses.

There were five items that measured motivation: "In this course, I prefer course material that really challenges me so I can learn new things," "Getting a good grade in this class is the most satisfying thing for me right now," "I like the subject matter of this course," "Understanding the subject matter of this course is very important to me," and "I expect to do well in this class." There were no differences between students who had taken calculus and those who had not on any of these items. The majority of students indicated that they wanted to do well in calculus and that they saw the course as valuable, regardless of whether or not they had taken it before. This suggests that motivation is not affected by whether or not students had prior experience in calculus.

There was no difference between the two groups of students in class attendance – those who had taken calculus and those who had not were equally likely to attend class. This suggests that students who had taken calculus before were not skipping class even if they already knew the material. Students who missed class frequently were doing so for other reasons, and they were just as likely to be students who had not taken calculus in high school as they were to be students who had taken calculus.

The third research question was "Do students who took calculus in high school report putting more effort or less effort into a college calculus course, as compared with those who did not take calculus in high school?" There were four items that measured effort: "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do," "I work hard to do well in this class even if I don't like what we are doing," "I work on practice exercises even when I don't have to," and "When course work is difficult, I either give up or only study the easy parts." The only statement that the two groups of students responded to differently was "I work on practice exercises even when I don't have to." Students who had taken calculus in high school were less likely to agree with this statement than those who had not. This suggests that students who had taken calculus before were deciding that they did not need to work on calculus problems if the professor was not going to collect them, and that their energy would be better spent on other courses. Students who had not taken calculus saw more value in doing practice problems, even if they were not collected, as they needed more practice to master the concepts.

Students who had taken calculus in high school and those who had not were equally willing to work hard when their calculus course was work was difficult. If they thought they did not need to do practice exercises, however, they did not do them, and students who had taken calculus before were more likely to think that they did not need to do practice exercises. Of course, some students may have wanted to do more practice exercises, but may not have had time due to other coursework, jobs, sports, or other extra-curricular activities. Students who had taken calculus before also may have been overestimating their abilities, and it is possible that they were not doing practice exercises but their grades were suffering for it. When separated by institution, the differences were not significant for either college, indicating that the significance for the combined responses was not very strong (p=.025).

Students who had not taken calculus in high school were more likely to agree with the statement "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do" than students who had taken calculus. This seems to suggest that the students who were repeating calculus were not becoming bored, as Beninati feared they were, or, at the very least, they were not letting boredom affect the amount or quality of the time they spent studying calculus.

In summary, students who took calculus in high school were able to spend less time on calculus and were less likely to work on practice exercises. In this sense, they put less effort into their college course than students who had not taken calculus, but they simply may not have needed to spend as much time on calculus to understand the material. Students who had taken calculus did not miss class any more frequently than those who had not, and the two groups were equally motivated to do well in their college calculus course. Results for help seeking were mixed, but it seems that students who had taken calculus before were less likely to seek help. It may be that they simply were less likely to have questions over the material because they were seeing it for the second time.

Recommendations

The study would have benefitted from including demographic questions on the survey, such as gender, age, and size of high school, so that it would have been possible to test for differences between different groups of students. For example, students who were taking calculus in their first semester of college, only a few months after finishing their high school calculus course, might be able to approach the course differently than students who were a year or more removed from high school calculus, who may not remember the material as easily.

There is some ambiguity in the survey item “I work on practice exercises even when I don’t have to” because the meaning of “I don’t have to” is not clear. This item would provide more information if it was separated into two items – one item on graded homework assignments, like “I complete all practice exercises that my professor counts toward my course grade,” and one item on problems that are assigned for practice but not graded: “I do practice exercises even if they are not going to be collected or graded.” Of course, many professors assign only one of these two types – either all assigned practice exercises are graded, or practice exercises are never graded. Hence, there must also be an item where students indicate whether their professor assigns graded practice exercises, assigns ungraded practice exercises, or assigns both types of practice exercises.

This study would have benefitted from conducting follow-up interviews with students. Students could have been asked to discuss whether they thought that taking calculus in high school had been valuable, and if they thought that it had any negative effects on them in their college calculus course, and if so, what these negative effects had been. Three students who completed the survey were informally asked about their experience in college calculus. All three students felt that taking calculus in high school was beneficial to them. One student mentioned that "At the beginning [of college calculus] we were doing the exact same stuff we had covered in high school." This student said that they would recommend taking calculus in high school because "it does help prepare you." Another student said that "Already seeing most of the material covered in the class helped when needing to understand new problems." A third student said that it was an advantage to take calculus in high school because "I knew the fundamentals to how to solve problems" but that he did not put his best effort into college calculus because "I was bored because it was very repetitive information." This student, however, would still recommend taking calculus in high school, saying that "even if they get bored with it, it's still good to know."

