Advanced Placement and College Success in Freshman and Sophomore Level Biology Courses

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Abstract

This investigation examines college success in freshman and sophomore level biology courses for students with biology AP credit by addressing the following questions: One, Does AP biology experience increase academic performance in freshman biology? Do AP students with scores of 3 significantly outperform non-AP students? Do AP students with scores of 5 significantly outperform non-AP students in sophomore level biology courses? Two groups of college freshman and sophomores, those with AP biology scores and those without, were matched in regards to gender and SAT scores and instructor of record. Results suggest that students with biology AP scores of 3 may not, as suggested by the College Board, be adequately prepared to enroll directly into sophomore level biology courses. Results from this dissertation suggest the following implications: (a) AP students with final AP exam scores of 1 and 2 have derived little if any benefit from their yearlong AP biology course and the AP final exam in regards to Freshman Biology I; (b) AP biology students with scores of 3 and 4 on their end-of-the-year biology AP exam appear to be well prepared to be successful, based on mean final grades, in Freshman Biology I; (c) There is no supporting evidence that suggests AP students with AP final exam scores of 3 or 4 are adequately prepared to enroll directly into sophomore level biology courses and be successful; and (d) AP students with scores of 5 who have enrolled directly into sophomore level biology courses did not significantly outperform, based on mean final grades, non-AP students who have taken the two semester sequence of freshman biology courses. Further research needs to be done at each college and university participating in the Advanced Placement program to set appropriate cut off scores for the end-of-the-year AP exam score in regards to awarding college credit. Moreover, a considerable amount of research carried out thus far fails to capture many of the variables known to be associated with college success. Therefore, further research done in this area needs to control for these other variables.

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Advanced Placement and College Success in Freshman and Sophomore Level Biology Courses

CHAPTER 1

Introduction

The College Board's Advanced Placement Program (here after known as AP), is a cooperative educational venture between secondary schools and higher education that has been in existence since the early 1950s. The original purpose of this program was to provide the best and brightest college bound high school seniors the opportunity to take college level courses while still enrolled in high school (The College Board, 2008g). These students not only gained college level experiences but also had the potential to earn college credit.

The focus of the AP program has since broadened its scope to include all high school students – grades 9 through 12 (The College Board, 2009c). The College Board (2005) states that AP courses and exams are designed to expose secondary school students to a structured and rigorous curriculum which is equivalent to course work that will be experienced at the college-level. Therefore, the assertion is that students with AP experiences are expected to be better prepared for college, have higher college GPAs, and graduate from college more quickly than those without AP experience.

According to the College Board (2008a), more than 90% of U.S. colleges and universities participate in the AP program, in turn offering freshman, sophomore, and at times junior level credit to high school students who successfully complete their AP courses and exams. AP examinations are offered each year in the month of May. The scores from these exams are then used by colleges and universities for the purpose of granting college credit for introductory-level coursework which then places students into more advanced college courses. The exam consists of a set of multiple-choice questions and essay questions. Scores from the two types of questions

are combined into a composite score ranging from 1 to 5. As recommended by the College Board and endorsed by the American Council on Education (2004), colleges and universities should award college credit for AP exam scores of 3 and higher. The College Board's (2008f) AP program, which first provided 2,199 examinations in ten subject areas (i.e., English Composition, Literature, Latin, French, German, Spanish, Math, Biology, Chemistry, and Physics) to the nation's most talented college bound youth in 1956, has since experienced exponential growth. During the 2007 school year, over 2.5 million AP exams were taken by high school students in 37 subject areas (The College Board, 2007).

Currently, the AP program receives considerable financial backing from states, the national government, and philanthropists. For example, several states such as Arkansas, Florida, and South Carolina have begun paying students to take AP exams (Clemmitt, 2006). According to the College Board (2009b), all but five states currently offer state and/or federal AP exam fee subsidies. Further, the US Department of Education, in 2006, awarded 33 grants totaling over $17 million for AP program subsidies (Byrd, Ellington, Gross, Jago, & Stern, 2007). During the 2007 State of the Union address, President Bush proposed training 70,000 high school teachers to lead Advanced Placement courses in math and science. This proposed program will come with a large price tag potentially costing millions of dollars that will likely be funded by taxpayers.

On August 29, 2007, the Governor of the Commonwealth of Virginia, Tim Kaine, announced that Virginia was awarded a $13 million grant from Exxon Mobil designated to provide funding for Virginia-based AP training and incentive programs for math and science courses (Virginia.gov, 2007). Also, in 2006, the Bill and Melinda Gates Foundation awarded grants totaling $16 million to programs in Chicago; Washington, DC; and Duval County, Florida aimed in part at funding AP courses (Byrd et al, 2007).

Several proposed benefits are associated with participating in AP coursework and its subsequent exams. First is the ability to receive college credit for coursework completed during high school (The College Board, 2005). Allowing high school students the ability to receive college credit while still enrolled in high school affords them the opportunity to complete their college degree more quickly. For example, if a student takes an AP Calculus course in high school and then takes and passes the end-of-the-year AP Calculus exam with a score of 3 or higher, he or she will receive credit from colleges and universities participating in the AP program. This advanced placement will allow the student to bypass Calculus 101 in college and enroll directly in Calculus 102.

The second benefit is the role AP coursework has in the college acceptance process. Since high school GPA is among the most important variables used by college and universities in the admissions process, GPA weighting is extremely important (Breland, Gernand, Cumming, & Trapani, 2002). According to Sadler and Tia (2007b), advanced courses such as those with an AP designation taken in high school are often weighted more heavily than standard high school courses. Noting that no national standard exists for the weighting of these advanced courses, they are often graded on a higher scale, as such, an A=5, B=4, C=3, D=2, F=1 as opposed to the typical A=4, B=3, C=2, D=1, and F=0 grading scale. Therefore, students taking AP courses have bonus points added to the grades appearing on their transcripts. As an example, Geiser and Santelices (2004) note, the mean high school GPA for the entering class at the University of California - Berkeley in 2003 was a 4.31. As a consequence, high school students taking AP courses have an advantage relevant to non-AP students in the admissions process.

A third benefit associated with the AP program is the rate at which AP students graduate from college. Educational Testing Services (ETS) researchers Morgan and Klaric (2007) have

demonstrated that only 45% of non-AP students graduated within a four-year period whereas 63% of students with AP exam credit in at least one course allowing college credit earn their college degrees within a four-year period. Expediting a student's time to degree in turn saves both time and money.

Fourth, students enrolled in AP courses benefit from the academic rigor and college equivalency provided from AP courses. According to the College Board (2008a), AP courses cover the breadth of information, skills, and assignments found in corresponding college courses. Consequently, they better prepare students for college level coursework which, in turn, results in greater success (expressed as GPA) in college relative to those who do not experience advanced coursework in high school. Said academic rigor and college equivalency of AP courses has been the aim of much of the research conducted regarding the Advanced Placement program as is evidenced by statements made by supporters of the AP program:

1. "A 3 is the grade that research consistently and currently finds predictive of college success and graduation" (The College Board, 2007, p. 2).
2. "AP candidates who are placed ahead in the field of their qualifying AP Examinations do better than a generality of local upperclassmen in those courses" (Casserly, 1986, p.13).
3. "The data from this study and several prior studies found that students who receive qualifying grades of 3, 4, and 5 on the AP Exams can directly enroll in upper level courses and flourish" (Morgan & Ramist, 1998, p.10).
4. "AP students earn higher GPAs in the advanced college courses into which their AP credit allow them to place, compared to students with the same high school class rank

and SAT score who did not earn AP credit and who did not skip the entry-level college course" (The College Board, 2007, p.11).

The evidence provided thus far suggests that the higher education system, as a whole, assumes that AP courses and the associated examinations are equivalent to freshman, sophomore, and, at times, junior-level college courses. As a result, these AP experiences adequately prepare participating students to forgo introductory level courses upon entry into college.

However, there is a small but growing concern in colleges and universities that students receiving AP credit by virtue of a qualifying AP exam score, in particular a score of 3, are not as prepared for college level work as suggested by the AP program and those who champion its claim relevant to college success. Available research conducted by independent researchers such as Byrd et al (2007); Geiser and Santelices (2004); Klopfenstein and Thomas (2009); Lichten (2000); Sadler and Tai (2007a) are at odds with the findings proposed by the proponents of the AP program.

Lichten (2000) suggests the quality of AP courses has precipitously decreased to the point that the College Board's recommended score of 3 on an AP exam is no longer indicative of college success and, therefore, the current grading scale needs modification. Klopfenstein and Thomas (2009) suggest that research conducted by the College Board, the owner of the AP program, and the ETS (administrator of the yearly AP exam) is fundamentally flawed as it does not account for the nature of the typical AP student, who is particularly intelligent, highly motivated, and is likely to perform well in college regardless of participation in the AP program. Byrd et al. (2007) state, "AP courses are too rigid, confining and single-minded, that they are a means to the ends of college admissions and credit rather than an opportunity for deep learning"

(p. 7). Consequently, AP courses appear to focus on covering content and not on a thorough understanding of the subject matter. Geiser and Santelices (2004) suggest that the number of AP courses taken in high school has little effect on predicting college success during a student's freshman year. Sadler and Tai (2007a) report that once student demographics and prior academic achievements are controlled for, the apparent advantage that AP students have in regards to college success relevant to non-AP students is reduced considerably.

During the month of November 2007, a website (http://excellencewithoutap.org/) was created by Gary Hammond, the Director of College Counseling at Sandia Preparatory School in Albuquerque, New Mexico; the website is relevant to this discussion for several reasons. According to Hammond (personal communication, March 13, 2008), this website was created in response to a number of the nation's leading college prep schools that desire to no longer be affiliated with the College Board's AP program, asserting that this program was not living up to its claims of college preparedness. Particularly interesting are two schools that no longer offering the AP experience: Lawrenceville School (NJ) and Phillips Exeter Academy (NH). As is discussed in the AP history section of this document, Lawrenceville School and Phillips Exeter Academy were instrumental in the creation of the Advanced Placement Program in the early 1950s (The College Board, 2008g).

Information presented thus far indicates that a strong difference of opinion exists within the literature as to the educational value high school students receive while participating in AP courses and its associated end-of-the-year exam in relation to success later in college. Of concern, and, therefore, the rationale for this dissertation is the lack of available research to substantiate whether or not the AP program and its associated end-of-the-year exams are offering

experiences that adequately prepare students to bypass their entry level coursework and enroll directly in upper division coursework upon entering college.

Since the AP program was created in the 1950's, less than a dozen research papers have been published regarding AP students and their academic achievements in college. A large percentage of the available research conducted in the past 50 years has been generated from the College Board, the owner of the AP program, and ETS, which administers over 2.5 million AP examinations annually. Recent investigations from Klopfenstein and Thomas (2005, 2009), Lichten (2000), as well as Sadler and Tia (2007a) in regards to the AP program and college success have offered contrasting results when compared to the College Board and ETS.

Statement of the Problem

Much of the available research regarding the Advanced Placement exams suggests that students receiving AP exam scores of 3 provides valid evidence that students are capable of receiving credit for introductory college courses. In so doing, students are placed in advanced courses upon entering college. Much of the available research suggests that in general this is a true statement. A closer examination of the available literature suggests that this may not be the case for students who take and pass the biology AP exam with the score of 3.

Purpose of the Study

The College Board, and endorsed by the American Council on Education (2004), states that an AP exam score of 3 provides sufficient evidence to award advanced placement upon college entry. Ultimately, it is the responsibility of all colleges and universities participating in the Advanced Placement program to have in place an appropriate Advanced Placement Policy. Therefore, the purpose of this study is two-fold: (a) to provide quantitative evidence that the commonly employed policy regarding advanced placement is properly set to allow entering

students, with the proper AP biology final exam score, the ability to bypass their introductory biology courses based on their AP biology exam scores; and (b) to add to the existing research pertaining to college success and the AP program.

Research Questions

The specific research questions that guide this study are:

Question #1. Does high school AP biology coursework experience increase college academic performance at Virginia Tech in freshman level biology courses after matching for SAT scores (math and verbal), instructor of record, and student gender relative to students who do not have AP biology experience?

Question #2. Do statistically significant differences occur among the various study groups (AP students scores 1-4 and non-AP students) in General and Principles of Biology I and, if so, where?

Question #3. Do biology AP students with final exam scores of 3, the score suggested by the Advanced Placement program to be used in awarding college credit for the two semester sequence of freshman biology, significantly outperform based on final grades those students without an AP experience in General or Principles of Biology I after matching for SAT scores (math and verbal), instructor of record, and student gender?

Question #4. Do AP students receiving an AP exam score of 5 (score necessary to bypass the introductory biology sequence) on their biology AP exam outperform (expressed as final sophomore biology course grade) non-AP students in selected sophomore level biology courses at Virginia Tech after matching for SAT scores (math and verbal), instructor of record, and student gender?

In order to provide a context for this study, a case study provides the locus and data for this analysis, and consequently becomes part of the background information needed in this review. The case in point is the AP policy at Virginia Tech, which is a large land grant, research extensive university. As currently listed in Virginia Tech's 2008-2009 Undergraduate Course Catalog & Academic Policies the policy for advanced placement in biology states:

- A minimum Advanced Placement score of 4 is equivalent to Principles of Biology II lecture and lab (BIOL 1106 and BIOL 1126) and General Biology lecture and lab (BIOL 1006 and BIOL 1116)
- A minimum Advanced Placement score of 5 is equivalent to Principles of Biology I and II lecture and lab (BIOL 1105 and BIOL 1125; BIOL 1106 and BIOL 1126) and General Biology I and II lecture and lab (BIOL 1005 and BIOL 1115; BIOL 1006 and BIOL 1116)

The current biology Advanced Placement Policy was set in place based on non-quantifiable evidence provided from professors teaching freshman and sophomore level biology courses. Via unsolicited conversations involving faculty teaching freshman and sophomore level biology courses, it was concluded that often times students with biology AP credit who enroll directly into the next sequent biology course often do not perform as well as those students who took the prerequisite courses at Virginia Tech. As such, the viability of the current AP policy sets the stage for this research.

