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Research Report
No. 2008-3

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Contents

Abstract

Performance was examined for five cohorts of 1998–2002 Texas public high school graduates through their first year and 1998–2001 cohorts through their fourth year of Texas public higher education. Student performance on college outcomes included (a) first- and fourth-year grade point averages (GPAs), (b) first- and fourth-year credit hours earned, and (c) four-year graduation status. Outcomes were compared across students who varied by three types of AP® (course only, exam only, and both course and exam) and two types of non-AP (dual enrollment only and other course only) experiences in high school. Phase 1 analyses addressed each of seven AP Exams separately. Within each cohort year and within each cohort related to the specific AP Exam, students in the various AP and non-AP groups were matched on ability (ranked SAT® score category) and free or reduced-price lunch (FRPL) participation status. Students in each of the separately analyzed AP English Language and Composition, AP English Literature and Composition, AP Calculus AB, and AP U.S. History course and exam groups, for example, significantly outperformed their respective AP course only, dual enrollment, and other course peers on the GPA, graduation rate, and most credit hours outcomes. Phase 2 analyses aggregated AP course/exam and non-AP experiences, taking into account SAT score category and FRPL status. Students who took AP courses and exams significantly outperformed students who took AP courses only and other courses only on all outcomes in all years and, in general, exceeded AP Exam only and dual enrollment only group performances on the outcomes. They also graduated from college within four years at consistently higher rates than those in the other groups. Results provide strong evidence of benefits to students who participate in both AP courses and exams in terms of higher GPAs, credit hours earned, and four-year graduation rates.

Introduction

Students in the College Board's Advanced Placement Program® (AP) benefit from participating in college-level courses while still in high school and by having the opportunity to earn AP Exam grades that may qualify for college course placement or credit (DiYanni, 2008). In addition, the professional development of AP teachers is designed to raise the quality of teaching in general, leading to further advanced curricular access and benefits to students (e.g., College Board, 2002). As others (e.g., California State University Institute for Education Reform, 2001; Camara and Millsap, 1998; Ewing, Camara, and Millsap, 2006) have recognized, school policies often play a further role regarding the extent to which students are allowed into AP or other rigorous high school courses, sometimes over and above the sheer availability of these courses. As the AP Program expands to include an increasingly diverse student body, periodic assessments of AP participation and performance are necessary to determine the benefits of the AP experience relative to non-AP high school course experiences and higher education achievement.

The following review summarizes the previous research on various college outcomes and AP/non-AP types of high school course experiences. In addition, recent rapid expansion in the AP Program is described, along with accompanying questions that have been raised concerning AP Program quality and equitable access to AP. Based on key limitations of previous research, purposes of the current study are identified.

College Outcomes and High School Course Experiences

Examples of college outcomes from studies of AP and non-AP students have included: cumulative grade point averages (GPAs), grades in courses sequent to courses skipped because credit by exam was obtained, number of courses in the same discipline of the AP Exam, rates that college majors or minors are selected in the subject area of the AP Exam, cumulative college credits or persistence, and time to or eventual degree completion. A number of studies (e.g., Casserly, 1986; Dodd, Fitzpatrick, De Ayala, and Jennings, 2002; Geiser and Santelices, 2004; Koch, Fitzpatrick, Triscari, Mahoney, and Cope, 1988; Morgan and Maneckshana, 2000; Morgan and Ramist, 1998; Willingham and Morris, 1986) have shown that students who earn AP grades of 3 or better on the 1–5 AP scale generally outperform students who earn lower grades or who do not take an AP Exam on various measures of college outcomes. To date, large-scale research has not compared AP and non-AP students within specific subgroups of AP students determined by each of the AP Exam grades on the 1–5 AP scale. Only a few studies (e.g., Adelman, 1999, 2006; Dougherty, Mellor, and Jian, 2006; Geiser and Santelices; Gonzalez, O'Connor, and Miles, 2001) have investigated the relationship between AP/honors/other high school courses taken and college/other outcomes.

Cumulative GPA

Relatively few researchers (e.g., Geiser and Santelices, 2004; Morgan and Maneckshana, 2000; Willingham and Morris, 1986) have examined relationships between students' AP Exam grades and their cumulative GPAs

using various first- through fifth-year college outcome measures. Their results consistently show higher GPAs for those students with the higher AP Exam grades. Geiser and Santelices used second-year GPA as the predictive criterion, while Willingham and Morris followed GPA through four years and Morgan and Maneckshana followed through students' fourth and fifth years of college.