Institutions should carefully consider the needs and prior experiences of their students when determining their placement in mathematics courses. It is a good idea to create a separate calculus course for students who have some prior calculus experience but are not proficient enough to take Calculus II, like the Duke University course, but it may not be practical for small institutions or institutions where few students enroll in calculus. Institutions should also consider offering a placement examination that closely mirrors the final examination given in a Calculus I course. CUPM recommends that a placement examination be offered to students with a score of 3 on the AP examination, but it could also be offered to students with a lower score and students who took a calculus course in high school but did not take the AP examination. If students are able to demonstrate proficiency on Calculus I topics, then they should at least have the option of taking a more advanced course. This placement examination could also give Calculus I professors valuable information about which skills these students need more practice with.

Another CUPM recommendation is that students with calculus experience be interviewed to assist in determining their placement. This would allow advisors to take into account factors other than test scores, and it could also allow students to have some choice in the matter. If the student has taken a placement examination, then this should also be part of the conversation. Students can assess themselves and determine if they need more practice with Calculus I material, or if they think that they will be bored and should opt for Calculus II.

It should be made clear to students with calculus experience that, if they take Calculus I, they may feel that they do not need to spend as much time outside of class on the material, but that they should carefully monitor themselves to make sure that they are able to do problems correctly. Being honest with students about the possibility of becoming overconfident may help some students stay on track. Students should also be encouraged to evaluate their progress during the first few days of class, and to switch to an easier or more advanced course before the drop/add deadline if they feel that they are in the wrong place.

This study has shown that students who take calculus in high school have, in some ways, a different experience in college calculus courses than students who do not take high school calculus. Many previous studies have found that students with high school calculus experience tend to earn better grades in college calculus, and this study has found that they spend less time outside of class on calculus and seek help less frequently. Incoming college students are increasingly likely to have taken some calculus in high school, and colleges may need to adjust their placement policies and course offerings to accommodate this change. It would be beneficial for any college or university to collect the types of data presented in this study. Including students' test scores or final grades in their college Calculus I course in the data would allow researchers to see if students who took calculus in high school were able to maintain good grades while spending less time on their calculus coursework, or if spending less time on calculus was having a negative impact on their grades. If colleges collect data on both final course grades and student motivation and effort for students who are repeating calculus material, as well as maintain flexible placement procedures for these students, they can limit the negative effects of boredom.

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Appendix A

Survey Instruments

Please answer the questions below by checking the appropriate box. Be as honest as possible – your professor will not have access to your answers and they will in no way affect your grade in this course.

1) Did you take a calculus course while in high school?

[ ] Yes (Please answer question 2)

[ ] No (Please skip questions 2 and 3 and go to question 4)

2) Did you take the Advanced Placement Calculus AB test after completing the class?

[ ] Yes (Please answer question 3)

[ ] No (Please skip question 3 and go to question 4)

3) Please indicate your score on the Advanced Placement Calculus AB test:

[ ] I don't remember

[ ] 1

[ ] 2

[ ] 3

[ ] 4

[ ] 5

The next questions are about the calculus class that you are <u>currently taking</u> at _____________________.

4) On average, how much time do you spend <u>per week</u>, outside of regular class time, on this class? (Studying, doing homework problems, etc.)

[ ] 0-2 hours

[ ] 2-4 hours

[ ] 4-6 hours

[ ] more than 6 hours

5) This semester, how many times have you visited the professor during office hours?

[ ] Never

[ ] 1-2 times

[ ] 3-4 times

[ ] more than 4 times

If you visited the professor during office hours, what was the reason for your visit?

(Check all that apply)

[ ] To ask a question about a math problem

[ ] To ask a question about my grade

[ ] Other (please specify) ____

6) How many times this semester did you ask for help from someone other than the professor (for example, a friend or another professor)?

[ ] Never

[ ] 1-2 times

[ ] 3-4 times

[ ] more than 4 times

7) How many times this semester did you attend a tutoring or extra-help session outside of regular class time?

[ ] Never

[ ] 1-2 times

[ ] 3-4 times

[ ] more than 4 times

8) How many times this semester did you miss class?

[ ] Never

[ ] 1-2 times

[ ] 3-4 times

[ ] more than 4 times

9) Please use the scale below to answer the questions. If you think the statement is very true of you, check 5; if you think the statement is not at all true of you, check 1. If the statement is more or less true of you, find the number between 1 and 5 that best describes you.