CHAPTER 2

Literature Review

This investigation questions the assumption made by the College Board that AP students receiving a score of 3 on the end-of-the-year AP biology exam should be given college level credit for the first two semesters of freshman biology. The existing literature regarding the relationship between college success and the AP program falls into two distinct perspectives. One, there is a body of research that has been conducted by the proponents of the AP program / exam and its relation to college success. These researchers are often employees of the College Board, the AP program's parent organization. Two, the contrasting perspective is supported by a small but growing body of evidence reported by independent researchers suggesting that AP students are no more likely to be successful in college level work than are those that have not experienced the AP program / exam. The following literature review is intended to provide an in-depth analysis of the research findings relevant to these two competing groups of researchers. This literature review begins with the background information on the AP program, including the following: (a) the history and the development of the AP course curricula and exams, (b) the process for high schools to acquire the AP designation needed to teach an AP course, (c) the validity and reliability of the AP exams, and (d) identification of students qualified to undertake AP courses. This descriptive information is followed by a detailed review of the related literature examining the AP program and its associated exams as it relates to college success.

The College Board's Advanced Placement Program

AP history. According to the College Board's AP Central website (2008g), the history of the Advanced Placement Program began in the early 1950s. The Ford Foundation, acting under the premise of improving the education offered in the United States, sponsored two studies

regarding the overlap of high school and college course content. Based on the findings from these studies, it was concluded that secondary schools and colleges should work together to avoid repetitious coursework found in high schools and colleges which in-turn would provide highly motivated college-bound students the ability to better and more quickly reach their fullest potential as students.

As a result of these two studies, a collaborative effort between three elite prep schools - Andover, Exeter, and Lawrenceville and three colleges - Harvard, Princeton, and Yale - in 1951 was largely responsible for the initiation the AP program (The College Board, 2008g). As an outcome of this collaboration, it was recommended that "secondary schools recruit imaginative teachers, that they encourage seniors to engage in independent study and college-level work, and that achievement exams be used to allow students to enter college with advanced standing" (The College Board, 2008e, p. 1).

The current AP program has evolved from this original proposal. Students now have the opportunity to take AP courses and exams throughout their high school careers (grades 9-12) and at times as early as eighth grade. The recruiting of "imaginative teachers" has been replaced with "teachers that are willing and able" (The College Board Call Center, personal communication, February 18, 2004).

Since the inception of the AP program, participation in the courses and examination, as well as the variety of available courses, have experienced continued growth. During the 1955-56 school year, 2,199 examinations were administered with 104 high schools and 130 colleges and universities (The College Board, 2008b) participating . Throughout the 1980-81 academic year, 178,159 AP exams were administered with 5,253 high schools and 1,955, colleges and universities participating in the AP program. Finally, during the 2006-07 school year, 2,533,431

exams were administered with 16,464 high schools and 3,743 colleges and universities participating in the AP program / examination (The College Board, 2008b).

Currently, AP program courses are offered in over 15,000 schools worldwide. According to the College Board's AP facts sheet (2005) website, most of the nation's colleges and universities, as well as institutions of higher education in over 30 countries worldwide, have an AP policy in place which potentially grants high school students credit via their AP examination scores for college level work. Presently, the AP program offers 37 courses and examinations ranging from art to statistics. For a complete list of courses offered as well as course descriptions see Appendix A.

Development of the AP course curricula and examinations. According to the College Board (2008f), AP course curricula are developed by an AP Development Committee for the 37 AP subject areas offered, with each committee comprised of six to eight members. Committee membership is typically composed of highly qualified secondary school and college teachers (The College Board, 2008f) for each discipline. In addition to the six to eight committee members, two AP content experts work with each committee (The College Board, 2008f). After an exhaustive search of the College Board's AP Central website, definitions of and criteria related to "highly qualified secondary school and college teachers," "AP content experts," or how one becomes a member of an AP Development Committee, no information related to the criteria could be found.

According to the College Board (2008f), the Development Committees are responsible for a range of activities, including creation of the end-of-the-year AP exam questions, development of the course description booklets discussing the content of each AP course, a review of the material that AP teachers and students can expect to encounter on the end-of-the-

year exam, as well as creation of sample syllabi which may be used by AP teachers. Once produced, this information (minus the AP exam questions) is then made available to high schools desiring to create an AP course as well as those currently teaching AP courses.

Advanced Placement designation. In order to teach an Advanced Placement course at the high school level and thereby receive the AP designation, schools must first apply, using a two-fold application process. First, an AP course Audit Form is completed attesting to the fact that the pre-set curricula (set by the AP Development Committee) are being followed. For example, a biology course given the AP designation must include the following topics: Molecules and Cells (25% of total curriculum taught), Heredity and Evolution (50% of total curriculum taught), and Organisms and Populations (25% of total curriculum taught). Evidence of AP teachers meeting these requirements is provided from their course syllabus which they submit to the College Board with the AP Audit Form. A thorough investigation of the available literature suggests that this syllabus renewal process is the only mechanism in place to demonstrate that the appropriate course content is being addressed in designated AP courses.

Second, schools must show evidence of necessary resources needed, as stated by the AP program, to include college level text books (definition of college level text books is not available in the associated literature) and that the schools have access to, in the case of a science course such as biology, scientific equipment/materials (scientific equipment/materials and access are not defined in the available literature) as well as adequate time to provide a hands-on, college-level biology lab (definition not provided in the available literature).

Once schools are granted authorization to teach an AP course, no further evaluation processes are involved from year-to-year unless the person teaching the course has changed the curriculum and/or resource requirements for the course undergo significant revision (The

College Board, 2008f). No definition of “significant revision” is offered in the available literature).

Authorization to use the AP designation indicates the College Board has given permission to use said designation on a student’s transcripts. The course is then listed as an authorized AP course in a ledger that is provided to all colleges and universities each fall and is also made available to the public on the College Board’s website (collegeboard.com).

The application for AP designation requires no associated fees nor are there any specific education backgrounds or certification requirements needed to become an AP course teacher. The College Board’s AP Central-Biology Course Requirements (2008d) website also notes that while certain topics must be addressed, as discussed earlier, each individual school is responsible for developing its own curriculum in regards to the courses being taught.

T*he AP exam administration and scoring process.* According to the College Board (2008i) the following procedure is used. AP examinations are administered each year during the month of May. Prior to the examination, the Development Committee convenes up to three times throughout each school year to create new examination questions. Exam questions are of two types: multiple-choice and essay (termed “free response” questions), which are created at least two years prior to the exam being administered. All test questions must be reviewed and agreed upon by the committee responsible for each discipline being tested. Multiple-choice questions are submitted by college and university faculty and the free response questions are written and pooled by all members of the committee. Once pooled free response questions are then chosen by the committee as a whole.

The multiple-choice questions are graded via computer while the free response questions are scored during the annual AP Reading, spanning seven days, which is accomplished “by

thousands of master AP teachers and college faculty teaching the corresponding college courses" (The College Board, 2008j, p.1). No reference can be found in the available literature as to what constitutes master AP teachers and college faculty.

According to the College Board (2008i), the scoring of free response questions, which takes place at the annual AP Reading, adheres to the following procedure. First, prior to the AP Reading (the scoring of the free response questions), the Development Committee creates a preliminary scoring standard for each question. Second, and prior to the AP Reading, the Chief Reader prepares a draft of the scoring guidelines for each free-response question based on suggestions from the Development Committee. Third, the Chief Reader, Question Leaders, Table Leaders, and ETS content experts meet at the reading site for the purpose of reviewing and revising of the previously drafted scoring guidelines which are then tested by pre-scoring randomly selected student papers. Fourth, the Chief Reader, Question Leaders, and Table Leaders conduct training sessions for each free-response question which are attended by all the readers who are scoring the particular question. If problems or ambiguities become apparent, the scoring guidelines are revised and refined until a final consensus by all involved is reached. Grading of the free response questions begins once this agreement has been affirmed.

As stated by the College Board (2008i), once multiple-choice and free response questions are graded, via computer and the AP Reading respectively, exams are then converted to composite scores which range from 1 through 5. Generation of the composite score requires a computer-based formula which combines both the multiple choice and free response scores (the grading formula is not provided in the available literature).

Relevant information such as the qualifications, numbers of people involved in exam scoring, and the selection process of those involved in exam scoring such as the Chief Reader,

Question Leaders, Table Leaders, and ETS Context Experts is not available in the available literature. With that said, the application process to become an AP Reader was located on the College Board (2008c) "Become an AP reader" website. College-level faculty desiring to become AP Readers must be currently teaching at a college or university and have taught at least one semester of a comparable AP course within three years prior to submitting their application. High school teachers wishing to become AP Readers must have taught an AP course for at least three years either in a typical face-to-face classroom setting or an online course prior to apply for the position of AP Reader. This three-year requirement can be waived if the AP course being taught is new (i.e., has been taught for less than the required three years).

A thorough search of the College Board (2008) website pertaining to how AP exam score boundaries are set was not successful. Sadler and Tai (2007a), however, have provided the following summary using the AP Physics C (Electricity and Magnetism Exam) retrieved from the College Board website in 2004. The cut-off score for which students earn a score of 5 is 19.7 out of a total of 35 exam questions correct which equates to a 56%. The cut-off score needed to earn a 4 is 40% or 13.6 correct answers, earning the score of 3 requires 31% which equates to answering approximately 11 correct answers.

AP Exam content validity. According to the College Board (2009a), the AP exam is validated via four methods. First, colleges routinely review students' incoming AP transcripts in regard to appropriate college course placement and in awarding college credit in reference to AP final examination scores. Although the College Board states that colleges routinely review incoming AP transcripts, further information regarding the mechanics and quality control of this practice could not be found.

Second, validity of the AP final exam scores (1 through 5) are scrutinized by ETS researchers (The College Board, 2009a). In so doing relevant questions such as "Are standards and the credit policies in individual subjects well set? Do students who receive advanced placement produce satisfactory work in the succeeding course? How do AP students compare with their classmates when they enter college?" (para. 4) are addressed. The answers to these questions will be examined closely during the detailed literature review later in this document.

Third, curriculum surveys are completed by college and university faculty as well as professional associations in related disciplines (The College Board, 2009a). Results of these surveys are used to reflect changes that may be taking place within the discipline. As a result, new test questions for AP exams are developed as needed to reflect advances in the chosen disciplines surveyed. According to the American Council on Education (2004), the AP program also encourages students, high school teachers and interested faculty members to evaluate the AP exams. The available literature does not further elaborate as to how often surveys are sent out to participating organizations, who these organizations are, how they are chosen for the survey, or survey return rates.

Fourth, in regards to the issue of test validation of AP scores, Sadler and Tai (2007a) note that the College Board administers AP exam questions to college students at the end of their course which are, in-turn, compared to high school student's end-of-the-year AP exam questions. Unfortunately, information of greater detail regarding the exam validation process does not appear to be available in the literature at this time.

AP exam test reliability. Documentation regarding the reliability of the AP exam score is limited. With that said the College Board (2008i) states, "Continuity is crucial and allows

colleges to be confident that an AP grade of 3 on this year's exam will represent, as nearly as possible, the same level of achievement as a grade of 3 on last year's exam" (p. 1).

Information provided from the available documentation (The College Board, 2008j) in regards to AP test reliability suggests that a percentage of identical exam questions, both multiple choice and free response questions, are embedded in each exam from year to year then analyzed using coefficient alpha statistics. This, in-turn, provides internal consistency data related to AP exams. Further explanation of what encompasses "internal consistency data" is not readily available. The Chief Reader uses the internal consistency data, details gathered from college comparability studies, AP exam score distributions from the past three years, and the Chief Reader's own observations of students' free-response answers, in regards to constructing the final decision regarding AP exam scoring. Since documentation relative to the reliability of the AP exams is limited, it is not known how many multiple-choice or free response questions are embedded in the exams from year to year or what is precisely meant in regards to the Chief Reader's observations in regards to testing reliability.

Identification of AP students. The College Board recommends that students interested in taking an AP course should speak with an AP teacher to discuss the rigors of the course to evaluate if the student is capable of academic success in an AP courses (The College Board, 2008a). Without any standardized acceptance policy in place, eligibility requirements for students wishing to participate in AP courses are set by the high schools offering AP courses and, as such, are not under the control of the College Board.

Empirical Research Summary

This component of the literature review provides an in-depth look at the major research efforts that have investigated the link between college success and the AP program / exams

conducted by the two aforementioned groups of researchers. First, the research conducted by the College Board and its counterparts who substantiate the positive influence of the AP program / exam as it relates to college success are reviewed. Second, the literature review focuses on studies conducted by independent researchers who disagree with the proponents of the AP program / exam and the relationship to college success. Third, related literature pertaining to the AP program / exam is discussed.

Proponents of the AP program. Burnham and Hewitt (1971) examined 143 male students enrolled in English, French, and math courses at Yale who had passing AP exam scores which allowed college credit for introductory courses. As a result, these students were granted advanced placement into sophomore-level courses. Burnham and Hewitt suggest their study is warranted due to the fact that "little hard evidence" (p. 939) has been published regarding the validity of the AP program and exams.

To judge the predictive value of AP exam scores relevant to end-of-the-semester grades in sophomore English, French, and math courses while enrolled at Yale, two statistics were employed: descriptive statistics and multiple regression analysis (Burnham & Hewitt, 1971). Descriptive statistics were used to quantify mean end-of-the-semester grades between the two groups (AP versus non-AP students). Multiple regression analysis was conducted controlling for SAT (verbal and math) and AP scores which were the dependent variables. End-of-the-semester grades in the aforementioned courses were the independent variables.

