# The Effect of Passing the AP Calculus Exam in High School

on

Academic Achievement in the First Semester of College.

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## Abstract

The purpose of this study was to determine if passing the Advanced Placement Calculus Exam in the senior year of high school had any effect on academic achievement in the first semester of the freshman year in college. The measurement tool was the Advanced Placement Calculus AB Exam of the College Entrance Examination Board (CEEB). This was a correlational study between the test results and grade point average after the first semester of the freshman year in college. The results from the data showed very little correlation between the two variables. Although there is some research in this area, future studies should focus on comparing the scores of the AP Calculus Exam and mathematics achievement, specifically, as opposed to overall grade point average.

# CHAPTER I

# INTRODUCTION

## Overview

Studying a college level mathematics class in high school can have a positive effect on a student academically, and can even grant them college credit or placement into upper level classes, if they are successful on the Advanced Placement Exam. Since the creation of the Advanced Placement program thousands of incoming college freshman have been granted credit for passing the AP exam and placed in the next level calculus class.

The popularity of the Advanced Placement program overall, and specifically calculus, increased over several decades and more high school students were registering for those classes and taking the AP exams. Taking AP classes and sitting for the exams was becoming a barometer of achievement at the high school level (Casement, 2003). Colleges and universities began to experience an influx of students who were being granted credit for passing the AP Calculus Exam, but who were not experiencing success in the next level calculus course in college. This alarming trend caused university math professors to question the rigor of the Advanced Placement calculus curriculum, as well as, the way in which it was being taught at the high school level.

Controversy still remains as to whether passing an AP exam is really a good indicator for whether a student is prepared for college academics, especially if that student is placed in the next level because of the score on the exam (Casement, 2003). This action research paper studies Advanced Placement calculus students who were successful on the AP exam and tracks their academic achievement during the first semester of their freshman year.

## Statement of Problem

What is the relationship between passing the AP Calculus exam in high school and academic achievement in the first semester freshman year of college as measured by GPA?

## Hypothesis

There is no relationship between students' Advanced Placement Calculus Exam score and grade point average in the first semester of freshman year in college.

## Operational Definitions

The independent variable in this study was a passing score on the Advanced Placement Calculus AB Exam of a 3, 4, or 5, on a scale of 1 through 5. The dependent variable was the academic achievement in the freshman year of college, which was defined by the overall grade point average.

# CHAPTER II

# REVIEW OF THE LITERATURE

## Overview

This review of the literature examines the role of taking an Advanced Placement calculus course in high school, passing the Advanced Placement exam, and subsequently going on to enroll in a four year college or university. The question raised is the achievement, or lack thereof, of students who have excelled in high school and now face the academic challenges of higher education. The review will be organized by the presentation of three main topics that will then be broken down into subsections.

The first section pertains to the current state of Advanced Placement calculus, including the increasing number of students who are taking the course, and the pressure most feel to sit for the Advanced Placement exam. The second section will touch upon academic achievement, which may or may not include mathematics, in the first year of college after a student has passed the Advanced Placement Calculus exam. This section will shed some light on the students who take the next level of calculus due to passing the Advanced Placement exam, as well as those who do not take any advanced math for that same reason; and subsequent varying levels of success those students experience. In addition, there will be a discussion of the decrease in the numbers of students actually taking advanced math due to the passing score on the exam in high school.

The third section will examine possible steps that should be taken at the high school level to increase success in college, mathematics and otherwise, as well as steps that colleges and

universities can take to increase achievement of students coming from the Advanced Placement program.

## The Advanced Placement Program

The Advanced Placement Program of the College Board is an endeavor between secondary schools and universities based on the premise that college level material can be taught to ambitious, well-prepared high school students. The goal of the program is to recognize and reward students who succeed in these courses in high school by encouraging colleges and universities to grant credit, advanced placement, or both, for achievement on the Advanced Placement Exams (Curry, MacDonald, & Morgan, 1999).

Since its inception, the Advanced Placement Program has been an important indicator used to gauge the status of American education. For years the program thrived and provided students with college credit before ever leaving high school. “For schools, AP enriches the quality of the curriculum, motivates teachers, sets high standards, and challenges students” (Curry, et al., 1999, p. 6). Research shows that access to this rigorous coursework during high school increases the chance of future academic success in terms of other standardized testing as well as college acceptance (McKillip & Rawls, 2013). The colleges and universities then use the Advanced Placement exam scores as a predictor of future college grade point average, and are able to opt students out of introductory classes and into higher-level courses in their freshman year.