1	2	3	4	5
Not at all true of me				*Very true of me*

	1	**2**	**3**	**4**	**5**
a. In this course, I prefer course material that really challenges me so I can learn new things ……………………….	[ ]	[ ]	[ ]	[ ]	[ ]
b. Getting a good grade in this class is the most satisfying thing for me right now. ……………………………………...…….	[ ]	[ ]	[ ]	[ ]	[ ]

	1	**2**	**3**	**4**	**5**
c. I like the subject matter of this course. ……………...…….	[ ]	[ ]	[ ]	[ ]	[ ]
d. Understanding the subject matter of this course is very important to me. ………………………………...…….	[ ]	[ ]	[ ]	[ ]	[ ]
e. I expect to do well in this class. …………………………….	[ ]	[ ]	[ ]	[ ]	[ ]
f. If I try hard enough, then I will understand the course material. ……………………………………....…….	[ ]	[ ]	[ ]	[ ]	[ ]
g. I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do.…………..…….	[ ]	[ ]	[ ]	[ ]	[ ]
h. I work hard to do well in this class even if I don't like what we are doing……………………………………...…….	[ ]	[ ]	[ ]	[ ]	[ ]
i. I work on practice exercises even when I don't have to…….	[ ]	[ ]	[ ]	[ ]	[ ]
j. When course work is difficult, I either give up or only study the easy parts. …………………………………...…….	[ ]	[ ]	[ ]	[ ]	[ ]
k. I ask the instructor to clarify concepts I don't understand well. …………………………………….....…….	[ ]	[ ]	[ ]	[ ]	[ ]

Appendix B

Results for Each College

Results for Students Attending College A

Table A1. Amount of time spent per week on calculus (outside of class time)

Amount of Time	No Calculus in High School	Calculus in High School	Total
0-2 hours	2	16	18
2-4 hours	4	19	23
4-6 hours	8	7	15
more than 6 hours	2	0	2
Total	16	42	58

Significant, X^2 (3, N = 58) = 13.87, p =.003

Table A2. Frequency of seeking help from course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	1	17	18
1-2 times	11	21	32
3-4 times	1	3	4
more than 4 times	3	1	4
Total	16	42	58

Significant, X^2 (3, N = 58) = 9.63, p =.022

Table A3. Frequency of seeking help from someone other than course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	3	13	16
1-2 times	7	11	18
3-4 times	2	10	12
more than 4 times	4	8	12
Total	16	42	58

Not Significant, X^2 (3, N = 58) = 2.69, p =.442

Table A4. Frequency of attending tutoring or extra-help session

Frequency	No Calculus in High School	Calculus in High School	Total
Never	11	38	49
1-2 times	3	4	7
3-4 times	0	0	0
more than 4 times	2	0	2
Total	16	42	58

Not Significant, X^2 (3, N = 58) = 6.71, p =.082

Table A5. Frequency of missing class

Frequency	No Calculus in High School	Calculus in High School	Total
Never	7	16	23
1-2 times	8	18	26
3-4 times	1	4	5
more than 4 times	0	4	4
Total	16	42	58

Not Significant, X^2 (3, N = 58) = 1.89, p =.594

Table A6. Intrinsic Goal Orientation: "I prefer course material that really challenges me so I can learn new things" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	0	7	7
3	10	11	21
4	5	22	27
5	0	1	1
Total	16	42	58
Mean Response	3.19	3.36	3.31
Standard Deviation	0.750	0.879	0.842

Not Significant, X^2 (4, N = 58) = 8.88, p =.064

Table A7. Extrinsic Goal Motivation: "Getting a good grade in this class is the most satisfying thing for me right now" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	0	2	2
3	2	9	11
4	8	18	26
5	6	13	19
Total	16	42	58
Mean Response	4.25	4.00	4.07
Standard Deviation	0.683	0.855	0.814

Not Significant, X^2 (4, N = 58) = 1.53, p =.821

Table A8. Task Value: "I like the subject matter of this course" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	2	2	4
3	6	15	21
4	6	14	20
5	1	10	11
Total	16	42	58
Mean Response	3.25	3.71	3.59
Standard Deviation	1.000	0.970	0.992

Not Significant, X^2 (4, N = 58) = 3.46, p =.483

Table A9. Task Value: "Understanding the subject matter of this course is very important to me" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	1	2	3
3	3	8	11
4	4	19	23
5	8	13	21
Total	16	42	58
Mean Response	4.19	4.02	4.07
Standard Deviation	0.981	0.841	0.876

Not Significant, X^2 (4, N = 58) = 2.41, p =.661

Table A10. Self-Efficacy for Learning and Performance: "I expect to do well in this class" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	0	3	3
3	8	7	15
4	2	14	16
5	6	18	24
Total	16	42	58
Mean Response	3.89	4.12	4.05
Standard Deviation	0.957	0.942	0.944

Not Significant, X^2 (4, N = 58) = 8.02, p =.091

Table A11. Control of Learning Beliefs: "If I try hard enough, then I will understand the course material" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	1	1	2
3	0	4	4
4	9	18	27
5	6	19	25
Total	16	42	58
Mean Response	4.25	4.31	4.29
Standard Deviation	0.775	0.749	0.749