Two research study groups were delineated as follows: (a) a group of students without AP experience that took the freshman courses at Yale and are currently enrolled in the next sequential course and (b) a group of students currently enrolled in the same sophomore level

course that had sufficient AP scores to allowing them to bypass the introductory freshman level course/s (Burnham & Hewitt, 1971).

Tables 1 and 2 summarize Burnham and Hewitt's (1971) results. Multiple regression analysis shown in Table 1 predicts that when non-AP students are compared with AP students, after controlling for the SAT scores, that AP students should have higher end-of-the-semester grades in the designated courses. Descriptive statistics contained in Table 2 confirm this prediction as AP students show higher grade percentages in English, French, and math.

Table 1

Data Summary - Burnham and Hewitt (1971) Multiple Correlation Data

Yale sophomore level course	Non-AP students end-of-the-semester grades and SAT scores	AP students end-of-the-semester grades and SAT scores
English (n=35)	.18	.22
French (n=87)	.34	.38
Math (n=21)	.64	.73

Table 2

Descriptive Statistics – Grade Performance Means

Sophomore course	AP scores 1-3 end of semester grade mean	AP scores 4-5 end of semester grade mean	Non-AP group end of semester grade mean
English	81.3	83.6	78.5
Math	76.8	82.6	73.3
French	80.9	83.1	77.4

Burnham and Hewitt (1971) concluded that male AP students who bypassed a freshman level course (in the represented subjects) at Yale by virtue of their AP exam scores performed better in English, math, and French courses, as represented by their end-of-the-semester grades,

than did non-AP students who took the introductory freshman level courses at Yale. Burnham and Hewitt (1971) conclude male students taking AP exams and passing (score of 3 or higher on a 5-point scale) are adequately prepared to compete with upper division college students.

Casserly (1986) investigated the validity of AP examination scores as indicators of a student's readiness to enroll in advanced sequent courses as a freshman. For example, if a student has a qualifying AP exam score of 3, he or she is then awarded advanced placement for Calculus 101 allowing him or her to enroll directly into Calculus 102 as a freshman. Casserly noted the need for this study was due to the growth of the AP program and complacency exhibited on behalf of colleges and universities participating in the AP program. Upon initiation of the AP program in the early 1950s, Casserly reported that colleges and universities received each student's AP exam booklets. Professors or committees representing the various AP disciplines would review the student's free-response questions and answers and judge whether college level credit was justified. As participation in the AP program grew, colleges and universities became willing to accept the AP Readers' judgments regarding college placement of AP candidates. As a result, advanced college placement became automatic based on the College Board / ETS recommendation that students who scored 3 or higher on an AP exam should be awarded college credit.

Casserly's (1986) study included nine colleges and universities and a total of 278 students. Males and females were approximately equal in number, as 51% were male and 49% were female. College and university participation was based on three criteria. First, the institutions were among the top 100 colleges and universities receiving AP candidates. Second, colleges and university were chosen to represent the contiguous United States; as such, schools

were chosen to represent North, South, West, and East. Third, the participating institutions all granted advanced placement (college credit) to students who scored from 3 to 5 on an AP exam.

Casserly (1986) used weighted mean differences between AP and non-AP students in analyzing students' performance in advanced courses relevant to their AP courses. Abbreviated results are shown in Table 3. Positive differences represented in Table 3 illustrate that AP students performed better (represented as end-of-the-semester grades) than did non-AP students in the advanced courses in which they were placed as a result of a passing AP score of 3 or higher. Conversely, weighted mean differences represented by negative numbers suggest that students without AP experience outperformed (represented as end-of-the-semester grades) AP students who were placed in an upper-division course.

Table 3

Weighted Mean Differences for AP and Non-AP Students'

College	Biology	Calculus AB	Chemistry	English Language
A	-.13	.47	-.27	.51
B	.82	1.04	.95	.27
C	-.20	.55	.27	.30
D	1.56	.28	.54	.09

Casserly (1986) used the above method across 17 subject areas at the nine participating colleges and universities and concluded that AP candidates who, by virtue of their AP exam score and are placed into sophomore sequent level courses, generally do better, as expressed by end-of-the-semester grades, than the sophomore students taking the same course who do not have AP experience.

In accordance with these findings, Casserly (1986) states, "The placement and credit policy suggested to colleges by the AP program seems justified and appropriate for the colleges in this study" (p. 13). Said differently, an AP exam score of 3 or higher is a valid determination

of a student's ability to perform as well as or better than those who do not have AP credit in a chosen discipline. Results found within this study concur with those of Burnham and Hewitt (1971), further suggesting that students taking AP courses in high school and passing the accompanying exam (score of 3 or higher) are adequately prepared to succeed in upper division college courses.

Willingham and Morris's (1986) report focused on the performance expressed as college grades of AP students versus non-AP students. The purpose of this study was to add to the current research regarding the use of AP final exam scores of 3 and higher to award advanced placement upon entering college. Willingham and Morris's research was a longitudinal study which followed 1,115 students with at least one passing AP exam score of 3 (the score necessary to be awarded college credit at the participating institutions) and higher through a four-year period, representing 117 high schools at nine private liberal arts institutions. Male and female students were of relatively equal numbers as 52% were male and 48% were female.

The private liberal arts institutions were chosen for this study due to the fact that they all had similar application processes. Similar application processes were important to the study in regards to statistical analysis allowing AP and non-AP students to be matched on the six acceptance criteria of SAT scores, high school rank, follow-through (defined as significant extracurricular accomplishment), school reference, high school honors, and personal statement. These six characteristics were used to create two matched groups: 932 AP students and 932 non-AP students.

Descriptive statistics and multiple regression were used to compare AP students versus non-AP students regarding the above measures as well as their cumulative end-of-the- year

GPAs. The independent variables used in this study were the six acceptance criteria. The dependant variables were represented by cumulative college GPAs for all four years studied.

The most substantial difference according to Willingham and Morris (1986) between AP and non-AP students was SAT scores, as AP students were twice as likely to achieve an SAT score of 600 or above. Of considerable interest is the regression analysis that Willingham and Morris performed in regards to the predictive value of AP grades in the preadmissions process as illustrated in Table 4. Willingham and Morris found school rank and combinations thereof to be adequate predictors of college success.

Table 4

Predictors of College Success, AP Versus Non-AP Variance

Predictors of college success	AP grade not included as predictor of college success	AP grade included as predictor of college success
School rank + SAT scores	.407	.529
School rank + SAT scores + school honors, follow through, school reference	.487	.541

Willingham and Morris (1986) further showed that students with AP exam scores of 3 or higher earned significantly higher cumulative GPAs at the end of their freshman year. On average, AP students had end-of-the-year GPAs of 2.96 whereas non-AP student's end-of-the-year GPA was 2.81. This pattern of higher cumulative GPAs was evident throughout the four years studied as AP students cumulative GPA was 3.13 and non-AP students four-year cumulative GPA was 2.88. Willingham and Morris suggest that students who qualify for placement into advanced college course based on their AP final exam scores are good indicators of success in college.

Willingham and Morris's (1986) report concurred with evidence presented by both Casserly (1986) and Burnham and Hewitt (1971), suggesting students who earn AP scores of 3 achieve higher college grades than do students not participating in the AP program. Willingham and Morris (1986) stated, "This result adds confirming evidence regarding the reasonableness of AP grading standards and the program's credit recommendations, which characterize 3 as qualified in the subject area" (p. 24).

While Willingham and Morris (1986) highlighted the positive values attributed to high school students and their college success by virtue of completing and passing AP exams, they also suggested in their closing remarks that success on AP exams does not exclusively predict college success. Willingham and Morris suggested, albeit undefined, that "AP students tended to come from somewhat more advantaged homes and from secondary schools that placed special emphasis on college preparation" (p. 27). Their data also suggested that the strongest indicator in the admissions process responsible for predicting college success was not that of successful completion of AP exams but rather high school rank with success on AP exams providing an additional 10.5% in predicting success at the college level as shown in Table 4. Finally, Willingham and Morris noted, "It is not possible to ascertain from this analysis to what extent the AP effect is caused by strong preparation in secondary school, or by other factors" (p. 29).

The research presented herein suggests that there may be a variety of possible covariates attributable to college success. As Willingham and Morris (1986) implied, it may be these other parameters - such as SAT scores, high school rank, high school curriculums steeped in math, science, and English, as suggested by Adelman (1999) - that prepare students for college level work and, therefore, may be instrumental in providing a more complete picture in regards to college success.

Morgan and Ramist's (1998) ETS report questioned the validity of the AP programs grading scale. Of critical importance, and thus the purpose of their research, was to evaluate whether or not a passing score of 3 on an AP exam qualifies as college level credit which, in-turn, allows a student to bypass entry level college courses and proceed directly to upper division college courses as freshmen.

Morgan and Ramist (1998) examined 27,268 students from 20 colleges and universities who had successfully completed at least one AP exam with a score of 3 or higher. The 20 colleges and universities were chosen for this study due to the fact they received the largest amount of entering students with AP grades for the year 1991. AP exam scores of 3, 4 and 5 representing 25 different disciplines ranging from art history to physics were analyzed. Twenty participating colleges provided information pertaining to course taken, course grades, gender, ethnicity, and corresponding SAT scores. Aggregate end-of-the-semester course grades of students who received AP credit in a given discipline were compared with aggregate end-of-the-semester course grades of those who did not receive AP preparation relevant to the course in question.

For example, students who received credit for introductory biology (Biology 101) and, therefore, bypassed the first semester of introductory biology were compared with those who took the next sequent equivalent biology course (Biology 102) (Morgan & Ramist, 1998). Course catalogues from each participating college were obtained to determine the entry level course each student was to receive credit for and also for the upper level courses AP students would be placed into relevant to their AP scores. Table 5 depicts the results of AP students versus non-AP students in second biology course which shows that AP students with AP final exam scores of 3 did not outperform, based on mean final grades, the non-AP students. However,

AP students with scores of 4 and 5 showed higher average end-of-the-semester grades than the non-AP students.

Table 5

AP Students Versus Non-AP Students in Second Biology Course

All colleges	Average grade	% A or B	Comparison with all students who took a lower level course	
All students who took lower-level course	2.68	61		
AP score 5	3.22	82	+.54	+21
AP score 4	2.93	69	+.25	+8
AP score 3	2.63	57	-.05	-4

Analysis for all 25 AP courses and corresponding college level course work was depicted in this manner. Morgan and Ramist (1998) compared and contrasted aggregated grade information across a variety of AP/college level disciplines. After comparing and contrasting all 25 disciplines, Morgan and Ramist concluded the following:

> AP students performed very favorably when compared to students who took the prerequisite courses…those receiving AP grades of 5 had higher course grade averages than the students who took the prerequisites course... the data from this study... found that students who receive qualifying grades of 3, 4, and 5 on the AP exams can directly enroll in upper level courses and flourish. (p. 8).

Suggested in the data, albeit not directly addressed, 32.5% of the students receiving an AP score of 3 for all disciplines studied had lower end-of-the-semester grades than did non-AP students who took the introductory course in college.

Of further concern is the sample size employed in Morgan and Ramist's (1988) report. At first glance, Morgan and Ramist suggest that 66,125 students were used in this assessment. A closer look at the research conducted shows that 33 of the 75 presented conclusions were based

on sample sizes of ten or less. In some cases, such as analysis of the AP Studio Arts, the data set consisted of one student.

ETS researchers Dodd, Fitzpatrick, DeAyala, and Jennings (2002) addressed the following question: "How do non-AP students who took the introductory college courses before the sequent course compare to AP students who placed out of the introductory course" (p. 1)? Dodd et al. (2002) justify the need for this study noting that some colleges and universities, regardless of prior research, question the use of an AP score of 3 to award college credit.

Four different entering classes from 1996-1999 were studied (Dodd et al., 2002). AP exam scores and the subsequent college level courses were used representing the disciplines of Calculus AB, English Language and Composition, and Biology. These courses were chosen for analysis due to the fact that they represent the largest proportion of exams per discipline taken from year to year.

Data for this report were provided both from ETS and from the University of Texas at Austin (Dodd et al., 2002). The independent variables captured, relevant to the research question, were AP exam scores, high school rank, SAT and/or ACT test scores. Dependant variables for this study are sequent courses for which the student has advanced placement. For example, if a student scored a 3 on his or her calculus AP exam, s/he would receive credit for calculus 101 and subsequently enroll in calculus 102. Calculus 102 would be considered the dependant variable in this study. Students who had ACT composite scores were converted to SAT total scores using the College Board conversion tables. For comparison purposes two groups, an AP group and a non-AP group, were created while controlling for the aforementioned independent variables. Statistical analysis consisted of descriptive statistics followed by analysis of covariance (ANCOVA) for each entering freshman class in the courses of English, math, and biology.

AP students receiving college credit (AP exam scores of 3 and higher for at least one college course in a course sequence) were compared to a group of non-AP students who took the equivalent courses while enrolled in the University of Texas at Austin. Thus, two study groups were created: (a) the AP-exempt student group with grades of 3 to 5 (i.e., those students who received advanced placement) and (b) the non-AP student group for each entering class. Groups were then matched in regards to their high school ranks and SAT (math and verbal) scores.

Dodd et al. (2002) concluded, "In general the results revealed that AP students who earn credit by examination earned equal or higher grades in the sequent course than the other groups"(p. 33), as is represented in Table 6. Upon ANCOVA analysis, Dodd et al. (2002) reported the AP group had significantly higher GPAs in both English and math courses taken at the University of Texas at Austin when compared to students without AP experience who took the prior course at the university during the four-year study.

Dodd et al. (2002) also reported that non-AP biology students significantly outperformed AP biology students in each year of the study. Upon the strength of these results, Dodd et al. (2002) suggested the AP program's current grading scale which endorses an end-of-the-year AP exam score of 3 is valid in its regards to college readiness.