In addition, Geiser and Santelices (2004) studied the relationship between the number of high school AP/honors courses taken and second-year GPA to better inform policy regarding the use of these courses in the University of California (UC) admissions process. Their results showed that the combined number of AP and honors courses taken accounted for very little variance in the second-year GPA for UC students after other predictors such as high school GPA and parents' education were included in the regression equation. They also included AP and honors courses as separate predictors in further regression analyses after accounting for similar predictors as before and found that each contributed negligible amounts to the prediction of first-year GPA. Camara and Michaelides (2005) expressed major concerns regarding the conceptual and technical quality of the UC analyses such as the failure to replicate exactly in the regression model the variables used in the UC admissions process.

Grades in Sequent Courses

Research conducted by Casserly (1986), Dodd et al. (2002), Koch et al. (1988), Geiser and Santelices (2004), Morgan and Crone (1993), Morgan and Maneckshana (2000), and Morgan and Ramist (1998) generally confirms that AP students who receive credit by exam for an initial college course in a subject-area sequence earn course grades equivalent to or higher than students who take both the initial and sequent course in the series. Dodd et al. also found that, in general, when they took the sequent course in college, AP students received grades greater than or equivalent to non-AP students who had been concurrently enrolled in an introductory college course while still in high school. As Ewing (2006) notes, the study of Dodd et al. has been unique, to date, among studies in its inclusion of non-AP students who had taken a concurrent or dual enrollment program course. These programs allow both high school and college credit for the same course and thereby provide an alternative to AP courses and exams in this respect.

Additional Courses or Major

Results from Dodd et al. (2002), Koch et al. (1988), Morgan and Maneckshana (2000), and Willingham and Morris (1986) indicated that students tend to complete more college course work in the subject area of the AP Exams they have taken than other students who have not taken AP Exams. In addition, for students who took specific AP subject exams—Biology, Physics, Calculus, Studio Art (portfolio), and Spanish Literature—Morgan and Maneckshana noted that they more often majored or minored in the subject area or another area closely related to the subject exam taken in comparison to students not taking the same subject exam.

Cumulative Credits or Persistence

Similar to their finding regarding UC students' second-year GPAs, Geiser and Santelices (2004) found that AP/honors courses provided virtually no increase in predictive accuracy after accounting for other factors (e.g., high school GPA, parents' education, SAT scores, SAT Subject Test scores) in the logistic modeling of students who dropped out because of substandard GPAs or persisted during their first or second years of college. These findings, however, captured only one- and two-year snapshots of intermediate student outcomes specific to the UC system and thus have limited generalizability, especially since bachelor's degree completion is the longer-term outcome of interest. In contrast, Adelman's (1999) in-depth examination of persistence through bachelor's degree attainment strongly argues for following students through age 30 and throughout their series of enrollments in multiple colleges (which often cross state lines) to obtain better longitudinal measures of cumulative credits (or persistence) and completion rates.

Degree Completion

Based on results from their study, Morgan and Maneckshana (2000) observed that most AP Exam takers completed a bachelor's degree in four years. Recent work by Dougherty et al. (2006) showed that Texas public higher education students who took a high school AP course and earned an AP Exam grade of 3–5 had higher five-year graduation rates than students who took an AP course and earned an AP Exam grade of 1–2, students who took an AP course but no AP Exam, and students who had no AP experience. More generally related to eventual college graduation are Adelman's (1999, 2006) large-scale studies of high school and college transcript student data collected from U.S. Department of Education longitudinal studies. From this work, Adelman (1999) found that the best high school predictor of bachelor's degree attainment—over and above the predictive power of an SAT-type test score, high school class rank, or GPA—was the intensity and quality of courses such as AP (within an overall academic intensity/quality composite variable) that students completed in high school. In Adelman's (2006) recent study, each of the individual variables in the academic curriculum intensity composite variable was analyzed for their separate contributions to the prediction of bachelor's degree completion, including

the number of AP courses taken (0, 1–2, and 3+). Among student variables in the composite, science momentum, representing a combination of high school mathematics and core laboratory sciences courses taken, was more highly correlated with bachelor's degree completion and the academic curriculum intensity composite than number of AP courses taken.