Not Significant, X^2 (4, N = 58) = 2.63, p =.621

Table A12. Effort Regulation: "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	4	9	13
2	3	17	20
3	6	6	12
4	3	6	9
5	0	4	4
Total	16	42	58
Mean Response	2.50	2.50	2.50
Standard Deviation	1.095	1.254	1.203

Not Significant, X^2 (4, N = 58) = 6.34, p =.175

Table A13. Effort Regulation: "I work hard to do well in this class even if I don't like what we are doing" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	2	3	5
3	6	9	15
4	5	24	29
5	3	6	9
Total	16	42	58
Mean Response	3.56	3.79	3.72
Standard Deviation	0.964	0.782	0.833

Not Significant, X^2 (4, N = 58) = 3.25, p =.518

Table A14. Effort Regulation: "I work on practice exercises even when I don't have to" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	12	12
2	7	15	22
3	7	9	16
4	1	4	5
5	1	2	3
Total	16	42	58
Mean Response	2.75	2.26	2.40
Standard Deviation	0.856	1.127	1.075

Not Significant, X^2 (4, N = 58) = 7.05, p =.133

Table A15. Effort Regulation: "When course work is difficult, I either give up or only study the easy parts" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	6	22	28
2	4	12	16
3	4	7	11
4	2	0	2
5	0	1	1
Total	16	42	58
Mean Response	2.13	1.71	1.83
Standard Deviation	1.088	0.918	0.976

Not Significant, X^2 (4, N = 58) = 6.64, p =.156

Table A16. Help Seeking: "I ask the instructor to clarify concepts I don't understand well" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	4	4
2	2	10	12
3	5	15	20
4	5	11	16
5	4	2	6
Total	16	42	58
Mean Response	3.69	2.93	3.14
Standard Deviation	1.014	1.045	1.083

Not Significant, X^2 (4, N = 58) = 7.00, p =.136

Results for Students Attending University B

Table B1. Amount of time spent per week on calculus (outside of class time)

Amount of Time	No Calculus in High School	Calculus in High School	Total
0-2 hours	5	12	17
2-4 hours	12	19	31
4-6 hours	13	6	19
more than 6 hours	4	0	4
Total	34	37	71

Significant, X^2 (3, N = 71) = 10.93, p =.012

Table B2. Frequency of seeking help from course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	13	25	38
1-2 times	14	9	23
3-4 times	7	4	11
more than 4 times	2	1	3
Total	36	39	75

Not Significant, X^2 (3, N = 75) = 5.92, p =.116

Table B3. Frequency of seeking help from someone other than course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	12	9	21
1-2 times	6	16	22
3-4 times	5	8	13
more than 4 times	13	6	19
Total	36	39	75

Significant, X^2 (3, N = 75) = 8.14, p =.043

Table B4. Frequency of attending tutoring or extra-help session

Frequency	No Calculus in High School	Calculus in High School	Total
Never	28	36	64
1-2 times	1	2	3
3-4 times	3	0	3
more than 4 times	4	1	5
Total	36	39	75

Not Significant, X^2 (3, N = 75) = 6.02, p =.110

Table B5. Frequency of missing class

Frequency	No Calculus in High School	Calculus in High School	Total
Never	11	13	24
1-2 times	10	15	25
3-4 times	8	5	13
more than 4 times	7	6	13
Total	36	39	75

Not Significant, X^2 (3, N = 75) = 1.82, p =.611

Table B6. Intrinsic Goal Orientation: "I prefer course material that really challenges me so I can learn new things" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	5	2	7
3	11	16	27
4	14	18	32
5	5	2	7
Total	36	39	75
Mean Response	3.47	3.46	3.47
Standard Deviation	1.000	0.790	0.890

Not Significant, X^2 (4, N = 75) = 3.88, p =.422

Table B7. Extrinsic Goal Motivation: "Getting a good grade in this class is the most satisfying thing for me right now" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	1	3	4
3	2	2	4
4	13	14	27
5	20	20	40
Total	36	39	75
Mean Response	4.44	4.31	4.37
Standard Deviation	0.735	0.893	0.818

Not Significant, X^2 (4, N = 75) = 0.92, p =.922

Table B8. Task Value: "I like the subject matter of this course" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	3	1	4
2	8	3	11
3	5	6	11
4	13	17	30
5	7	12	19
Total	36	39	75
Mean Response	3.36	3.92	3.65
Standard Deviation	1.268	1.010	1.168

Not Significant, X^2 (4, N = 75) = 5.10, p =.277

Table B9. Task Value: "Understanding the subject matter of this course is very important to me" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	0	1	1
3	5	5	10
4	16	10	26
5	14	22	36
Total	36	39	75
Mean Response	4.17	4.31	4.24
Standard Deviation	0.878	0.977	0.928