Table 6

Descriptive Statistics for AP and Non-AP Students Enrolled in Similar Courses

Academic year	Group	Mean GPA English	Mean GPA Math	Mean GPA Biology
1996	AP students	3.30	2.86	2.80
	Non-AP	3.01	2.47	2.99
1997	AP students	3.22	2.91	2.55
	Non-AP	3.11	2.48	3.06
1998	AP students	3.22	2.94	2.84
	Non-AP	3.03	2.64	2.99
1999	AP students	3.24	3.21	2.64
	Non-AP	3.04	2.60	2.84

Morgan and Klaric's (2007) College Board report investigated two related questions: (a) "Is the performance of AP students in intermediate level courses into which they are placed based on AP Exam scores, comparable to that of non-AP students?" and (b) "Is the performance comparable after accounting for group differences based on SAT scores" (p. 2)? Morgan and Klaric proposed that answering these two questions would provide further evidence suggesting that an AP Exam score of 3 adequately prepares students to bypass introductory college courses and enroll directly into upper division courses at the college level.

A total of 45,029 incoming college students from 27 institutions of higher education were the focus of this study (Morgan & Klaric, 2007). Morgan and Klaric focused their research efforts on ten AP Exams and corresponding college courses ranging from biology to psychology. Student AP Exam scores (from 3 to 5) and SAT scores were included in the study and are identified as the independent variables and end-of-the-semester scores in closely associated college courses are the dependent variables.

Morgan and Klaric's (2007) research is similar to research conducted by Morgan and Ramist (1998) with two noteworthy exceptions. First, SAT scores, not used in the Morgan and

Ramist (1998) study, were used in the current study from which regression analysis was performed on AP versus non-AP students after accounting for group differences based on SAT scores. Second, care was taken to ensure that sample sizes of at least 100 were used, which was not the case in the Morgan and Ramist (1998) study. Recall that Morgan and Ramist at times used sample sizes of less than ten and as small as one in their study.

The findings from Morgan and Klaric's (2007) research are consistent with the findings of Morgan and Ramist's (1998) study. Students with AP scores from 3 to 5 exhibited higher grades in sequent upper division courses than did their non-AP counterparts who took the entry level course while attending the college or university in question. For example, the average end of semester biology grade for non-AP students was 2.80, those with AP scores allowing them exemption (score of 3) from the introductory course were 2.87.

Similar findings were expressed when accounting for SAT scores albeit the differences were of smaller magnitude (Morgan & Klaric, 2007). When SAT scores were included for those with an AP score of 3 the average end-of-the-semester grade was 2.83 whereas non-AP students GPA were 2.80. Morgan and Klaric also show that after controlling for SAT scores students receiving advanced placement into upper division biology via an AP exam score of 3 did not significantly outperform, as expressed by final end-of-the-semester aggregate biology grades, relative to non-AP students.

AP exam proponent summary. Literature reviewed thus far has focused primarily on students who have taken AP exams in a variety of disciplines and have received passing scores of 3 or higher on a 5-point scale and, as a consequence, were awarded advanced placement allowing them to bypass introductory courses and take upper division college courses as freshman. The researchers of the Advanced Placement program and its grading scale discussed

thus far all present evidence that a passing score of 3 on an AP final exam adequately demonstrates that these students are capable of performing at a higher level (expressed as college grades) than students without AP experiences in upper division college courses.

However, some of the studies reported by the AP proponents have found shortfalls in the AP testing grading scheme. For example, the aforementioned literature suggests students receiving AP exam scores of 3 in biology courses often do not outperform, represented as final grades in advanced biology courses, their non-AP peers who have taken the introductory biology course in college.

Casserly (1986) demonstrated that 50% of the participating colleges showed that non-AP students significantly outperformed AP students with in biology scores. Morgan and Ramist's (1998) study revealed that biology students with AP exam scores of 3 were outperformed, expressed as grade averages, by non AP-students. Dodd et al. (2002) showed that, for all of the four years that were studied, non-AP biology students significantly outperformed AP students with AP biology exam scores of 3 and higher in advanced courses. Morgan and Klaric (2007) also showed that students receiving advanced placement into upper division biology via an AP exam score of 3 did not significantly outperform, as expressed by final end-of-the-semester aggregate grades, relative to non-AP students.

The prior literature review has focused on available research suggesting that the AP program and its associated exams are equivalent to college and university introductory classes. As such, an AP exam score of 3 and higher presents sufficient evidence that high school students are capable of undertaking advanced level coursework as freshmen in college. Research reviewed from this point forward presents a different view in regards to the AP program and its exams in relation to college success.

The proponents of the AP program and its associated exams suggest that an AP exam score of 3 or higher predicts college success and in turn these students receiving AP credit are ready to undertake upper division coursework. The detailed literature critique provided thus far also suggests that students receiving an AP exam score of 3 do not have higher grades in regards to college and university biology courses when compared to non-AP students who have taken the introductory college and university biology courses. Therefore, the literature presented thus far brings into question the validity of using an AP biology exam score of 3 to allow students to bypass their introductory biology course in college and advance directly to upper division biology courses.

Research regarding the AP exam and college success presented thus far is limited in scope as it fails to include many of variables known to be responsible for success at the college and university level. Variables such as student socio-economic status, parental education, and high school curriculum strength have not been included in the aforementioned studies. As such, the proponents of the AP program, discussed thus far, have addressed a limited number of variables to help explain the relationship between the Advanced Placement program and college success. The critics of the AP program have included many of these variables in their research regarding college success and the AP program.

Critics of the AP program. Klopfenstein and Thomas (2005, 2009) analyzed the impact of AP coursework relative to college persistence in first-year college students as well as students' first semester college GPAs. Their sample consisted of over 28,000 Texas high school graduates subsequently enrolling in one of the 31 public colleges and universities in the state of Texas.

Upon reviewing the available research regarding AP and college success, Klopfenstein and Thomas (2005, 2009) suggested two reasons for their research. One, Klopfenstein and

Thomas (2005) were of the opinion that prior research performed (and reviewed within this document) by "the College Board and ETS is fundamentally flawed as it fails to account for the nature of the typical AP student who is particularly bright and motivated and likely to experience positive college outcomes even in the absence of AP experience" (p. 2). Two, the effectiveness of the AP program, most notably an AP exam score of 3 may not, as currently suggested, adequately prepare students to attempt advanced college courses as freshmen. Klopfenstein and Thomas (2005, 2009) suggested that the apparent discrepancy in the AP exam grading scale could be due in large part to the exponential expansion of students participating in the AP program and its exams as suggested by Casserly (1986) and Lichten (2000). Colleges and universities used to receive AP exam booklets. College faculty and / or committees representing the various disciplines would then review the students' free response questions and answers to determine whether or not college credit is warranted. At some undetermined time, due to the expansion of the AP program, this procedure became null and void and was replaced by the recommendation of the College Board that students receiving a score of 3 or higher on their end-of-the-year AP exam should be awarded college credit.

As Klopfenstein and Thomas (2005, 2009) contended, there is a need to improve upon the prior research noting there are other potentially important variables which suggest college success. Klopfenstein and Thomas (2005, 2009) thus focused on an array of student, family, and school characteristics that are of potential importance in regards to the issue of college success.

While previous research had focused on students' AP exam scores, Klopfenstein and Thomas (2005, 2009) included in their study all students that took an AP class regardless of AP exam participation and or AP exam score. They defend this position by suggesting that AP courses by definition should provide ample experiences conducive to college success.

Klopfenstein and Thomas (2005, 2009) used descriptive statistics and regression techniques controlling for over 30 potential college success predictor variables which are the independent variables for this study. The dependant variables for this study were college retention rates at the end of the freshman year as well as first-semester college GPAs. The rationale and defense for the use of these potential college success predictors were not revealed in Klopfenstein and Thomas's research documents. These variables included, but were not limited to, student ability and effort expressed as SAT math and verbal scores, class rank, honors and AP courses, student socio-economic backgrounds, and school type (i.e., suburban or rural).

Data regarding college success were analyzed by employing regression methods, specifically least ordinary squares. After controlling for the balance of a student's high school curriculum, family, and school characteristics Klopfenstein and Thomas's (2005, 2009) results suggested that AP students were generally no more likely than non-AP students to have higher first semester grade point averages.

Sadler and Tai (2007a) approached the linkage between AP exam scores and college success in a unique fashion. Whereas Klopfenstein and Thomas (2005, 2009) looked at all students taking an AP course, Sadler and Tai (2007a) chose to look at students who received passing AP scores and for undisclosed reasons took the introductory college course for which they had been awarded advanced placement. For example, student X received a 3 on his AP biology exam which gives him credit for Biology 101. Instead of accepting his advanced placement into Biology 102, student X has chosen to take Biology 101.

Using descriptive statistics as well as correlation coefficients, Sadler and Tai (2007a) addressed "the College Board's claim of the equivalence of Advance Placement courses as measured by AP exam scores with the comparable college course" (p.1). The covariates used in

this study were similar to but more narrow in scope than those of the Klopfenstein and Thomas (2005, 2009) study as only AP scores, both verbal and math SAT scores, parental education, and last high school math and English grades were considered. Sadler and Tai (2007a) chose to analyze data focusing on first semester introductory college courses in three disciplines: biology, chemistry, and physics from 55 colleges and universities. Using survey results they identified 1,029 students who reported taking and passing an AP exam and were currently enrolled in the equivalent course for which they received advanced placement. In defense of using students' self-reported data, Sadler and Tai note self-reported data - in particular self-reports of course taking patterns, grades, and standardized test scores made by college students - tend to be highly accurate as referenced by Baird (1976) and Anaya (1999).

Sadler and Tai (2007a) found a correlation between high SAT scores and high AP scores similar to Morgan and Klaric (2007). Sadler and Tai (2007a) also found high correlations between AP scores of 4 and 5 with high math and science grades earned in high school. After controlling the aforementioned variables, Sadler and Tai suggested that approximately 50% of the advantage prescribed by the proponents of the AP program regarding college success are accounted for by existing variables, such as demographics and prior academic achievement, by the student prior to or independent of their Advanced Placement experiences and or exam scores.

Research published by Lichten (2000) focused on the AP final exam grading scale of 1-5 and the College Board's proposal that an AP final exam score of 3 was accepted for advanced placement into upper division college courses "at virtually all four-year colleges and universities, including the most selective" (p.3). As such, the purpose of Lichten's survey was to provide evidence that the above statement was true and whether or not the current grading scale should be re-defined.

Lichten (2000) surveyed 40 colleges and universities in regards to their AP acceptance criteria. Participating colleges and universities were divided into three groups: (a) highly selective, (b) selective, and (c) non-selective relevant to in-coming students' SAT scores and total number of AP exams taken and passed with a score of 3 or higher. The three categories were defined as follows. Highly selective schools are those whose students had a mean AP Exam score equal to or greater than 3.4 and SAT scores greater than or equal to 610. Selective schools had AP Exam scores with an average range of 2.6 – 3.4 and an average SAT score ranging from 500-610. Non-selective schools had an average AP score equal to or less than 2.6 and SAT scores below 500. The rationale for grouping colleges and universities by the above criteria was not given.

Survey results were then compared to the aforementioned College Board statement suggesting that a score of 3 on an AP exam was accepted by virtually all colleges and universities. Lichten's (2000) survey results do not support the aforementioned statement made by the College Board or the proponents thereof who suggest that an AP Exam score of 3 is sufficient evidence that high school students are ready to advance directly into advanced level college courses. Lichten's (2000) survey of colleges and universities found 41% of the highly selective schools accepted an AP score of three, 50% of the selective schools accepted an AP score of 3, and 93% of the non-selective schools accepted a 3.

Lichten (2000) proposed that the current AP grading scale is not reflective of college grading standards and should, therefore, be reconfigured. As such, students receiving scores of 4 would be considered qualified to receive advanced placement upon arrival at college. In turn, an AP final exam score of 3 should show that a student is possibly qualified to receive college credit. Lichten concluded that the current discrepancy in the AP exam grading scale is due in

large part to the exponential expansion of students participating in the AP program and its exams also supported by Klopfenstein and Thomas (2005, 2009).

Critic summary. As noted in the literature review, there is a growing body of evidence that calls into question the relationship between Advanced Placement and college success, particularly in biology AP experiences. A thorough review of the available research suggests that overall an AP exam score of 3 indicates that students are able to take upper division courses and have higher college grades when compared to non-AP students. While overall this may be true, it does not appear to be the case when individual disciplines are taken into consideration. As is evidenced by the research reports provided from Casserly (1986), Morgan and Ramist (1998), Dodd et al. (2002), and Morgan and Klaric (2007), students in certain disciplines with AP exam scores of 3 did not outperform non-AP students who took introductory coursework in college.

Independent researchers, such as Klopfenstein and Thomas (2005, 2009) as well as Sadler and Tai (2007a), collectively purport that while it may be true that AP students perform at equal or higher levels than their non-AP peers, this increased performance is likely do to other mitigating factors that, when controlled for, more accurately predict college success. For example, Klopfenstein and Thomas (2005, 2009) suggest that after having controlled for students' high school curriculum, family, and school characteristics, they are generally no more likely to succeed at the college level than are non-AP students.

Lichten (2000) suggests that the current AP grading scale is not reflective of college grading standards due to the exponential increase in students taking part in the AP program, resulting from a lack of communication between the AP program and colleges and universities. As such, the current grading scale of the AP exam should be reconfigured in which students receiving scores of 4 are qualified to receive advanced placement upon arrival at college.

Currently, millions of students participate in AP coursework/exams which will potentially allow them to enroll directly into upper division college courses. Therefore, it is imperative that sound research informs the decision regarding students advanced placement into upper division college level work. Failure to do so may potentially introduce risk for the students in question as college success may hang in the balance.

Related Relevant Literature

According to Oxtoby (2007), the proliferation of AP courses, currently listed at 37, may do more harm than good to students entering college. The rationale for this is two-fold. First, Oxtoby (2007) suggested AP courses provide breadth and not depth, and, moreover, teach to the test (i.e., the AP exam). In so doing, students entering advanced courses at the college level may not have a grasp on the basic information needed to succeed academically. Since breadth, Oxtoby (2007) noted, is the issue, AP teachers must quickly move through the AP curriculum in order to save the last two to three weeks of the year to prepare students for the AP exam.