Rapid Expansion in the AP® Program

During the past decade, rapidly increasing numbers of students qualified to obtain college course placement or credit prior to matriculation in higher education because of their performance on AP Exams and in dual/concurrent enrollment courses. Since the first group of 1,229 students took 2,199 AP Exams in 1956, steady growth in the AP Program predominated nationally until a new phase of more rapid growth emerged in the 1990s (DiYanni, 2008). From 1998 to 2005, the numbers essentially doubled to nearly 1.2 million students taking over 2 million AP Exams in 2005 (College Board, 1998, 2005b).

In many states, state legislation and policies and state and federal funding fueled rapid growth in the AP Program in a variety of ways, including paying most or all of the exam fees for low-income students and helping to cover the professional development costs for AP teachers so more students can participate in the AP Program (DiYanni, 2008). For example, in Texas (Texas Education Agency, 2005), where data for this study were obtained, considerable state funding and implementation of the AP Incentive Program has included: (a) providing AP Exam fee reductions to financially needy students, (b) paying the AP Exam fee for students completing an AP course in the same subject, (c) paying training subsidies for AP teachers, (d) one-time equipment grants to schools offering new AP courses, and (e) monetary awards to schools for students earning AP Exam grades of 3–5.

AP Quality and Equitable Access

Since the 1990s, the College Board has stepped up vigorously to promote increases in overall access and equity in access across the diversity of student groups to the AP Program. College Board efforts have ranged from its AP Equity Policy Statement (e.g., College Board, 2005a, p. 53) to other efforts, including the intensive cooperation and support of AP initiatives, far-reaching collaborative efforts with various institutions and their representatives (e.g., Commission on the Future of the Advanced Placement Program, 2001), development of widespread training for AP teachers, AP Exam fee reductions for students in financial need, and other initiatives.

As a result of recent acceleration in and promotion of AP course and exam participation, various authors and groups (e.g., Commission on the Future of the Advanced Placement Program, 2001; Geiser and Santelices, 2004; Hurwitz and Hurwitz, 2003; Klopfenstein, 2004; Lichten, 2000) have questioned whether: (a) AP course quality is being maintained, (b) unprepared (and even prepared) students are being pushed to take AP courses and exams, (c) historically underserved groups of students should or do have greater access to AP, and (d) AP courses or exams contribute to student success in college. Moreover, Camara, Dorans, Morgan, and Myford (2000) questioned how limiting AP Program access to simply the most educationally advantaged students overall would provide any large-scale impact on improving educational quality and, consequently, society at large.

Research Purposes

Based on previous research and some of the recent trends in AP Program operations, it was apparent that a need existed for broad-scale research concerning the long-term impact of AP on measures of student success in college. Thus, this study attempted to inform several major areas in which lingering questions remain and in which much research remains to be done.

First, this study examined several college outcomes for 1998–2002 Texas public high school graduates who had different types of AP and non-AP experiences in high school—both an AP course and exam, AP Exam but no course, AP course but no exam, dual enrollment course only, and other non-AP and non-dual-enrollment course experiences. While Dougherty et al. (2006) compared many similar groups of a 1998 high school graduation cohort on five-year college graduation rates, this study was unique in (a) analyzing not only graduation rates but also GPAs and credits earned, (b) including students who took dual enrollment courses only in high school, and (c) comparing a greater number of AP course and exam subgroups by AP Exam grades of 1, 2, 3, and 4–5. This study also contrasted with Adelman's (1999, 2006) broadscale research on college outcomes for high school graduates in that his data lacked AP Exam grades and the common metric advantage they provide on student performance in AP courses. This study included data and analyses to make such comparisons but was unique in the separate examinations of a variety of AP and other non-AP course-taking experiences related to seven AP Exam subjects and also aggregated across AP subject areas with respect to college outcomes. The specific AP

Exam subject analyses also included ethnicity and gender as independent variables, along with the group variable for types of AP and non-AP experiences.

Second, several researchers (e.g., Dodd et al., 2002; Geiser and Santelices, 2004; Morgan and Maneckshana, 2000) have found AP students to be relatively more successful than non-AP students on a variety college success measures. However, research samples in individual studies have included, at best, students from only one large or highly selective institution or students from a typical set of 30 or so institutions agreeing to participate in a given study. This study had unique access to data for 1998–2002 Texas public high school graduates who attended Texas public higher education institutions.