Not Significant, X^2 (4, N = 75) = 4.05, p =.399

Table B10. Self-Efficacy for Learning and Performance: "I expect to do well in this class" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	3	2	5
3	6	5	11
4	13	13	26
5	14	19	33
Total	36	39	75
Mean Response	4.06	4.26	4.16
Standard Deviation	0.955	0.880	0.916

Not Significant, X^2 (4, N = 75) = 0.93, p =.920

Table B11. Control of Learning Beliefs: "If I try hard enough, then I will understand the course material" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	0	1
2	1	0	1
3	3	4	7
4	12	11	23
5	19	24	43
Total	36	39	75
Mean Response	4.31	4.51	4.41
Standard Deviation	0.951	0.683	0.824

Not Significant, X^2 (4, N = 75) = 2.65, p =.618

Table B12. Effort Regulation: "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	9	10	19
2	9	12	21
3	9	8	17
4	4	8	12
5	5	1	6
Total	36	39	75
Mean Response	2.64	2.44	2.50
Standard Deviation	1.355	1.165	1.256

Not Significant, X^2 (4, N = 75) = 4.43, p =.351

Table B13. Effort Regulation: "I work hard to do well in this class even if I don't like what we are doing" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	2	5	7
3	10	9	19
4	11	11	22
5	11	13	24
Total	35	39	74
Mean Response	3.86	3.77	3.80
Standard Deviation	1.060	1.135	1.085

Not Significant, X^2 (4, N = 74) = 1.29, p =.863

Table B14. Effort Regulation: "I work on practice exercises even when I don't have to" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	2	7	9
2	15	11	26
3	8	10	18
4	5	8	13
5	6	3	9
Total	36	39	75
Mean Response	2.94	2.72	2.83
Standard Deviation	1.218	1.213	1.212

Not Significant, X^2 (4, N = 75) = 5.20, p =.268

Table B15. Effort Regulation: "When course work is difficult, I either give up or only study the easy parts" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	12	12	24
2	14	16	30
3	6	4	10
4	2	7	9
5	2	0	2
Total	36	39	75
Mean Response	2.11	2.15	2.13
Standard Deviation	1.116	1.065	1.082

Not Significant, X^2 (4, N = 75) = 5.20, p =.267

Table B16. Help Seeking: "I ask the instructor to clarify concepts I don't understand well" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	6	6
2	9	2	11
3	8	13	21
4	12	9	21
5	7	9	16
Total	36	39	75
Mean Response	3.47	3.33	3.40
Standard Deviation	1.082	1.325	1.208

Significant, X^2 (4, N = 75) = 12.22, p =.016

Appendix C

Results for Each Course Type at University B

Results for Calculus for the Life Sciences

Table C1. Amount of time spent per week on calculus (outside of class time)

Amount of Time	No Calculus in High School	Calculus in High School	Total
0-2 hours	3	7	10
2-4 hours	1	1	2
4-6 hours	1	0	1
more than 6 hours	0	0	0
Total	5	8	13

Not Significant, X^2 (3, N = 13) = 2.02, p =.569

Table C2. Frequency of seeking help from course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	1	6	7
1-2 times	2	2	4
3-4 times	2	0	2
more than 4 times	1	0	1
Total	6	8	14

Not Significant, X^2 (3, N = 14) = 6.42, p =.093

Table C3. Frequency of seeking help from someone other than course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	1	1	2
1-2 times	0	5	5
3-4 times	2	2	4
more than 4 times	3	0	3
Total	6	8	14

Significant, X^2 (3, N = 14) = 7.88, p =.049

Table C4. Frequency of attending tutoring or extra-help session

Frequency	No Calculus in High School	Calculus in High School	Total
Never	5	8	13
1-2 times	0	0	0
3-4 times	0	0	0
more than 4 times	1	0	1
Total	6	8	14

Not Significant, X^2 (3, N = 14) = 1.44, p =.697

Table C5. Frequency of missing class

Frequency	No Calculus in High School	Calculus in High School	Total
Never	2	5	7
1-2 times	3	2	5
3-4 times	1	0	1
more than 4 times	0	1	1
Total	6	8	14

Not Significant, X^2 (3, N = 14) = 3.27, p =.352

Table C6. Intrinsic Goal Orientation: "I prefer course material that really challenges me so I can learn new things" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	1	1
2	1	1	2
3	2	3	5
4	3	3	6
5	0	0	0
Total	6	8	14
Mean Response	3.33	3.00	3.14
Standard Deviation	0.816	1.069	0.949

Not Significant, X^2 (4, N = 14) = 0.93, p =.920

Table C7. Extrinsic Goal Motivation: "Getting a good grade in this class is the most satisfying thing for me right now" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	0	2	2
3	1	0	1
4	2	2	4
5	3	4	7
Total	6	8	14
Mean Response	4.33	4.00	4.14
Standard Deviation	0.816	1.309	1.099