The Advanced Placement Program has been criticized over the years, and a more recent study shows that “there is a quiet but growing skepticism at selective colleges about the quality of AP courses, and a reluctance to continue awarding credit to entering students who have taken

them" (Casement, 2003, p. 1). Despite the popularity of the program, there existed skepticism with how the program was operating as it grew, and how some questioned its worth as a college equivalency program for upper echelon universities and colleges that consider themselves elite.

As the program expanded and became more inclusive, proponents "hail[ed] it as the de-facto national curriculum that will raise standards at schools where they need to be raised" (Casement, 2003, p. 4). A report in 2010 suggested that elite selection bias was lessening, and access to AP courses and examinations was becoming available to more students in more high schools across the country, more than ever (McKillip & Rawls, 2013). Yet again, due to this ever growing and considerably larger national program, colleges and universities became increasingly wary of the quality of the program. "Despite the fact that…studies have shown AP students perform as well if not better than other groups of college students, some college faculty members report that these overall findings are not always the case" (Dodd, Fitzpatrick, De Ayala, Jennings, & College, 2002, p. 1). This led to these institutions becoming more selective with awarding credit to students. In fact, in 2002 "Harvard announced that a minimum score of 5 would be required for college credit for any of the AP exams…This move came after a study…found that students who used AP credit to skip introductory courses fared significantly worse at the next level than students who took those courses" (Casement, 2003, p. 5). This led to a widespread push for the Ivy League schools to modify their policies governing the Advanced Placement program and how they award credit. In fact some of the schools refused credit entirely for some of the Advanced Placement exams but did grant placement out of the introductory course that matched that curriculum.

The Advanced Placement program no longer serves a small elite subgroup of high school students, but is becoming a more common experience for those who are college bound.

"Throughout the United States many high school students are currently enrolled in AP courses and some are receiving college credit" (Thompson & Rust, 2007, p. 416). Scoring well on the Advanced Placement exams may not grant college credit, however, "applicants bearing AP courses on their transcripts will still be looked upon favorably" (Casement, 2003, p. 13).

## Mathematics Achievement in College after AP Calculus in High School

Amidst the Advanced Placement movement, calculus has been in the forefront, establishing itself as the standard of high school academic excellence. "Unfortunately, for the majority of those students, AP calculus has become not a steppingstone but a stumbling block. Each year hundreds of thousands of our best first–year college students are precluded from careers in science, technology, engineering, and mathematics because they fail to advance beyond AP calculus" (Bressoud, 2010, p.1).

There has been a steady increase in number of students taking the Advanced Placement calculus exam. In 2007, over 276, 000 students took an AP Calculus exam, which was a 30% increase over a 5 year period (Laurent, 2009). Although the number of students sitting for the AP calculus exam increases annually, the number of students who choose to take the next level of calculus when they arrive at college in the fall is falling. According to Bressoud (2010), 50,000 students scored a 3 or better on the Advanced Placement exam in 1990, which most likely would qualify them to take Calculus II or higher. That fall, 110, 000 of those students enrolled in Calculus II. Bressoud (2010) goes on to write that in 2005, 160, 000 students passed the exam, yet only 104, 000 of those students enrolled in Calculus II in the fall. In addition, "tens of thousands of students who did not take AP Calculus instead earned college credit for calculus via

the International Baccalaureale program…Those students, too, could have taken Calculus II but did not" ( p. 2).

There is no definitive answer as to why there is a decrease in students who go on to study higher-level mathematics in college after passing the Advanced Placement calculus exam. There is the usual finger pointing with college professors blaming poor high school mathematics instruction that lacks rigor and conceptual understanding. Of course, high school teachers blame "outdated pedagogical practices in many colleges, especially professors' reliance on lectures and failure to engage students in active learning" (Bressoud, 2010, p. 2). There is limited research that suggests "AP students who receive credit by exam for an initial college course in a subject area sequence earn course grades equivalent to or higher than students who take both the initial and sequent course in the series" (Hargrove et al., 2008, p. 2).