Second, Oxtoby (2007) suggested that the expansion of the AP programs course offerings allow students to take specialized courses. While this option may increase course offerings in high school, it may also limit a student's ability to participate in more relevant coursework such as higher level English, math, and science courses which have been shown to be valuable in regards to college success, as suggested by Adelman (1999) as well as Rose and Beats (2001).

For all the above reasons, strong evidence is needed to substantiate the claim that a score of 3 on AP exams qualify students to proceed to advanced level courses upon entering college. Prior research, contained within this document, suggests that predicting college preparedness is more complex than assessing a single variable such as an end-of-the-year exam as is offered by the Advanced Placement program. An AP experience may be one of many indicators related to a

successful college experience, but as prior research suggests there may be a multitude of related factors responsible.

Preparing students for the academic rigors of college life should be a fundamental goal of any high school offering an AP experience. Once a student arrives on campus, it is imperative that colleges and universities have in place up-to-date policies regarding the acceptance of Advanced Placement credits.

Only through analyzing available data can an appropriate Advanced Placement Policy be created. As has been shown within this document, there are issues concerning the validity associated with an AP exam score of 3 and college success. Currently, there are those who support colleges and universities using an AP final exam score of 3 to award college level credit, and, conversely, those who do not. Ultimately, it is the responsibility of colleges and universities to set in place an appropriate AP Policies for both the institution and discipline in question.

CHAPTER 3

Methodology

Introduction

Currently the proponents of the AP program and the American Council on Education (2004) recommend that an end-of-the-year AP exam score of 3 provides sufficient evidence that a student has mastered the course material and should be awarded college credit, which, in turn, allows them to bypass introductory level college course. Further, there is evidence to suggest that an AP exam score of 3 may not provide sufficient evidence to award college credit for biology courses.

The College Board's AP program and its associated exam present several issues of concern related to college success. These issues include, but are not limited to, how students are selected to take AP courses, weighting of high school GPA's, qualifications of those who teach AP courses, appropriate cut-off scores for advanced placement, and the policies that colleges and universities have in place in regards to accepting AP exam scores as being equivalent to introductory college courses. While the issues surrounding the Advanced Placement program are many, this dissertation will examine four questions related to biology AP exam scores and college success in freshman and sophomore level biology courses taught at Virginia Tech. Chapter three describes the research design, research questions, dependent and independent variables, data collection process and data source, and data analysis procedures relevant to each research questions.

Research Design

This research employed a correlation study design, incorporating descriptive statistics, correlations, independent t-tests, analysis of variance (ANOVA), and post hoc evaluation when

appropriate. For each research question, two groups were compared to one another in relation to their final grades in freshman and sophomore level biology courses taught at Virginia Tech. The two groups were comprised of students with AP end-of-the-year biology final exam scores of 1 through 5 and students who had not taken an AP end-of-the-year biology exam. For each research question, these two groups were matched based on SAT scores, both math and verbal, gender and instructor of record for each biology course taken at Virginia Tech.

Focus of Study - Research Questions

Question #1. Does high school AP biology coursework experience increase college academic performance at Virginia Tech in freshman level biology courses after matching for SAT scores (math and verbal), instructor of record, and student gender relative to students who do not have AP biology experience?

Question #2. Do statistically significant differences occur among the various study groups (AP students scores 1-4 and non-AP students) in General and Principles of Biology I and, if so, where?

Question #3. Do biology AP students with final exam scores of 3, the score suggested by the Advanced Placement program to be used in awarding college credit for the two semester sequence of freshman biology, significantly outperform based on final grades those students without an AP experience in General or Principles of Biology I after matching for SAT scores (math and verbal), instructor of record, and student gender?

Question #4. Do AP students receiving an AP exam score of 5 (score necessary to bypass the introductory biology sequence) on their biology AP exam outperform (expressed as final sophomore biology course grade) non-AP students in selected sophomore level biology courses

at Virginia Tech after matching for SAT scores (math and verbal), instructor of record, and student gender?

Data Sources and Collection Procedures

Prior to initiating the data collection process, appropriate approval from Virginia Tech's Institutional Review Board for Research Using Human Subjects (IRB) to conduct the research in question was obtained. Upon receiving said permission from the IRB, Advanced Placement data variables were collected from the Administrative Information Systems Department (AIS) affiliated with Virginia Tech.

Data obtained from the AIS / Virginia Tech database included AP biology examination scores (1through 5), first completed freshman level biology or sophomore level biology course, end-of-the-semester course grade, date (year and semester) and professor of record from which the course was taken, student SAT scores both math and verbal, as well as gender. Data were obtained for all freshman and sophomore biology course grades from the Fall of 2001 semester to the Spring semester of 2006 for the following courses: General Biology I (Biology 1005), Principles of Biology I (Biology 1105), General Biology II (Biology 1006), and Principles of Biology II (Biology 1106) as well as all grades in selected sophomore level biology courses: Genetics (Biology 2004), Cell and Molecular Biology (Biology-2104), Evolutionary Biology (Biology 2704), and Ecology (Biology 2804).

Variables used for this study were collected for two reasons. First, the variables mentioned prior have been captured by AIS since 2001, and, second, these variables have been shown by previous research contained within this document to be positively correlated to college success. Therefore using available data, supplied by AIS, the issue of college success and biology AP scores at Virginia Tech can be investigated.

The data set represents 799 Virginia Tech students with biology AP scores of 1 through 5 representing 79 different college majors offered at Virginia Tech. Students who received biology AP final exam scores of 4 and 5 received advanced placement and, as such, had the opportunity to enroll directly into the next sequent biology course. A comparison group meeting the above parameters minus AP experiences was also obtained. The two groups, AP students and non-AP students were then compared and contrasted to one another in relation to success expressed as mean final grades in freshman and sophomore biology courses.

Those excluded from the data were students who have achieved acceptable AP scores placing them out of an introductory course and for unknown reasons had chosen to retake the course for which they were awarded AP credit. Dependent and independent variables related to the four research questions are listed in Table 7.

Table 7

Research Questions One through Four, Independent and Dependant Variables

	Independent variables	Dependent variables
Research question 1	SAT (Math & Verbal) Biology AP exam scores 1 through 4 Gender	Final grades for General and Principles of Biology I
Research question 2	SAT (Math & Verbal) Biology AP exam scores 1 through 4 Gender	
Research question 3	SAT (Math & Verbal) Biology AP exam scores of 3 Gender	Final grades for General and Principles of Biology I
Research question 4	SAT (Math & Verbal) Biology AP exam scores Gender	Final grades for sophomore level biology courses

Data Analysis Procedures

Question #1. Two groups, those with and those without biology AP exam scores, were compared and contrasted to one another in regards to their final grade in freshman biology (General and Principles of Biology I) at Virginia Tech. Preliminary analysis evaluated the descriptive statistics and correlations of the independent variables of biology AP scores, SAT verbal and math scores, as well as student gender. Second, as an analytical method an independent t-test was conducted. Prior to analysis the two test groups were matched via the independent variables which include SAT scores (verbal and math), gender, and instructor of record.

Question #2. Five groups, non-AP students and students with biology final exam scores of 1,2,3, and 4 were compared and contrasted to one another in regards to their final grade in freshman biology (General and Principles of Biology I) at Virginia Tech. Again, prior to statistical analysis the two study groups were matched via SAT scores (verbal and math), gender, and instructor of record. ANOVA was conducted to show if a significant differences existed between groups followed by a Student-Newman-Keuls post hoc evaluation.

Question *#3.* Statistical analysis for question three was conducted in a similar fashion to that of question one with one minor exception. All AP students were matched to non-AP students in question one in regards to SAT scores (verbal and math), gender, and instructor of record.; however, in question two, only students with AP final exam scores of 3 were matched to students without AP experiences. As such, a subset population from question one was analyzed.

Question #4. Analysis for question four used the identical matching process performed in the prior research questions followed by independent t-test analysis. The study population

consisted of AP students with final exam scores of 5 on the biology AP exam and non-AP students enrolled in sophomore biology courses.

CHAPTER 4

Results

The following chapter reports the results of this study and is comprised of three sections. The first section provides the rationale for the statistics used for evaluation. Section two provides the descriptive statistics. Section three reports the results pertinent to each research question.

Rationale for Statistics

Descriptive statistics provided the basic features of the data, which included central tendencies, ranges, and standard deviations. Correlation statistics were used to quantify the degree of relationship among the AP scores and SAT scores. The independent t-test was employed to assess whether the means of two study groups are statistically different from one another. ANOVA analysis provided information as to whether or not the five research groups in question two are statistically different from one another followed by post hoc analysis using Student-Newman-Keuls, which illustrated where the differences in mean final grades of the five study groups occurred.

Descriptive Statistics

Table 8 displays the relative numbers of participants, both AP and non-AP students, as well as the titles and numbers of each course considered for this study. The research population spanned the years 2001 to 2006 and represents a total of 24,588 participants and their end-of-the-semester grades in freshman or sophomore level biology courses taken at Virginia Tech. A total of 799 students received biology AP final exam scores ranging from 1 to 5. After closer scrutiny of the data, it was determined that a small portion of the data (n=37) was not usable for this study due to the fact that some AP students enrolled in a biology course for which they had received AP credit for and were, therefore, removed from the study.

Approximately 3.34% of the population within this study represents students with biology AP scores. Of the 799 students with biology AP credit, approximately 70% of the population represent female students (n=552) while approximately 30% (n=242) are male.

Table 8

Biology Courses, Total Participants and Total AP Participants from 2001 to 2006

Course	Title	Total # grades per course 2001-2006	Total # AP participants 2001-2006
Biology 1005	General Biology I	5052	221
Biology 1105	Principles of Biology I	4060	392
Biology 1006	General Biology II	4826	1
Biology 1106	Principles of Biology II	3842	29
Biology 2004	Genetics	2606	13
Biology 2104	Cell and Molecular	2066	12
Biology 2704	Evolutionary	2097	13
Biology 2804	Ecology	2105	14

Table 9 depicts the numbers of AP students in each biology course studied as well as their associated AP exam scores. Data pertaining to Freshman Biology II (BIOL 1006 and 1106) cannot be statistically analyzed. During the study period, 30 students received biology AP final exam scores high enough (AP score of 4) to place them out of the second semester of freshman biology (BIOL 1006 and 1106). As such, these students were required to take the first semester of freshman biology (BIOL 1005 or 1105) and were then exempt from the second semester of freshman biology (BIOL 1006 or 1106). Upon the successful completion of the first semester of freshman biology, 28 of the 30 students (97%) then had the opportunity to enroll directly into sophomore level biology courses but chose instead to repeat the course for which they were granted advanced placement.

Since the aim of this research is, in part, to compare AP students to non-AP students in their first biology course at Virginia Tech, analysis cannot be conducted on this group of

students. While statistical analysis cannot be carried out on this potentially important group, it does, however, lend potentially valuable information which is examined in the discussion section of this dissertation.

Table 9

Biology Courses and AP Exam Scores

Course	AP1	AP2	AP3	AP4	AP5	Totals
BIOL 1005	27	117	59	19	NA	217
BIOL 1105	19	150	148	71	NA	410
BIOL 1006	NA	NA	NA	1	NA	1
BIOL 1106	NA	NA	NA	29	NA	29
BIOL 2004	NA	NA	NA	NA	13	13
BIOL 2104	NA	NA	NA	NA	12	12
BIOL 2704	NA	NA	NA	NA	13	13
BIOL 2804	NA	NA	NA	NA	14	14

Mean SAT math, verbal, and total scores for AP and non-AP students are reported in Tables 10 and 11, respectively. SAT scores were captured for two primary reasons. One, prior research shows them to be adequate predictors of college success, as confirmed in Table12 and, two, SAT scores from AP and non-AP students allow for matching students of comparable ability.

Table 10

SAT Descriptive Statistics for AP Students

	N	Mean	SD
SAT math	799	607	63.534
SAT verbal	799	599	65.738
SAT total	799	1207	109.52155

Table 11

SAT Descriptive Statistics for All Biology Courses from 2001-2006

	N	Mean	SD
SAT math	21132	578	67.092
SAT verbal	21132	589	67.248
SAT total	21132	1166	114.124

Table 12 suggests a strong correlation with AP students regarding SAT scores as they are all significant at the 0.01 level. As such, it will be important to include SAT total scores when analyzing students' performance in biology courses as they are strongly correlated with biology AP exam scores. Prior research relating to college success from Willingham and Morris (1986), Dodd et al. (2002), Morgan and Klaric (2007), Sadler and Tia (2007), as well as Klopfenstein and Thomas (2005, 2009) all share supporting documentation regarding the positive correlation between SAT scores and AP scores.

Table 12

Correlations AP Students with SAT Math, Verbal, and Total Scores

	Biology AP	*SAT math*	*SAT verbal*	*SAT total*
Biology AP	1.00	.359*	.468*	.489*
SAT math		1.00		
SAT verbal			1.00	
SAT total				1.00

* indicate p<.01

Results

Research Question One

Does high school AP biology coursework experience increase college academic performance at Virginia Tech in freshman level biology courses after matching for SAT scores (math and verbal), instructor of record, and student gender relative to students who do not have AP biology experience?

The equal variance assumption, as seen in Table 13, has not been met between the two test groups in General Biology I ($F = 6.402$, $p < 0.05$), as such, the unequal variance t-value is used for interpretation. This analysis was found to be statistically significant ($t = -3.521$, $p < 0.05$) with a p-value of 0.000 as illustrated in Table 13. The effect size = .10 which based on Cohen's Benchmarks is small. As such, students with AP experiences, scores 1 through 4 cumulatively, significantly outperformed non-AP students in regards to their mean final grades in General Biology (BIOL-1005). Comparing AP students versus non-AP student in Principles of Biology reveals results consistent with those found in General Biology as the difference in mean final grades between the two groups was found to be statistically significant ($t = -4.716$, $p < 0.05$) with a p-value of 0.000 as illustrated in Table 14. The effect size = .10 which based on Cohen's Benchmarks is small.