Not Significant, X^2 (4, N = 14) = 2.92, p =.572

Table C8. Task Value: "I like the subject matter of this course" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	1	1	2
3	1	1	2
4	3	2	5
5	0	3	3
Total	6	8	14
Mean Response	3.00	3.63	3.36
Standard Deviation	1.265	1.506	1.393

Not Significant, X^2 (4, N = 14) = 2.98, p =.562

Table C9. Task Value: "Understanding the subject matter of this course is very important to me" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	1	1
2	0	0	0
3	1	1	2
4	3	1	4
5	2	5	7
Total	6	8	14
Mean Response	4.17	4.13	4.14
Standard Deviation	0.753	1.458	1.167

Not Significant, X^2 (4, N = 14) = 3.06, p =.547

Table C10. Self-Efficacy for Learning and Performance: "I expect to do well in this class" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	1
2	0	0	0
3	1	1	2
4	3	2	4
5	2	5	7
Total	6	8	14
Mean Response	4.17	4.5	4.36
Standard Deviation	0.753	0.756	0.745

Not Significant, X^2 (4, N = 14) = 1.23, p =.874

Table C11. Control of Learning Beliefs: "If I try hard enough, then I will understand the course material" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	0	0	0
3	0	0	0
4	4	2	6
5	2	6	8
Total	6	8	14
Mean Response	4.33	4.75	4.57
Standard Deviation	0.516	0.463	0.514

Not Significant, X^2 (4, N = 14) = 2.43, p =.657

Table C12. Effort Regulation: "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	2	2
2	2	3	5
3	2	2	4
4	0	1	1
5	2	0	2
Total	6	8	14
Mean Response	3.33	2.25	2.71
Standard Deviation	1.366	1.035	1.267

Not Significant, X^2 (4, N = 14) = 5.02, p =.286

Table C13. Effort Regulation: "I work hard to do well in this class even if I don't like what we are doing" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	1	2	3
3	1	2	3
4	3	2	5
5	1	2	3
Total	6	8	14
Mean Response	3.67	3.50	3.57
Standard Deviation	1.033	1.195	1.089

Not Significant, X^2 (4, N = 14) = 0.93, p =.920

Table C14. Effort Regulation: "I work on practice exercises even when I don't have to" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	3	3
2	3	1	4
3	1	0	1
4	1	3	4
5	1	1	2
Total	6	8	14
Mean Response	3.00	2.75	2.86
Standard Deviation	1.265	1.669	1.460

Not Significant, X^2 (4, N = 14) = 5.83, p =.212

Table C15. Effort Regulation: "When course work is difficult, I either give up or only study the easy parts" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	2	3
2	3	4	7
3	1	1	2
4	1	1	2
5	0	0	0
Total	6	8	14
Mean Response	2.33	2.13	2.21
Standard Deviation	1.033	0.991	0.975

Not Significant, X^2 (4, N = 14) = 0.19, p =.996

Table C16. Help Seeking: "I ask the instructor to clarify concepts I don't understand well" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	2	2
2	2	1	3
3	0	3	3
4	4	1	5
5	0	1	1
Total	6	8	14
Mean Response	3.33	2.75	3.00
Standard Deviation	1.033	1.389	1.240

Not Significant, X^2 (4, N = 14) = 8.01, p =.091

Results for Applied Calculus

Table D1. Amount of time spent per week on calculus (outside of class time)

Amount of Time	No Calculus in High School	Calculus in High School	Total
0-2 hours	1	1	2
2-4 hours	3	6	9
4-6 hours	4	2	6
more than 6 hours	0	0	0
Total	8	9	17

Not Significant, X^2 (3, N = 17) = 1.61, p =.656

Table D2. Frequency of seeking help from course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	3	7	10
1-2 times	3	2	5
3-4 times	2	0	2
more than 4 times	0	0	0
Total	8	9	17

Not Significant, X^2 (3, N = 17) = 3.75, p =.289

Table D3. Frequency of seeking help from someone other than course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	2	3	5
1-2 times	2	2	4
3-4 times	2	1	3
more than 4 times	2	3	5
Total	8	9	17

Not Significant, X^2 (3, N = 17) = .677, p =.879

Table D4. Frequency of attending tutoring or extra-help session

Frequency	No Calculus in High School	Calculus in High School	Total
Never	4	8	12
1-2 times	1	0	1
3-4 times	1	0	1
more than 4 times	2	1	3
Total	8	9	17

Not Significant, X^2 (3, N = 17) = 3.62, p =.305

Table D5. Frequency of missing class

Frequency	No Calculus in High School	Calculus in High School	Total
Never	4	1	5
1-2 times	1	4	5
3-4 times	2	1	3
more than 4 times	1	3	4
Total	8	9	17