As mentioned earlier, with the expansion of the Advanced Placement program in general, and the importance put on studying calculus specifically, there is pressure put on schools to offer Advanced Placement calculus and to get students to take the course, which may cause underprepared students to go into the subject prematurely (Bressoud, 2010). There is research that suggests that there is very little difference between the college grade point average of those who take AP courses in high school and those who did not; "just because students take AP courses in high school, they do not necessarily do better in college" (Fara, 2010, p. 20). In fact, studies show that simply the number of AP courses that a student takes in high school has very little connection to future success in college: "mere participation in rigorous high school courses is not a valid indicator of a student's likelihood of college success, but performance on the AP Exam is a valid indicator of success" (Mattern, Shaw, Xiong & College, 2009, p. 1).

Some would say the largest problem is improper alignment with the curriculum established by the Advanced Placement calculus program, and that which a university may follow. Calculus AB, the program that corresponds to Calculus I in college, provides an overview of common techniques and applications of differentiation and integration. However, Calculus I in most colleges now focuses more on the theoretical and sophisticated treatment of differential calculus. This is not a problem for the upper echelon of calculus students, who are able to keep pace with the instruction and be prepared for Calculus II. However the majority of high school calculus students get through calculus with algorithms and procedural understanding, rather than the deeper conceptual knowledge now required to be successful. These students either retake the course to earn a better grade, or never complete the course at all. Most never even attempt Calculus II (Bressoud, 2010).

## Actions to be Taken to Meet the Challenges of College Mathematics

Bressoud (2010) believes that there are three major steps that need to be taken to meet the challenges created by the incredible growth of high school calculus. First, more information needs to be gathered about what happens to students who study calculus in high school. This would include data concerning how many are not really ready for college calculus, how many successfully take calculus their freshman year, how many never attempt calculus, and how important is it to take calculus while in high school.

A study by Dickey (1986) suggests that high school students who take AP Calculus BC course are in fact qualified to move on to the next level as the results showed these “students achieve as well, or better than, their college counterparts” (p. 143).

The second step is to establish and enforce guidelines for high school calculus programs. Bressoud (2010), believes that there is nothing wrong with the growth of the Advanced Placement calculus program, and those students at schools without a calculus offering may be at a disadvantage. “But calculus offered in high school must be designed to facilitate success in college mathematics for all students who take it, rather than creating obstacles for all but the very best” (p. 3).

The third step would be to re-examine first year college mathematics. Bressoud (2010) believes that there should be an appropriate course for students who studied calculus in high school but still are not ready for college level calculus. There should be a calculus-based course that builds on previous knowledge while preparing the students for future mathematics courses.

There is also the belief that colleges and universities should offer support programs for first year mathematics students; even those who plan to go into fields requiring extensive mathematics, such as engineering. According to Hillock, Jennings, Roberts, and Scharaschkin (2013), there is a 30% failure rate for the first year single variable calculus and linear algebra course; and a large number of those students are engineering majors. Statistical data has shown that these at-risk students have similar background skills, i.e., poor algebraic skills, poor grasp of trigonometry, and an inability to differentiate and integrate simple functions.

In their study, Hillock, et al., (2013) contended that students who attend a support program to assist with mathematics and study skills will ultimately increase their passing and retention rate. The program itself consisted of a weekly one hour tutorial session. The key features of the program included structured lessons, continual assessment, drill and practice, in-depth coverage rather than broad coverage of topics, and a focus on examination preparation.

The groups finding did show significant success for the group that regularly attended the support program.

## Summary

The past several decades have seen explosive growth in high school student participation in the Advanced Placement program, especially in calculus. In previous years, the Advanced Placement exams were held in very high regard, and used as a predictor of future academic success. Success on the exams also enabled students to earn college credit for the work they did in high school, as well as granting them advancement into the next level of coursework. This still holds true for the Advanced Placement program today, but there seems to be a shift in the credibility of the program, how colleges and universities perceive the program, and how students who are products of the program are achieving when they get to college.

There is a lingering controversy in the mathematics world as to the Advanced Placement calculus curriculum that is approved by the College Board. Some at the university level believe it does not reflect what is supposed to be taught at the college level, and therefore should not be a valid indicator of what high school math students truly understand about calculus. For this reason many colleges and universities only accept exam scores of 4 or 5 for credit, and are reluctant to grant advanced placement even with those scores. Those that do begin their college mathematics in the next level course are sometimes finding the material to be more demanding than anticipated.