Third, this study was unique in that it followed student transfers across higher education institutions in Texas using data for 1998–2001 Texas public high school graduate cohorts through four years of attendance and transfers among Texas public institutions of higher education, while the 2002 cohort was followed for one year. Although this represented a notable advantage over previous studies of AP students, without access to out-of-state and nonpublic in-state secondary and postsecondary data, the disadvantage in this study was that student attendance and transfers to and from such institutions could not be tracked. This contrasted with Adelman (1999, 2006), who had access to somewhat similar data on a national level but did not have student data on AP Exams.

Fourth, few studies (e.g., Dodd et al., 2002; Dougherty et al., 2006; Geiser and Santelices, 2004) have attempted to control for differences in ability or college readiness by using either SAT or other types of exam scores. Of these, Dodd et al. was unique in applying such a control by matching students on SAT score category. The need for an ability control has been demonstrated in numerous validity studies over several decades documenting the relationship between students' freshman-year GPAs and their SAT scores (e.g., Kobrin and Michel, 2006). This study extended the Dodd et al. matched comparison-group design strategy to a statewide study of college outcomes among student groups distinguished by their differences in AP and non-AP experiences. It further added a control for individual differences in family income by subdividing students within SAT score categories by free or reduced-price lunch (FRPL) participation versus nonparticipation status in one set of analyses. In a second set of analyses, SAT score categories and FRPL status were used as blocking variables. In a third set of analyses, a different control for individual differences in ability or college readiness further subdivided the AP course and exam group by mean AP Exam grade category.

Research Questions

Research questions were grouped by the two phases of the study. In Phase 1, for each of five high school graduate cohorts (1998–2002) and for each of seven AP Exams studied separately—English Language and Composition, English Literature and Composition, Calculus AB, Biology, Chemistry, United States History, and Spanish Language—students with AP and non-AP experiences related to the given AP Exam subject were compared. Each AP Exam studied best met criteria for (a) popularity among AP subject exams taken in Texas and (b) representing one of five academic subject areas: English, mathematics, sciences, social sciences, and foreign language.

In Phase 2, AP subject exams and courses taken were first aggregated to identify students distinguished by three types of experience with *any* AP Exam subject—both course and exam, course only, and exam only. Then, for non-AP students, dual enrollment courses corresponding to any subject of an AP Exam were aggregated to identify those who took dual enrollment courses only versus those who took other (non-AP and non-dual-enrollment) courses only. The number of different AP Exams represented in Phase 2 aggregations for each cohort year included: 31 in 1998; 32 in 1999; 30 in 2000; 31 in 2001; and 34 in 2002. Appendix A shows the correspondences between specific AP Exams/courses and dual enrollment courses used in defining Phase 1 groups, and Appendix B shows those used in defining Phase 2 groups.

Phase 1— Subject-Specific AP Exams

1. For AP Exams studied separately, are there differences in college outcomes by gender and ethnicity among students with various types of AP (course and exam, course only, and exam only) and non-AP (dual enrollment course only and other course only) experiences related to the subject exam when matched on SAT scores and FRPL participation (family income) status?

Phase 2— Subject-Aggregated AP Exams

2. Are there differences in college outcomes by SAT score rank (1: 400–850; 2: 860–970; 3: 980–1080; 4: 1090–1600), collapsed to yield sufficient sample sizes, and FRPL participation among students with various types of aggregated AP and non-AP experiences—AP course and exam, AP Exam only, AP course only, dual enrollment course only, and other courses only?

3. For the 2001 cohort, are there differences in college outcomes by SAT score rank (1: 400–850; 2: 860–970; 3: 980–1080; 4: 1090–1600) and FRPL participation among students with various types of aggregated AP and non-AP experiences—AP course only, dual enrollment course only, other courses only, and four AP course and exam/mean AP Exam grade (1, 2, 3, 4–5) groups?
4. How do each of the five cohorts of aggregated AP course and exam students compare in terms of college outcomes when their average AP Exam grade categories (1, 2, 3, 4–5) and overall numbers of AP courses (1–3, 4, 5+ and 1–2, 3, 4, 5+) and exams (1, 2, 3, 4+) are analyzed?

Method

This study follows five cohorts of 1998–2002 Texas public high school graduates through their first year and four cohorts of 1998–2001 graduates through their fourth year of attendance at Texas public higher education institutions. Criteria for student inclusion into these cohorts included: (a) attendance at a Texas public higher education institution within the first fiscal year (fall through summer) following high school graduation and (b) data on all of the independent and dependent variables.