Not Significant, X^2 (3, N = 17) = 4.89, p =.180

Table D6. Intrinsic Goal Orientation: "I prefer course material that really challenges me so I can learn new things" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	3	0	3
3	2	3	5
4	3	5	8
5	0	1	1
Total	8	9	17
Mean Response	3.00	3.78	3.41
Standard Deviation	0.926	0.667	0.870

Not Significant, X^2 (4, N = 17) = 4.66, p =.324

Table D7. Extrinsic Goal Motivation: "Getting a good grade in this class is the most satisfying thing for me right now" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	0	1	1
3	0	0	0
4	2	2	4
5	6	6	12
Total	8	9	17
Mean Response	4.75	4.44	4.59
Standard Deviation	0.463	1.014	0.795

Not Significant, X^2 (4, N = 17) = 0.94, p =.918

Table D8. Task Value: "I like the subject matter of this course" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	0	1
2	3	0	3
3	1	2	3
4	3	6	9
5	0	1	1
Total	8	9	17
Mean Response	2.75	3.89	3.35
Standard Deviation	1.165	0.601	1.057

Not Significant, X^2 (4, N = 17) = 6.30, p =.178

Table D9. Task Value: "Understanding the subject matter of this course is very important to me" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	0	0	0
3	3	2	5
4	3	3	6
5	2	4	6
Total	8	9	17
Mean Response	3.88	4.22	4.06
Standard Deviation	0.835	0.833	0.827

Not Significant, X^2 (4, N = 17) = 0.81, p =.937

Table D10. Self-Efficacy for Learning and Performance: "I expect to do well in this class" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	1	1	2
3	2	2	4
4	3	4	7
5	2	2	4
Total	8	9	17
Mean Response	3.75	3.78	3.76
Standard Deviation	1.035	0.972	0.970

Not Significant, X^2 (4, N = 17) = 0.08, p =.999

Table D11. Control of Learning Beliefs: "If I try hard enough, then I will understand the course material" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	1	0	1
3	1	1	2
4	3	1	4
5	3	7	10
Total	8	9	17
Mean Response	4.00	4.67	4.35
Standard Deviation	1.069	0.707	0.931

Not Significant, X^2 (4, N = 17) = 3.55, p =.470

Table D12. Effort Regulation: "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	2	3
2	3	3	6
3	3	1	4
4	0	3	3
5	1	0	1
Total	8	9	17
Mean Response	2.63	2.56	2.59
Standard Deviation	1.188	1.236	1.176

Not Significant, X^2 (4, N = 17) = 5.29, p =.259

Table D13. Effort Regulation: "I work hard to do well in this class even if I don't like what we are doing" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	0	1	1
3	2	4	6
4	4	2	6
5	2	2	4
Total	8	9	17
Mean Response	4.00	3.56	3.76
Standard Deviation	0.756	1.014	0.903

Not Significant, X^2 (4, N = 17) = 2.28, p =.684

Table D14. Effort Regulation: "I work on practice exercises even when I don't have to" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	4	2	6
3	1	3	4
4	1	2	3
5	1	1	2
Total	8	9	17
Mean Response	2.63	3.00	2.82
Standard Deviation	1.302	1.225	1.237

Not Significant, X^2 (4, N = 17) = 1.95, p =.745

Table D15. Effort Regulation: "When course work is difficult, I either give up or only study the easy parts" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	5	4	9
3	2	1	3
4	0	3	3
5	0	0	0
Total	8	9	17
Mean Response	2.13	2.67	2.41
Standard Deviation	0.641	1.118	0.939

Not Significant, X^2 (4, N = 17) = 3.40, p =.494

Table D16. Help Seeking: "I ask the instructor to clarify concepts I don't understand well" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	1	1
2	5	1	6
3	0	4	4
4	2	2	4
5	1	1	2
Total	8	9	17
Mean Response	2.88	3.11	3.00
Standard Deviation	1.246	1.167	1.173

Not Significant, X^2 (4, N = 17) = 7.63, p =.106

Results for Analytical Geometry – Calculus I

Table E1. Amount of time spent per week on calculus (outside of class time)

Amount of Time	No Calculus in High School	Calculus in High School	Total
0-2 hours	1	4	5
2-4 hours	8	12	20
4-6 hours	8	4	12
more than 6 hours	4	0	4
Total	21	20	41

Significant, X^2 (3, N = 41) = 7.91, p =.048

Table E2. Frequency of seeking help from course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	9	12	21
1-2 times	9	5	14
3-4 times	3	4	7
more than 4 times	1	1	2
Total	22	22	44

Not Significant, X^2 (3, N = 44) = 1.71, p =.634

Table E3. Frequency of seeking help from someone other than course professor

Frequency	No Calculus in High School	Calculus in High School	Total
Never	9	5	14
1-2 times	4	9	13
3-4 times	1	5	6
more than 4 times	8	3	11
Total	22	22	44