# CHAPTER III

# METHODS

The purpose of this study was to investigate the relationship between passing the AP Calculus exam in high school and academic achievement in the first semester freshman year of college as measured by GPA.

## Design

The study consisted of a correlational study for the problem statement. The participants sat for the AP Calculus AB exam in the spring of their senior year in high school. The participants then reported their grade point average after the first semester of the freshman year in college. The study took place over a 7 month time period. The variables were a passing score on the AP Calculus AB exam with a 3, 4, or 5, on a scale of 1 through 5 and the academic achievement in their freshman year of college according to the overall grade point average.

## Participants

The study was conducted with high school seniors in an AP Calculus AB classroom in Maryland. This was a heterogeneous grouping including 15 students that participated in the study. The socioeconomic background of the students would be considered middle class to upper middle class. Fourteen students were white, and one student was from another racial group. Ten students were males and four students were females. This group consisted of capable learners with similar academic abilities. This was a non-probability, purposive sample.

## Instrument

The instrument used in this study was the Advanced Placement Calculus AB Exam of the College Entrance Examination Board (CEEB). A score of 3 or better on a scale of 1 through 5 is considered passing for this test. The study compared participant performance on this exam in the spring semester senior year in high school to their first semester freshman year grade point average the following fall. The Advanced Placement program was established as early as 1956 and has been a well recognized barometer of student aptitude to comprehend college-level academics. Hundreds of thousands of students worldwide take advantage of the Advanced Placement program, and thousands of colleges and universities grant college credit to students who perform well on the tests. The Advanced Placement Exams have been tested for validity and reliability by the Educational Testing Service.

Evidence of measurability is prepared by the Educational Testing Service through formal test analyses using psychometric characteristics including validity, reliability, item quality, and evenness of appraisal. The Advanced Placement Calculus Exams reportedly measure very well even when comparing the two levels of the exam: AB and BC. Both exams are highly reliable internally, with the multiple choice correlating well to the free response problems, and the two forms are reliable with each other as well.

## Procedure

The students began the study of Advanced Placement Calculus in August of their senior year in high school. The instruction they received was in accordance with the course standards and outcomes prescribed by Baltimore County Public Schools. These standards are in direct

alignment with the syllabus dictated by the College Entrance Examination Board. This includes analysis of the topic of limits, differentiation, integration, and the applications of those topics.

In preparation for the Advanced Placement exam there was an intense study period for several weeks prior to the exam date. This included classroom time dedicated to multiple choice and free response items reflecting those that would appear on the exam. The students also took part in a mock exam that mirrored the content and timing that the students would experience on test day. Finally, the students participated in a calculus crunch session on the Saturday morning prior to the actual test the following week.

Scores of the participants were retrieved in July following the exam. The scores were available through the College Board website. Advanced Placement teachers are granted access to the AP Audit page where the scores can be viewed. Scores of the seniors in the class were recorded to be a part of the study. Email addresses were collected from each of the participants in order to be able to collect their grade point average data later that year.

In January of the following year a survey was emailed to the participants to solicit their grade point average from the fall semester of their freshman year in college. A response was received from all participants and the data was recorded to be compared to their test scores and further analyzed.

# CHAPTER IV

## RESULTS

This study was designed to determine if passing the Advanced Placement calculus exam in the senior year of high school had any effect on the academic achievement of students in the first semester of their freshman year. The academic achievement was measured using the first semester freshman year grade point average (GPA). The null hypothesis held that there would be no significant relationship between AP exam scores and freshman college GPA.

A correlation was run to determine if there was any significant relationship between students' AP Exam scores and first semester college GPA. Results showed no significant relationship between AP Exams and first semester college GPA, $r = .028$, $p > .05$. The null hypothesis was supported. These results and their implications will be discussed in the next chapter.

Table 1

*Means and Standard Deviations of the Variables.*

| Variable | Mean (SD) |
|---|---|
| AP Exam Score | 4.53 (.743) |
| First Semester GPA | 3.73 (.458) |

# CHAPTER V

# DISCUSSION

## Implications of the Results

The null hypothesis that there is no relationship between students' Advanced Placement Calculus Exam score and grade point average in the first semester of freshman year in college was supported. The data indicates no significant relationship between Advanced Placement exam scores and first semester freshman year grade point average. Although the mean score on the AP exam would be considered strong on the scale of 1 through 5, and likewise, the mean GPA would be considered above average, the *r* value reflects very little correlation between the two sets of data. This lack of correlation suggests no indication that scoring well on the Advanced Placement calculus exam was a cause of the students' success in their freshman first semester. Therefore the null hypothesis is supported.