TABLE 13

Independent t-test of AP Versus Non-AP Students in General Biology I

General Biology I, Independent Samples t-test					
	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	6.402	.012	-3.521	440	.000
Equal not variances assumed			-3.521	435.536	.000

Table 14

Independent t-test of AP Versus Non-AP Students in Principles of Biology I

Principles of Biology I, Independent Samples t-test					
	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	.474	.491	-4.716	782	.000
Equal not variances assumed			-4.716	781.939	.000

Research Question Two

Do statistically significant differences occur among the five study groups (AP students scores 1-4 and non-AP students) in General and Principles of Biology I and, if so, where?

ANOVA was performed followed by Student-Newman-Keuls post hoc analysis. Results from the ANOVA analysis found in Table 15 suggest a significant differences exist among the five research groups in General Biology I as $F = 16.688$, $p < 0.05$ with a p-value of 0.000. The Student-Newman-Keuls post hoc analysis further delineates the differences between groups

enrolled in General Biology I as is represented in Table 16. The effect size = .90 which based on Cohen's Benchmarks is large.

Table 15

ANOVA Results for General Biology I

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	51.191	4	12.798	16.688	.000
Within Groups	335.129	437	.767		
Total	386.320	441			

Table 16

Differences between Groups - Final Mean GPA for General Biology I

		General Biology I mean grades Student-Newman-Keuls			
AP score	N				
1	28	2.043			
NO AP	221		2.645		
2	115		2.870		
3	59			3.358	
4	19			3.558	
Sig.		1.000	0.239	0.294	

Students with AP biology final exam scores of 1 were found to be significantly different from non-AP students, as well as AP students who received final AP biology exam scores of 2, 3, and 4, and were also found to have the lowest mean GPA for the General Biology I population. Students without AP biology experience at the high school level, as well as students that scored a 2 on the final AP biology exam, were found to have similar mean final grades of 2.645 and 2.870 respectively in General Biology I. Students with AP biology final exam scores

of 3 and 4 were found to be similar to one another in regards to their mean final grades in General Biology I with final GPAs of 3.358 and 3.558 as illustrated in Table 16.

Results from the ANOVA analysis found in Table 17 suggest significant difference exist among the five research groups in Principles of Biology I exists as $F = 25.574$, $p < 0.05$ with a p-value of 0.000. The effect size = .90 which based on Cohen's Benchmarks is large.

The Student-Newman-Keuls post hoc analysis further delineates the differences between groups enrolled in General Biology I as is represented in Table 18.

Table 17

ANOVA Results for Principles of Biology I

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	83.398	4	20.849	25.574	.000
Within Groups	635.084	779	.815		
Total	718.482	783			

Table 18

Differences between Groups - Final Mean GPA for Principles of Biology I

Principles of Biology I mean grades Student-Newman-Keuls					
APSCORE	N	1	2	3	4
1	19	1.911			
2	151		2.562		
No-AP	392		2.571		
3	151			3.063	
4	71				3.477
Sig.		1.000	.956	1.000	1.000

ANOVA analysis between AP and non-AP groups in Principles of Biology I reveal some similarities as well as differences between groups relevant to General Biology I. Students with

AP scores of 1 received the lowest end-of-the-semester mean GPA's (1.911). Non-AP students performed similarly to AP students scoring a 2 on the AP Biology final exam with mean end-of-the-semester biology GPA's of 2.571 and 2.562, respectively, whereas AP students receiving scores of 3 and 4 were unique unto themselves with mean end-of-the-semester biology GPA's of 3.063 and 3.477, respectively. Results pertaining to mean final grade distributions as well as differences between groups enrolled in Principles of Biology I groups are found in Tables 17 and 18.

Research Question Three

Do biology AP students with final exam scores of 3, the score suggested by the Advanced Placement program to be used in awarding college credit for the two semester sequence of freshman biology, significantly outperform based on final grades those students without an AP experience in General or Principles of Biology I after matching for SAT scores (math and verbal), instructor of record, and student gender?

General Biology I and AP scores of 3. Results from the independent t test analysis confirm that there is a statistically significant difference between the two research groups as $t = 2.760$, $p < 0.05$ with a p-value of 0.007, as represented in Table 19. The effect size = .20 which based on Cohen's Benchmarks is small.

Students with AP biology final exam scores of 3 when matched by ability (SAT math and verbal scores), gender and instructor of record significantly outperform the non-AP students in regards to their mean final grades in General Biology I.

TABLE 19

AP Students with Scores of 3 Versus Non-AP Students in General Biology I

	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	.089	.767	2.760	116	.007
Equal not variances assumed			2.760	110.616	.007

Principles of Biology I and AP scores of 3. Results of this analysis are consisted with those found in General Biology I. Differences in mean final grades between the two study groups were found to be statistically significant as $t= 3.045, p < 0.05$ with a p-value of 0.003 as represented in Table 20. The effect size = .10 which based on Cohen's Benchmarks is small.

Students with AP biology final exam scores of 3, when matched on ability defined as SAT math and verbal scores, gender, and instructor of record significantly outperform the non-AP students as represented by mean final grades in Principles of Biology I.

TABLE 20

AP Students with Scores of 3 versus Non-AP Students in Principles of Biology I

	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	.108	.743	3.045	302	.003
Equal not variances assumed			3.045	300.200	.003

General and Principles of Biology II. Ninety three percent (28 out of 30) of the students with AP credit allowing them to bypass Principles or General Biology II elected to, for currently undocumented reasons, take the course for which they were awarded advanced placement at Virginia Tech. In effect, these students retook the same course for which their biology final AP score of 4 granted them credit. As such, this group cannot be analyzed as one of the goals of this research is to compare AP versus non-AP students enrolled in their first biology course at Virginia Tech. While this group cannot be statistically analyzed, it can possibly provide insight to the strength of students' biology AP experience, which will be addressed further in the discussion section.

Research Question Four

Do AP students receiving an AP exam score of 5 (score necessary to bypass the introductory biology sequence) on their biology AP exam perform as well or better than (expressed as final sophomore biology course grade) non-AP students in selected sophomore level biology courses at Virginia Tech after controlling for SAT scores (math and verbal) and gender differences?

Independent sample t-test results from each of the four aforementioned sophomore level biology courses resulted in calculated p-values above the 0.05 level as is shown in Table 21 indicating that there is not a significant difference between students with biology AP scores of 5 and non-AP students in regards to their final grades in the associated sophomore level biology courses. When analyzed as a whole (all sophomore level courses combined), again, there is no significant difference in mean final grades revealing that AP students did not perform significantly better than did non-AP students ($t = 0.573$, $p > 0.05$).

Table 21

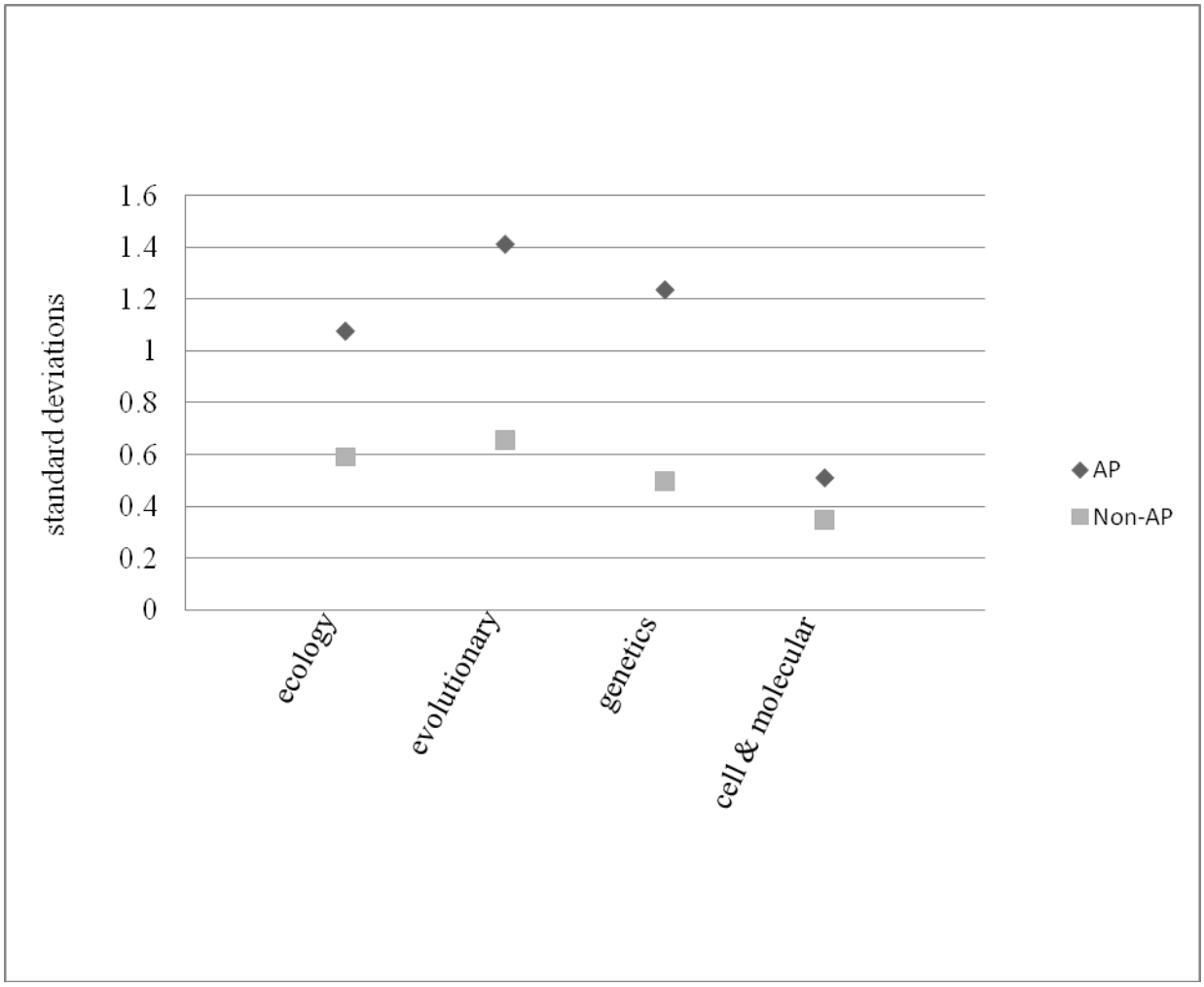
p - Values and Significance in Sophomore Level Biology Courses at Virginia Tech

Sophomore biology course	F value	P value	Significant
Genetics (n=26)	3.735	0.203 > 0.05	no
Cell and Molecular Biology (n=24)	0.267	0.782 > 0.05	no
Evolutionary Biology (n=26)	2.279	0.944 > 0.05	no
Ecology (n=28)	1.355	1.00 > 0.05	no
Combined Biology courses (n=104)	8.050	0.573> 0.05	no

As depicted in Figure 1 the standard deviations (SD) referencing AP versus non-AP student's mean final grades in sophomore level biology courses all reveal a similar trend as they are larger (typically twice as large) for students with AP experiences when compared to those without AP credit who took the two sequence freshman biology courses at Virginia Tech. For example, the SD of final grades in Evolutionary Biology (BIOL 2704) is 0.6305 for AP students whereas the SD for non-AP students is 1.3587. This trend is also present when analyzing all sophomore level biology courses combined as the SD of final grades for AP students is 1.1392 and the SD for non-AP students final grades are 0.5901. Statistically speaking, this represents a significant difference as $F = 8.050$, $p < 0.005$ which is well below the 95% confidence interval needed to demonstrate significance.

Figure 1

Standard Deviations of AP and non-AP student's Final Grades in Sophomore Level Biology Courses



Chapter 5

Discussion and Conclusions

The AP program is designed to afford students access to college-level curriculum while pursuing their high school education. Further, this program comes with the claim that students taking and passing an AP final exam with a score of 3 or higher are prepared to bypass the comparable introductory college course and proceed directly to upper division coursework in their first year. The purpose of this study is to test this claim. Specifically, the study examines the effects of high school AP biology coursework on subsequent performance in freshman and sophomore level biology courses taught at Virginia Tech.

Chapter 5 is comprised of five interrelated sections. Section one addresses the results of the analytical section of this study in relation to each of the four research questions. Section two addresses the limitations of this study. Section three provides the conclusions of this study. Section four focuses on the overarching implications of the results. And lastly, section five discusses the need for further research in the area of college success and the Advanced Placement program.

Summary of Results and Discussion

Students with biology AP final exam scores of 1 through 4 were compared to a group of non-AP students participating in General Biology I (biology for non-science majors). AP students, as a whole, significantly outperformed students who did not take an AP biology course during high school. Further, post hoc analysis showed that AP students with scores of 1 seem minimally prepared (mean GPA of 2.043) for the rigors of General Biology I. Non-AP students and AP students with exam scores of 2 performed at a comparable level (mean grades of 2.645 and 2.870, respectively). Therefore, students with AP scores of 2 appear to be no more prepared

for General Biology I than do those who have not experienced an AP biology course at the high school level. AP students with end-of-the-year AP exam scores of 3 and 4 (mean grades of 3.358 and 3.558 respectively), appear to be adequately prepared to take freshman level biology at Virginia Tech

Similar results hold true for students enrolled in Principles of Biology I (biology for science majors). Again, a significant difference in mean final grades exists between the two groups showing that AP students outperformed non-AP students. Post hoc evaluation results suggest that AP biology students with scores of 1 are underprepared (mean GPA of 1.911) for Principles of Biology I. Non-AP students and AP students with end-of-the-year AP exam scores of 2 performed at a comparable level (mean grades of 2.562 and 2.571, respectively). These results suggest that students with AP scores of 2 are no more prepared for freshman biology I than those who have not taken biology AP coursework at the high school level. AP students with end-of-the-year AP exam scores of 3 and 4 (mean grades of 3.063 and 3.477 respectively), appear to be adequately prepared to take freshman level biology at Virginia Tech. These findings, in both General and Principles of Biology I, point to a clear advantage for AP students who score a 3 or 4 on the AP biology exam regarding their performance in freshman biology (General and Principles of Biology I) at Virginia Tech.