Significant, X^2 (3, N = 44) = 8.01, p =.046

Table E4. Frequency of attending tutoring or extra-help session

Frequency	No Calculus in High School	Calculus in High School	Total
Never	19	20	39
1-2 times	0	2	2
3-4 times	2	0	2
more than 4 times	1	0	1
Total	22	22	44

Not Significant, X^2 (3, N = 44) = 5.03, p =.170

Table E5. Frequency of missing class

Frequency	No Calculus in High School	Calculus in High School	Total
Never	5	7	12
1-2 times	6	9	15
3-4 times	5	4	9
more than 4 times	6	2	8
Total	22	22	44

Not Significant, X^2 (3, N = 44) = 3.04, p =.385

Table E6. Intrinsic Goal Orientation: "I prefer course material that really challenges me so I can learn new things" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	0	1
2	1	1	2
3	7	10	17
4	8	10	18
5	5	1	6
Total	22	22	44
Mean Response	3.68	3.50	3.59
Standard Deviation	1.041	0.673	0.82

Not Significant, X^2 (4, N = 44) = 4.42, p =.352

Table E7. Extrinsic Goal Motivation: "Getting a good grade in this class is the most satisfying thing for me right now" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	1	0	1
3	1	2	3
4	9	10	19
5	11	10	21
Total	22	22	44
Mean Response	4.36	4.36	4.36
Standard Deviation	0.790	0.658	0.718

Not Significant, X^2 (4, N = 44) = 1.43, p =.838

Table E8. Task Value: "I like the subject matter of this course" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	0	1
2	4	2	6
3	3	3	6
4	7	9	16
5	7	8	15
Total	22	22	44
Mean Response	3.68	4.05	3.86
Standard Deviation	1.249	0.950	1.112

Not Significant, X^2 (4, N = 44) = 1.98, p =.739

Table E9. Task Value: "Understanding the subject matter of this course is very important to me" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	0	1
2	0	1	1
3	1	2	3
4	10	6	16
5	10	13	23
Total	22	22	44
Mean Response	4.27	4.41	4.34
Standard Deviation	0.935	0.854	0.888

Not Significant, X^2 (4, N = 44) = 3.72, p =.445

Table E10. Self-Efficacy for Learning and Performance: "I expect to do well in this class" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	0	0
2	2	1	3
3	3	2	5
4	7	7	14
5	10	12	22
Total	22	22	44
Mean Response	4.14	4.36	4.25
Standard Deviation	0.990	0.848	0.918

Not Significant, X^2 (4, N = 44) = 0.72, p =.949

Table E11. Control of Learning Beliefs: "If I try hard enough, then I will understand the course material" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	0	1
2	0	0	0
3	2	3	5
4	5	8	13
5	14	11	25
Total	22	22	44
Mean Response	4.41	4.36	4.39
Standard Deviation	1.008	0.727	0.868

Not Significant, X^2 (4, N = 44) = 2.25, p =.689

Table E12. Effort Regulation: "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	8	6	14
2	4	6	10
3	4	5	9
4	4	4	8
5	2	1	3
Total	22	22	44
Mean Response	2.45	2.45	2.45
Standard Deviation	1.405	1.224	1.302

Not Significant, X^2 (4, N = 44) = 1.13, p =.889

Table E13. Effort Regulation: "I work hard to do well in this class even if I don't like what we are doing" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	1	2
2	1	2	3
3	7	3	10
4	4	7	11
5	8	9	17
Total	21	22	43
Mean Response	3.81	3.95	3.88
Standard Deviation	1.167	1.174	1.159

Not Significant, X^2 (4, N = 43) = 2.79, p =.594

Table E14. Effort Regulation: "I work on practice exercises even when I don't have to" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	1	3	4
2	8	8	16
3	6	7	13
4	3	3	6
5	4	1	5
Total	22	22	44
Mean Response	3.05	2.59	2.82
Standard Deviation	1.214	1.054	1.147

Not Significant, X^2 (4, N = 44) = 2.88, p =.579

Table E15. Effort Regulation: "When course work is difficult, I either give up or only study the easy parts" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	10	9	19
2	6	8	14
3	3	2	5
4	1	3	4
5	2	0	2
Total	22	22	44
Mean Response	2.05	1.95	2.00
Standard Deviation	1.29	1.046	1.161

Not Significant, X^2 (4, N = 44) = 3.54, p =.472

Table E16. Help Seeking: "I ask the instructor to clarify concepts I don't understand well" (1 = not at all true of me; 5 = very true of me)

	No Calculus in High School	Calculus in High School	Total
1	0	3	3
2	2	0	2
3	8	6	14
4	6	6	12
5	6	7	13
Total	22	22	44
Mean Response	3.73	3.64	3.68
Standard Deviation	0.985	1.329	1.157

Not Significant, X^2 (4, N = 44) = 5.36, p =.252