## Theoretical Consequences

The results in this study showed very little correlation between the variables. Had the data actually suggested a high correlation between AP Exam scores and freshman year GPA, one would still be hard pressed to arrive at any conclusion regarding causation. A correlational study, regardless of the strength of the relationship, does not show a cause and effect relation between variables. Thus, a statement could not be made that passing the AP exam causes higher achievement in college. The most that could be said is that passing the AP Calculus exam in high school tends to lead to higher achievement in the freshman year of college.

## Threats to the Validity

One significant threat to validity would be in the way in which part of the data was gathered. The grade point averages for the participants were gathered via email. Each student simply responded to the email asking for their GPA for the first semester freshman year. There could possibly have been some embellishment in the data which then would skew the scores. The Advanced Placement scores, however, were collected directly from the College Board website. The data is password protected in the AP Scores Report, available only to educators with access to the scores of those particular students.

The second threat to validity in this study would simply be the sample size. The AP Exam scores of fifteen students were used and compared to their first semester freshman year grade point averages. Such a small sample of students could, in fact, have an effect on the validity of the findings.

The third threat to validity lies in the type of sample used in this study. This study used the AP Exam scores of the participants who were high school seniors enrolled in AP Calculus AB. Therefore, participants were chosen using a non-probability, purposive sampling technique. This type of quantitative sampling chooses students for a particular reason. The reason, in this case, was the fact that the students passed the AP Calculus AB exam, and were enrolled in a college or university. This type of sampling can be prone to researcher bias which then puts the data and results of the study into question.

Finally, a threat to the validity of this study comes from the type of study itself. This correlation study relied on the internal structure of the AP Calculus Exam to be a valid indication of a student's ability to do calculus. However, the study compares success on this test to future success in college. This assumes that an external structure exists to the AP Calculus Exam that

corresponds to the grade point averages of students in college. This assumption could have an effect on the validity of the study.

## Connection to Previous Research

The study conducted by Mattern et. al. (2009) set out to investigate a similar problem statement to this research. The researchers focused on students taking AP Exams for English Language, Biology, Calculus AB, or US History, and compared those scores to their freshman year overall grade point averages, and their subsequent return for a second year of college. The study included three separate groups of students for each subject: those who did not take any AP Exams, those who scored a 1 or 2, and those who scored a 3 or above.

The data in the study concluded that higher performance on an AP Exam, regardless of the subject matter, corresponded to higher freshman year grade point averages (Mattern, et al., 2009). The researchers did observe, however, that the group of students who scored either a 1 or 2, did not perform significantly better than the groups that did not take an AP Exam.

The researchers concluded that "while association is not equivalent to causation, the results of this study do provide support for the role of participation in the AP Exam in subsequent college performance and success" (Mattern et. al., 2009, p. 12).

## Implications for Future Research

This study showed no correlation between passing the AP Calculus Exam and grade point average in the freshman year of college. Although, there has been research suggesting that doing well on AP Exams does in fact have a positive effect on achievement in college. That research in the area of mathematics, however, has been minimal.

Education researchers should continue to study the effects of the AP program in mathematics in order to modify and improve upon the program; as it does not just affect high school students in this country, but on the international stage, as well.

One such study may include tracking students who are recognized for passing the AP Calculus AB Exam, and are then placed in a college Calculus II class. The researchers would compare their course grade to the course grades of the students who took the same class after taking Calculus I at that institution. This, of course, could also be done for students who pass the AP Calculus BC Exam and are inevitably placed in a college Calculus III course. A study of this nature would also shed light on the Advanced Placement curriculum and whether it truly parallels the coursework of college calculus.

The literature available on the topic will show a divide in the opinions of the Advanced Placement program overall; therefore, it is important for future studies to continue, especially in mathematics.

## Conclusion

This study suggests very little correlation between passing the AP Calculus AB Exam and achievement in the freshman year of college. However, the calculations in this study are generated with a rather small sample size. Larger studies have shown that taking AP courses and scoring well on the AP Exams does tend to support achievement at the college level.

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