Data Sources

All Texas public higher education data were obtained from the Texas Higher Education Coordinating Board (THECB), including data on students' first- and fourth-year GPAs and credit hours earned and graduation status. All prematriculation data were obtained by THECB from the Texas Education Agency (TEA). TEA high school public education student data included high school courses taken, high school graduation dates, free or reduced-price lunch (FRPL) program participation, gender, and ethnicity. AP Exam grades (1995–2002) and SAT scores (classes of 1998–2002) for Texas students were obtained by THECB from the College Board. Data merges produced files suitable for this study's analyses, after student identifying information had been removed.

Initially, data merges identified the total number of students by cohort who attended a Texas public higher education institution any time within the first fall through summer fiscal year following graduation from a Texas public high school as follows: 58,899 in 1998; 60,041 in 1999; 61,789 in 2000; 62,709 in 2001; and 59,531 in 2002. Subsequent data merges identified the number and percentage of students by cohort who had data on all of the first- and fourth-year outcomes necessary for Phase 2 analyses including: 38,907 (66.1 percent) in 1998; 39,912 (66.5 percent) in 1999; 41,740 (67.6 percent) in 2000; and 42,199 (67.3 percent) in 2001. These were the numbers available for analyses prior to exclusions that were made due to small cell sizes. Since no fourth-year outcomes were available for the 2002 cohort, only first-year outcomes were analyzed and, thereby, the number of students in the cohort remained unchanged from initial data merges. As a result, the 2002 analysis cohort was larger than the prior four cohorts where attrition was a factor; thus, 2002 mean first-year GPAs and credit hours earned were somewhat lower than those same means for prior cohorts.

Additional data files were created for each of the seven sets of AP subject-specific analyses for Phase 1. AP Exams studied were selected on the basis of popularity among Texas AP Exam takers and to ensure that the academic subject areas of English, mathematics, sciences, social sciences, and foreign language were represented by at least one AP Exam subject. Note that student data in each of the seven subject files within a cohort year were not independent because AP and non-AP students take courses and/or exams in more than one subject area. The total number of students by subject and cohort in Phase 1 analyses are shown in Table 1.

Table 1
Student Totals for Phase 1 Analyses

	High School Graduate Cohorts				
Subject	***1998***	***1999***	***2000***	***2001***	***2002***
English Language	9,413	12,528	17,682	20,971	29,498
English Literature	10,266	12,265	16,428	18,450	22,457
Calculus	4,984	7,654	10,149	12,374	14,483
Biology	2,847	4,104	5,553	5,403	5,950
Chemistry	1,546	2,234	3,239	3,491	3,770
U.S. History	4,722	6,299	10,104	11,681	18,923
Spanish Language	1,853	2,356	3,471	3,754	4,851

Note: Student records are not independent across subjects within a cohort year. The 2002 cohort includes all students in first-year college attendance; prior cohorts include only students who graduated from college within four years or were still in college attendance by the end of fourth year. After preliminary analyses were conducted, some subgroup exclusions were necessary due to sample sizes too small for inclusion in the inferential analyses.

Design

This study compared students with various types of high school course experiences and AP Exam participation (group independent variable) in terms of their college performance on a number of outcome measures. College outcomes (dependent variables) were first- and fourth-year GPAs and college credit hours earned, and fourth-year baccalaureate graduation status. These same outcomes were used to address all research questions in this study. Group was used as an independent variable in all research questions, except in Research Question 4.

Dependent Variables

First- and fourth-year GPA was estimated by summing grade points earned across relevant fiscal years (fall–summer) of college attendance, dividing by college credit hours earned. First- and fourth-year credit hours earned were cumulated across the relevant fiscal year time periods. Neither credits earned through dual enrollment nor AP Exam grades were available for inclusion in the credits earned data. Higher education course credits earned in developmental education and pass/fail courses were not used.

Fourth-year graduation rate was calculated by dividing the number of students who had graduated within four years of college attendance by the total number of study participants (i.e., graduates plus those still in college attendance during the fourth year after high school graduation).[1] This ensured that graduation rate was determined for the same cohort used for the GPA and credit hours outcomes. Note that the denominator includes neither students who graduated from nonpublic high schools and attended a higher education institution nor Texas public high school graduates who attended out-of-state or nonpublic in-state higher education institutions, because of database limitations. One reason a four-year graduation rate was chosen, rather than a five- or six-year rate, was so this outcome could be compared across four cohorts (1998–2001) of data available for this study. Another reason was that the four-year graduation rate is viewed by Texas policy leaders as a necessary goal and standard for students and institutions.