Comparisons were made between students with biology AP final exam scores of 3 to a corresponding subset of non-AP students. This analysis reveals that this group of AP students significantly outperformed students who have not experienced a high school biology AP course / final exam based on their mean final grades in both General and Principles of Biology I. Consequently, AP students with final biology AP exam scores of 3 are adequately prepared to be successful in freshman biology.

In comparing AP students with scores of 5 to non-AP students who took the two semesters of freshman biology at Virginia Tech were found to have performed at comparable levels. For example, mean end-of-the-semester grades for non-AP students, for all sophomore level biology courses analyzed, is 3.308 whereas AP students mean end-of-the-semester grades are 3.20. Although AP students were outperformed, this difference was found to be statistically insignificant. As such this group of AP students seems well prepared to be successful when enrolling directly into sophomore-level biology courses.

Research Limitations

At this point, it is appropriate to highlight some of the limitations regarding data related to college success, the AP program, and this study. Many of the variables known to be associated with college success such as socio-economic status, parental education, and strength of high school curriculum have not been captured for this study. The inability to capture these variables provides further support to suggest students with AP exam scores of 3 are not, as suggested by the College Board, adequately prepared to attempt sophomore level biology courses at Virginia Tech. Klopfenstein and Thomas (2005, 2009), Sadler and Tia (2007a), as well as Willingham and Morris (1986) suggested that studies lacking adequate controls regarding college success, such as socioeconomic status, and attending high schools that emphasize college preparation, potentially overestimate the positive effects attributed to AP courses and the associated end-of-the-year exams in regards to college success.

Willingham and Morris (1986) reported that AP students come from more “advantaged homes” (p. 27) as well as from high schools that place considerable emphasis on college preparation. Sadler and Tia (2007a) suggested that studies, lacking sufficient controls when analyzing college success and Advanced Placement, run the risk of overestimating the effects of

the AP experience. Klopfenstein and Thomas (2005, 2009) noted that much of the prior research relating to AP and college success lack sufficient controls. As such, they fail to account for a typical AP student who is exceptionally bright and motivated and likely to experience college success regardless of participation in the AP program. Since this dissertation admittedly falls short in capturing variables which are known to be directly related to college success, the value ascribed to AP final exam scores in freshmen biology may be overestimated.

Conclusions

A large percentage of prior research conducted on the Advanced Placement program and its relationship to college success share common themes. First, most have chosen to include several institutions of higher education in their study. Two, validity studies regarding the Advanced Placement grading scale have generally analyzed students scoring 3 or higher on the AP end-of-the-year exam and then comparing their success to non-AP students in sophomore level course.

The approach of this study departs somewhat from the prior research norms. First, AP students with final exam scores of 1 through 4 were combined and compared / contrasted to non-AP students in identical courses. The rationale for comparing all AP students (scores 1 through 4) to non-AP students is similar to that voiced by Klopfenstein and Thomas (2005, 2009) who suggest that an Advanced Placement Biology course should, by definition, provide high school students with an experience that is similar to a course taught at the collegiate level. Second, students with AP biology final exam scores of 3 were matched to non-AP students with similar ability (SAT scores) and compared and contrasted to one another in respect to college success in those classes. Third, as opposed to focusing on AP students with end-of-the-year final exam

scores of 3 who proceed directly to sophomore-level courses, this dissertation analyzes students with AP scores of 5 who then proceed to sophomore-level biology courses.

As noted in Byrd et al. (2007), Advanced Placement biology courses taught in high schools worldwide are designed to replicate a two-semester sequence of freshman biology for biology majors at the collegiate level. Within the available literature regarding college success and the Advanced Placement program, there is supporting evidence provided from ETS researchers that suggests that students with AP scores of 3 are capable of enrolling in upper division college courses and outperforming students who have not experienced AP courses at the high school level. However, there is a small body of evidence from research conducted by Klopfenstein and Thomas (2005, 2009), Lichten (2000), as well as Sadler and Tia (2007a) which suggests an AP final exam score of 3 in biology may not be sufficient in awarding college credit for introductory biology course(s).

Although AP students with scores of 5 performed well in sophomore-level biology courses, they were outperformed, albeit insignificantly, by non-AP students who took the two semester sequence of freshman biology. As such, these AP students do show the ability to be successful in sophomore-level biology courses. While this group of AP students is shown to be successful in sophomore-level biology courses, there is insufficient evidence to corroborate the claim made by the College Board that AP students with scores of 3 are adequately prepared to enroll directly into sophomore-level biology courses at Virginia Tech.

From the research results provided herein, there is no supporting evidence to back the claim made by the College Board that a biology AP final exam scores of 3 is equivalent to the two-semester sequence of biology course. Rather, the overarching results of this study provide supporting evidence to prior research that is critical of both the AP program and its current

grading scale. Lichten (2000) contended that an end-of-the-year AP final exam score of 3 is insufficient to award college-level credit equivalent to a two-semester sequence of courses. As a result, according to Lichten (2000), the Advanced Placement grading scale should be adjusted upwards indicating that AP students scoring a 4 on their end-of-the-year AP exam are possibly qualified to receive college level credit. The research conducted within this study supports Lichten's (2000) argument that students scoring a 3 on the end-of-the-year AP exam may not be prepared to bypass their introductory level courses in biology.

Klopfenstein and Thomas (2005, 2009) suggest that after controlling for students high school and family characteristics, AP students are no more likely to be successful at the college or university level than are students who have not experienced Advanced Placement coursework at the high school level. The results of this dissertation, acknowledging that many of the variables responsible for college success have not been controlled for, support the conclusions of Klopfenstein and Thomas.

Sadler and Tia (2007a) voice similar results in regards to the Advanced Placement program and later success at the college or university level. They suggested AP courses in the sciences afford the opportunity for students to experience a more rigorous and fast paced course which is modeled after a college level course. Once demographics and high school academic rigor are accounted for, the advantage attributed to AP course work and its subsequent exam is dramatically diminished. Again, the results presented within this dissertation, even when controlling for limited variables related to college success, are similar to those reported by Sadler and Tia.

The College Board/ETS research professes the virtues of an AP experience with verbiage such as the following:

1. “Students with AP grades of 3 or better had higher grade averages…than the non-AP group who first took an introductory course” (Morgan & Klaric, 2007, p. 9).
2. “The data from this study and several prior studies found that students who receive qualifying grades of 3, 4, and 5 on the AP Exams can directly enroll in upper level courses and flourish” (Morgan & Ramist, 1998, p.10).
3. “AP students earn higher GPAs in the advanced college courses into which their AP credit allow them to place, compared to students with the same high school class rank and SAT score who did not earn AP credit and who did not skip the entry-level college course” (The College Board, 2007, p.11).

The research contained herein and supported by Klopfenstein and Thomas (2005, 2009), Lichten (2000), as well as Sadler and Tia (2007a) cannot support these statements.

Implications

The current Advanced Placement policy at Virginia Tech awards students scoring a 4 on their end-of-the-year AP biology exam credit for General or Principles of Biology II. As per the results of this study, it is suggested that the current biology AP policy should be revamped. Students with Advanced Placement scores of 4 should no longer be awarded credit for General or Principles of Biology I and II. The rationale behind this suggestion is threefold.

First, 97% of the students with biology AP exam scores of 4 have chosen, after taking General or Principles of Biology I, to enroll in General or Principles of Biology II for which they were given advanced placement. This information suggests that after experiencing the first semester of freshman biology AP students may not feel that their AP experience has adequately prepared them to accept their AP credits and forego the second semester of freshman biology. Second, AP students with final exam scores of 4 in who are enrolled in General or Principles of

Biology I do, in fact, perform well. Considering that they are, as defined by the College Board, taking this course for the second time, the advantage is clear and should be reflected in their final grades.

Third, since an all-inclusive list of variables attributed to college success has not been captured for this study, there is a high probability that the value attributed to the AP biology program / end-of-the-year exam is overestimated. With that said, the results contained herein do not provide convincing evidence that these students should be awarded advanced placement for either General or Principles of Biology I and II.

The AP policy for biology courses at Virginia Tech also states that students with biology AP exam scores of 5 are to be awarded credit for the two semester sequence of freshman biology – General or Principles of Biology I and II. While statistically speaking AP and non-AP students enrolled in sophomore-level biology courses performed at comparable levels, based on mean final grades, both groups performed admirably with mean final GPAs of 3.308 for the non-AP students and a mean GPA of 3.206 for the AP students. As such, this study affirms the current Advanced Placement policy at Virginia Tech, which allows students with AP scores of 5 to be awarded college credit for the two-semester sequence of freshman biology – General or Principles of Biology I and II.

Colleges and universities participating in the Advanced Placement program must be cognizant of the fact that the College Board merely suggests that AP scores of 3 are equivalent to freshman level courses at the college level. As such, it is the responsibility of all colleges and universities participating in the AP program and not the College Board to set appropriate Advanced Placement cut-off scores which, in turn, allow AP students to bypass certain courses.

Colleges and universities across the nation owe it to their incoming students to create, to the best of their ability, an Advanced Placement Policy that best reflects the needs of their students.

Further Research

Based on the findings of this dissertation, further research regarding the Advanced Placement program and college success needs to be conducted. The College Board currently suggests that students receiving AP end-of-the-year exam scores of at least 3 provides ample evidence that these students are prepared to forego introductory courses and enroll directly in upper division courses. The results of this dissertation as well as the results of other researchers question this recommendation.

Further, the Advanced Placement program has been in existence for over 50 years. For a program to have existed for such a long period of time, it is unusual to see such a small amount of published research. Again, it is important noting the incredible proliferation of the program, as well as the financial involvement at the state and federal levels, to quantify the effectiveness of the AP program. As such, studies such as those contained within this dissertation need to be conducted with greater frequency at each college and university participating in the AP program.

Much of the research presented herein, as well as the research carried out in this dissertation, fail to capture all of the known variables responsible for college success. Taking an Advanced Placement course while enrolled in high school may be one variable responsible for later success in college but, as such, it is only one variable. Therefore, further research needs to be conducted to include these other variables known to influence college success such as socio-economic status, parental education, and strength of high school curriculum. In so doing, a clearer picture of the true value ascribed to the AP program and its end-of-the-year exam may be assessed.

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APPENDIX A

AP Subject List (The AP Ledger)

Exam Title and Descriptions

Art—Art History: A three-hour exam covering a full-year introductory college course in art history. The first part of the exam is a one-hour multiple-choice section; the second part allows two hours for seven short essays based on slides and/or a quotation from a primary source or document, and two 30-minute essays addressing typical and significant problems in art history. One of the 30-minute essays requires in-depth discussion of at least one work from beyond the European tradition.

Art—Studio Art Drawing, Studio Art 2-D Design, Studio Art 3-D Design: Three portfolio evaluations, each of which covers a one-semester or full-year college course with the same name or content. Each portfolio contains three sections: Quality; Concentration (an in-depth, individual project); and Breadth (demonstration of a wide range of experience). The AP Studio Art section of AP Central includes questions and answers about the portfolios and works by AP students (found under "Exam Questions") for each of the portfolios.

Biology: A three-hour exam covering a full-year introductory college course in biology with laboratory. The exam contains 1 hour and 20 minutes of multiple-choice questions, a 10-minute reading period, and 1 hour and 30 minutes of free-response questions. Both sections of the exam test students' understanding of ideas that unite the major content areas: molecules and cells; heredity and evolution; and organisms and populations. Both sections may include questions based on the objectives of the 12 recommended AP Biology laboratory investigations.

Calculus—Calculus AB, Calculus BC: Two 3-hour-and-15-minute exams covering topics typically included in about two-thirds of a full-year college-level calculus sequence (Calculus AB) or those included in a full-year, college-level calculus sequence (Calculus BC). Both Calculus courses require a similar depth of understanding of common topics, and graphing-calculator use is an integral part of the courses. Both exams contain 1 hour and 45 minutes of multiple-choice questions and 1 hour and 30 minutes of free-response questions. Both the multiple-choice and free-response sections contain parts where a graphing calculator is required and parts where calculator use is prohibited. Visit the AP Calculus section of AP Central for detailed information on the calculator policy and the most current list of AP-authorized calculators. Students taking Calculus BC will receive a sub-score grade for the AB portion of the exam in addition to the overall composite grade.

Chemistry: A 3-hour-and-5-minute exam covering a full-year introductory college course with laboratory. Section I of the exam is 1 hour and 30 minutes long and contains 75 multiple-choice questions. No calculator use is permitted for Section I of the exam. Section II of the exam is 1 hour and 35 minutes long and is divided into two parts. Part A, during which calculator use is permitted, is 55 minutes long and contains three quantitative problems, one of which is on chemical equilibrium. Part B, during which no calculators are permitted, is 40 minutes long and contains one question requiring students to write balanced equations for three chemical reactions

(and to answer a short question about each reaction), plus two essay questions. In every exam either one of the quantitative problems or one of the essays will be on the topic of laboratory. A periodic table is provided for students to use with Sections I and II of the exam, and a list of commonly used equations and constants is provided during Section II of the exam only. Calculators are permitted only for the problems in Part A of Section II.

Chinese Language and Culture: This exam assesses learning at the level of a fourth-semester college/university course. It assesses interpretive, interpersonal, and presentational communication skills in Mandarin Chinese, along with knowledge of Chinese culture. Section I consists of multiple-choice questions that assess communication skills in the interpersonal and interpretive modes using listening and reading questions. The free-response section assesses communication skills in the interpersonal and presentational modes by requiring the student to produce written and spoken responses.

Computer Science—Computer Science A, Computer Science AB: Two three-hour exams covering either a first-semester introductory college course (Computer Science A) or a full-year introductory college course (Computer Science AB). Each exam contains 1 hour and 15 minutes of multiple-choice questions and 1 hour and 45 minutes of free-response questions. At least five multiple-choice questions and one free-response question are based on the AP GridWorld Simulation Case Study. Available on AP Central, the case study includes a program that students should work with throughout the school year. Java is used as the programming language for AP Computer Science. An appendix containing a quick reference to the Java library classes and program code for the case study is provided for students to use with Sections I and II of the exam. This appendix is also available on AP Central. Students may take the AP Computer Science A and the AP Computer Science AB Exams in the same year. However, students wishing to take both AP Computer Science Exams in May 2008 must take one of the exams during the late-testing period.

Economics—Macroeconomics, Microeconomics: Two 2-hour-and-10-minute exams, each covering a one-semester introductory college course. Both exams contain a 1-hour-and-10-minute multiple-choice section and a one-hour free-response section that includes a 10-minute reading and planning period. The AP Macroeconomics Exam covers basic economic concepts; measurement of economic performance; national income and price determination; financial sector; stabilization policies; international economics; and economic growth. The AP Microeconomics Exam covers basic economic concepts; supply and demand; theory of consumer choice; production and costs; firm behavior and market structure; factor markets; and market failure and the role of government.

English—Language and Composition, Literature and Composition: The AP English Language and Composition Exam is 3 hours and 15 minutes in length and covers a full-year introductory college course. The exam contains one hour of multiple-choice questions and 2 hours and 15 minutes of free-response questions. The AP English Language and Composition Exam tests students' skills in analyzing prose passages and asks them to demonstrate their composition skills by writing essays in various rhetorical modes. One of the three free-response questions requires students to synthesize information from a variety of sources to inform their own discussion of a topic. Students have a 15-minute reading period to accommodate the

additional reading required for the question; the writing time for the free-response section is two hours. The AP English Literature and Composition Exam is three hours in length and covers a full-year introductory college course. The exam contains one hour of multiple-choice questions and two hours of free-response questions. The exam tests students' skills in analyzing selected poems and prose passages and their ability to write critical or analytical essays based on poems, prose passages, novels, or plays.

Environmental Science: A three-hour exam covering a one-semester introductory college course with laboratory. The exam contains 1 hour and 30 minutes of multiple-choice questions and 1 hour and 30 minutes of free-response questions. The four free-response questions include one data-set question, one document-based question, and two synthesis/evaluation questions.

French—Language, Literature: The AP French Language Exam is approximately 2 hours and 40 minutes in length and covers a third-year French Composition or Conversation college course. The exam contains 1 hour and 25 minutes of multiple-choice questions and 1 hour and 15 minutes of free-response writing and speaking. It evaluates students' ability to understand written and spoken French and to respond in correct and idiomatic French. Beginning with the 2008 AP French Language Exam, there will be a change in the presentation of the multiple-choice section of the exam. The questions based on listening dialogues (that is, both questions and suggested answers) will be printed in the exam booklets. No part of these questions will appear on the recording. The AP French Literature Exam is three hours in length and covers a third-year Introduction to French Literature college course. The exam contains 1 hour and 20 minutes of multiple-choice questions and 1 hour and 40 minutes of free-response questions, and measures students' ability to understand, analyze, and interpret literary texts, and to write competent critical essays in French. Note: The AP French Literature required reading list has been revised for the 2007-08 course and exam.

German Language: This exam is approximately 2 hours and 30 minutes in length and covers material roughly equivalent both in content and in difficulty to a third-year college German language course. The exam contains approximately 1 hour and 20 minutes of multiple-choice questions and 1 hour and 10 minutes of free-response writing and speaking, and evaluates students' ability to understand written and spoken German and to respond in correct and idiomatic German.

Government and Politics—Comparative, United States: Two 2-hour-and-25-minute exams covering one-semester introductory college courses. Both exams contain 45 minutes of multiple-choice questions and 1 hour and 40 minutes of free-response questions. The AP Comparative Government and Politics Exam covers an introduction to comparative politics; sovereignty, authority and power; political institutions; citizens, society, and the state; political and economic change; and public policy. Six countries form the core of this exam: China, Great Britain, Iran, Mexico, Nigeria, and Russia. The AP United States Government and Politics Exam covers constitutional underpinnings of U.S. government; political beliefs and behaviors; political parties, interest groups, and mass media; institutions of national government (the Congress, the presidency, the bureaucracy, and the federal courts); public policy; and civil rights and civil liberties.

History—European: A 3-hour-and-5-minute exam covering a full-year introductory college course. The exam contains 55 minutes of multiple-choice questions, a 15-minute reading period, a 45-minute document-
based question (DBQ), and two 35-minute thematic essays chosen from several options. Questions on intellectual-cultural, political-diplomatic, and social-economic history form the basis of every section of the exam.

History—United States: A 3-hour-and-5-minute exam on a full-year introductory college course. The exam contains 55 minutes of multiple-choice questions, a 15-minute reading period, a 45-minute document-based question (DBQ), and two 35-minute essays chosen from several options. The exam covers political institutions, behavior, and public policy; social change and cultural and intellectual developments; diplomacy and international relations; and economic developments. The time period for the DBQ will not be announced.

History—World: A 3-hour-and-5-minute exam covering a full-year introductory college course. The exam contains 55 minutes of multiple-choice questions, a 10-minute reading period, and a 40-minute document-based question (DBQ), a 40-minute question dealing with continuity and change over time, and a 40-minute comparative question focusing on broad issues in world history. The exam covers impact of societal interactions; change and continuity across world history periods; impact of technology and demography; social and gender structures; cultural and intellectual developments; and functions and structures of states. The chronological frame of the course is the period from approximately 8000 b.c.e. to the present.

Human Geography: A 2-hour-and-15-minute exam covering a one-semester introductory college course. The exam includes a one-hour multiple-choice section and a 1-hour-and-15-minute free-response section. The exam covers the nature and perspectives of geography; population; cultural patterns and processes; political organization of space; agricultural and rural land use; industrialization and development; and cities and urban land use.

Italian Language and Culture: This exam assesses learning at the level of a fourth semester college/university course in Italian and is approximately three hours in length. It assesses students' level of Italian language proficiency and cultural knowledge. Section I of the exam contains 1 hour and 20 minutes of multiple-choice questions that assess listening and reading comprehension. Section II contains 1 hour and 25 minutes of free-response questions that assess writing and speaking ability as well as cultural knowledge. It includes two fill-in exercises, two compositions (one on a cultural topic), a spoken narration, and a simulated conversation.

Japanese Language and Culture: This exam assesses the level of learning attained by students who have received approximately 300 hours of instruction in college- or university-level Japanese. It assesses interpretive, interpersonal, and presentational communication skills in Japanese, along with knowledge of Japanese culture. Section I contains multiple-choice questions that assess communication skills in the interpretive mode using listening and reading questions. The free-response section assesses communication skills in the interpersonal and presentational modes by requiring the student to produce written and spoken responses.

Latin—Literature, Vergil: Two three-hour exams covering intermediate (fourth- to sixth-semester) college work on either the works of Catullus and a choice of Cicero, Horace, or Ovid (Literature), or the Aeneid (Vergil). Colleges may cover the material required by the AP course in either one or two semesters. Each exam consists of a one-hour section of multiple-choice questions based on four Latin passages of poetry or prose (in each exam, one passage is from the course syllabus and three passages are to be read at sight), and a two-hour section of translations and essays on the readings required in the course syllabus.

Music Theory: The exam is approximately three hours in length and covers a full-year introductory college course. It contains approximately 1 hour and 20 minutes of multiple-choice questions, 1 hour and 10 minutes of free-response questions, and a sight-singing performance section that lasts approximately 8 minutes per student. In the free-response section, students are asked to do two exercises each of melodic and harmonic dictation; two part-writing exercises (one from figured bass, one from Roman numerals); and a composition exercise entailing composing a bass line from a given melody. In the sight-singing component, students are asked to sing two diatonic melodies after a brief practice period. Students will receive subscore grades for the aural (listening and sight-singing) and nonaural (written) portions of this exam in addition to the overall composite grade.

Physics—Physics B, Physics C: Mechanics, Physics C: Electricity and Magnetism: Physics B is a three-hour exam covering a full-year noncalculus college survey course intended for students not majoring in a physical science or engineering. The exam contains 1 hour and 30 minutes of multiple-choice questions and 1 hour and 30 minutes of free-response questions. Physics C: Mechanics and Physics C: Electricity and Magnetism are 1-hour-and-30-minute exams each covering one semester of an introductory college course with calculus, intended for students planning to major in a physical science or engineering. Each contains 45 minutes of multiple-choice questions and 45 minutes of free-response questions. For both the Physics B and C exams, tables of commonly used equations are provided for use on the free-response section only. Scientific calculators, including programmable and graphing calculators, are permitted only for the free-response sections.

Psychology: A two-hour exam covering a one-semester introductory college course. The exam contains 1 hour and 10 minutes of multiple-choice questions and 50 minutes of free-response questions. The exam covers history and approaches; research methods; biological bases of behavior; sensation and perception; states of consciousness; learning; cognition; motivation and emotion; developmental psychology; personality; testing and individual differences; abnormal psychology; treatment of psychological disorders; and social psychology.

Spanish—Language, Literature: The AP Spanish Language Exam is approximately 3 hours in length and covers a third-year college course in advanced Spanish. The exam contains roughly 1 hour and 20 minutes of multiple-choice questions and 1 hour and 40 minutes of free-response questions. The multiple-choice section measures listening and reading comprehension in the interpretive mode. The free-response section tests the productive skills of speaking and writing as well as command of standard Spanish grammar and usage. Some of the questions in the free-response section integrate several skills (speaking, writing, listening, and reading) and use of interpersonal, interpretive, and presentational modes. Spanish Literature is a 3-hour-and-10-

minute exam covering a third-year college introduction to Peninsular and Latin American literature written in Spanish. The exam contains 1 hour and 20 minutes of multiple-choice questions and 1 hour and 50 minutes of free-response questions on required works and poetry analysis.

Statistics: A three-hour exam covering a one-semester introductory noncalculus-based college course. The exam contains 1 hour and 30 minutes of multiple-choice questions and 1 hour and 30 minutes of free-response questions. The free-response section requires students to answer five open-ended questions and complete an investigative task involving more extended reasoning. The exam covers exploring data; sampling and experimentation (planning and conducting a study); anticipating patterns (exploring random phenomena using probability and simulation); and statistical inference (estimating population parameters and testing hypotheses). Students are expected to bring a graphing calculator with statistical capabilities to the exam, and to be familiar with its use. Graphing calculators may be used for both sections of the exam.

APPENDIX B

Statistical Tables

Independent t-test of AP students Versus Non-AP students in General Biology I

General Biology Independent Samples t-test					
	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	6.402	.012	-3.521	440	.000
Equal not variances assumed			-3.521	435.536	.000

Independent t-test of AP Students Versus Non-AP Students in Principles of Biology I

Principles of Biology Independent Samples t-test					
	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	.474	.491	-4.716	782	.000
Equal not variances assumed			-4.716	781.939	.000

ANOVA Results for General Biology I

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	51.191	4	12.798	16.688	.000
Within Groups	335.129	437	.767		
Total	386.320	441			

Differences between Groups - Final Mean GPA for General Biology I

General Biology I mean grades Student-Newman-Keuls					
AP score	N				
1	28	2.043			
NO AP	221		2.645		
2	115		2.870		
3	59			3.358	
4	19			3.558	
Sig.		1.000	0.239	0.294	

ANOVA Results for Principles of Biology I

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	83.398	4	20.849	25.574	.000
Within Groups	635.084	779	.815		
Total	718.482	783			

Differences between Groups - Final Mean GPA for Principles of Biology I

		Subset for alpha = .05			
APSCORE	N	1	2	3	4
1	19	1.911			
2	151		2.562		
no-AP	392		2.571		
3	151			3.063	
4	71				3.477
Sig.		1.000	.956	1.000	1.000

AP Students with Scores of 3 Versus Non-AP Students in General Biology I

AP3 versus non-AP matched Independent Samples t-test					
	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	.089	.767	2.760	116	.007
Equal not variances assumed			2.760	110.616	.007

AP Students with Scores of 3 Versus Non-AP Students in Principles of Biology I

AP3 versus non-AP matched Independent Samples Test					
	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	.108	.743	3.045	302	.003
Equal not variances assumed			3.045	300.200	.003

p - Values and Significance in Sophomore Level Biology Courses at Virginia Tech

Sophomore biology course	F value	P value	Significant
Genetics (n=26)	3.735	0.203 > 0.05	no
Cell and Molecular Biology (n=24)	0.267	0.782 > 0.05	no
Evolutionary Biology (n=26)	2.279	0.944 > 0.05	no
Ecology (n=28)	1.355	1.00 > 0.05	no
Combined Biology courses (n=104)	8.050	0.568 > 0.05	no

APPENDIX C

IRB

Office of Research Compliance
Institutional Review Board
1880 Pratt Drive (0497)
Blacksburg, Virginia 24061
540/231-4991 Fax: 540/231-0959
E-mail: moored@vt.edu
www.irb.vt.edu
V I R G I N I A P O L Y T E C H N I C I N S T I T U T E U N I V E R S I T Y A N D S T A T E U N I V E R S I T Y

cc: File
DATE: February 13, 2007
MEMORANDUM
TO: Jackson Evans
FROM: David M. Moore
IRB Exempt Approval: "Advanced Placement Credits and College Students" , IRB # 07-076

I have reviewed your request to the IRB for exemption for the above referenced project. I concur that the research falls within the exempt status. Approval is granted effective as of February 13, 2007.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.

2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

SUBJECT:
FWA00000572(expires 7/20/07)
IRB # is IRB00000667.