Phase 1—Matching Procedure and Independent Variables

Initially, students were grouped according to the types of AP and non-AP experiences they had in high school. Related to each of the seven AP Exams separately studied—AP English Language and Composition, AP English Literature and Composition, AP Calculus AB, AP Biology, AP Chemistry, AP U.S. History, and AP Spanish Language—five groups were formed (the group independent variable). The five groups included those who took (a) the specific AP course and corresponding exam, (b) the specific AP course but no exam, (c) the specific AP Exam but no AP course, (d) only a dual enrollment course in the same subject area as the specific AP Exam studied (see Appendix A), or (e) only any other high school course in the same subject area. For example, those in the two non-AP course groups (d and e) for analyses specific to AP English Language and Composition took either a dual enrollment course or another type of non-AP course in the same subject area as AP English Language. Only in the 2000–02 AP English Language and Composition, AP English Literature and Composition, and AP Calculus AB and 2002 AP U.S. History analyses was there a sufficient number ($n > 9$ per MANOVA cell) of non-AP students who took a related dual enrollment course to include a dual enrollment group in the analyses. The same held true for inclusion of an AP Exam only (but no AP course) group in 1998–2002 AP English Language and Composition, AP English Literature and Composition, and AP Spanish Language analyses only.

Note also that TEA did not collect dual enrollment course data prior to the 2000 graduating class; thus, dual enrollment course information was available for 2000–02 only, and all 1998-99 dual enrollment course only students fell into the other course(s) group. Because no summer dual enrollment course information was collected during 2000–02, some dual enrollment students may be grouped inadvertently into the other course(s) group. Still, summer dual enrollment in Texas does not involve a significant number of students. Another issue was the lack of any official designation of dual enrollment courses corresponding to AP courses. Therefore, dual enrollment courses completed in the same subject area of each specific AP Exam studied (as designated in the TEA course data) were used to define dual enrollment course only students in Phase 1 (see Appendix A). For Phase 2, the authors independently reviewed a TEA list of dual enrollment courses and, by consensus, included only dual enrollment courses that appeared to best match all AP subject exams analyzed in aggregate (see Appendix B).

The Phase 1 design used two matching variables, SAT total score and FRPL participation status, to partially control for preexisting student differences in college readiness and family income. After an SAT score rank had been determined for a student, students were additionally

[1] If the cohort denominator had been defined as the total number of college graduates plus those attending college within the year following high school graduation, college dropouts over four years would have been included in the denominator. However, such a denominator would have hindered the accurate identification of true dropouts from those who "stopped out" or who transferred to out-of-state or in-state nonpublic higher education institutions, thereby contaminating the graduation rate comparisons among AP and non-AP students. These comparisons were the main interest of the study—not the comprehensive study of eventual graduation rates.

classified by FRPL or non-FRPL participation status within each SAT score category, which resulted in a 10 x 2, or 20-category, matching design. SAT score categories included: (1) 400–590, (2) 600–690, (3) 700–790, (4) 800–890, (5) 900–990, (6) 1000–1090, (7) 1100–1190, (8) 1200–1290, (9) 1300–1390, and (10) 1400–1600.

After the groups were created and matching categories determined, a matching procedure was conducted to better equalize the groups. First, the numbers of the AP course and exam students within each of the 20 SAT rank and FRPL status categories were determined. Next, samples of students in each of the other course groups were selected to match as closely as possible the numbers of AP course and exam students in each of the 20 SAT rank and FRPL status categories. The same process was followed in selecting the samples of students from the respective AP course only, AP Exam only (when applicable), and dual enrollment course only groups. When the number of students in the matching category of the group sampled was smaller than the equivalent AP course and exam group, all students in that group category were included. Otherwise, if the number of students in a group category was larger than the equivalent AP course and exam group category, a sample of matching size was drawn to represent the SAT rank and FRPL status distributions of students in the AP course and exam group category.

Gender and ethnicity were the other independent variables, besides group, included in the Phase 1, Research Question 1 analyses. Gender and ethnicity from the TEA data were used because they were available for the most students in the data files. Ethnicity consisted of five groups: Native American, Asian American, African American, Hispanic, and white. However, numbers of Native American students were insufficient for inclusion in ethnicity analyses, as were numbers of African Americans in the AP Spanish Language analyses. Small cell sizes also led to the exclusion of gender as an independent variable in 1998 AP Biology, AP Chemistry, and AP Spanish Language analyses.

Phase 2—Group Aggregation Procedures and Independent Variables

For Research Questions 2–3, Phase 2 was designed to address comparisons among five possible AP and non-AP groups of students based on their aggregate course and/or exam experiences. Thus, students with any AP course *and* any AP Exam experience were placed into the AP course and exam group. The other two AP groups included students who had taken (a) any AP course but no AP Exam and (b) any AP Exam but no AP course. The two remaining groups included non-AP students who had taken (c) any dual enrollment course that matched an AP Exam subject (see Appendix B), and (d) other courses only. In contrast, Research Question 4 addressed comparisons only within the AP course and exam group in terms of mean AP Exam grades and the number of AP Exams and courses completed.

Initial analyses for Research Question 2 attempted to match students in each of the AP and non-AP course aggregated groups on the same 20 categories of SAT and FRPL participation status categories used in the subject-specific Phase 1 analyses. Unlike in Phase 1, however, matching other AP and non-AP groups to a much larger, aggregated group of students with both AP course and exam experience (i.e., across all rather than one AP Exam subject) was not viable because of substantially fewer numbers of FRPL students in both the higher SAT score categories and in some of the other AP (e.g., AP Exam only) and non-AP (e.g., dual enrollment only) groups. Although using SAT Total score as a covariate in Phase 2 analyses was considered, its interaction with the group variable was problematic for tenability of the MANCOVA and ANCOVA homogeneity of group regressions assumption. Thus, the most viable approach was to use SAT total (or equivalent) score and FRPL status as blocking variables to account for potential interactions among these two variables and the group variable on the college outcomes. Based on further analyses, a set of four SAT total score categories for the SAT rank variable (1: 400–850; 2: 860–970; 3: 980–1080; 4: 1090–1600) was determined for all Phase 2 analyses to assure a sufficient number of students in each category.

For Research Question 3, four AP course and exam mean grade (1, 2, 3, 4–5) groups were formed in order to assure sufficient cell sizes. Because of insufficient cell sizes ($n < 10$) when it was included in preliminary analyses, the AP Exam only group ($n = 388$) was excluded from the AP graded groups analyses. Thus, seven AP and non-AP groups resulted—four AP course and exam/mean AP grade groups and the AP course only, dual enrollment only, and other courses groups. Other independent variables—SAT rank and FRPL status—were parallel to those used in Research Question 2 analyses. Because Research Question 3 was an exploratory variation on Research Question 2, only 2001 cohort data were used—that is, the most recent cohort with all five outcomes and the greatest number of AP and non-AP groups.

Unlike Research Questions 1–3, Research Question 4 addressed only the AP course and exam group and the relationship between the college outcomes and another set of independent variables—mean AP grade and the number of AP Exams and courses taken. For each independent variable, the categories included: (a) mean AP grade (rounded): 1, 2, 3, and 4-5; (b) number of AP Exams: 1, 2, 3, 4, and 5 and above (5+); (c) and number of AP courses: 1-3, 4, and 5 and above (5+) (1998–1999) and 1-2, 3, 4, and 5+ (2000–02). These categories were selected to assure adequate cell sizes. When mean AP grade was not a whole number, decimal values of 0.5 or

greater were rounded up to the nearest AP grade (whole number); those lower than 0.5 were rounded down to the nearest AP grade.

Analyses

Both multivariate and univariate analyses, along with post hoc comparisons, were conducted, as appropriate, given the research questions and the outcome variables used throughout the study. Thus, MANOVAs were used to analyze differences in multivariate means by the independent variables on the linear composite of both first- and fourth-year GPA and credit hours earned dependent measures. The MANOVAs were followed by separate ANOVAs on each of the GPA and credit hours outcomes. For any statistically significant ($p < .01$) MANOVA effect, the corresponding ANOVA effect was assessed for significance ($p < .01$) on each GPA and credit hours outcome. If any ANOVA effect was significant, the corresponding Tukey-Kramer post hoc comparisons among all possible pairs of least-square means between groups/categories of the main effect or interaction were tested for significance ($p < .01$). Least-square means were estimated with the MANOVA procedure.

To test for significant differences in four-year graduation rates by the independent variables for each research question, logistic regression was used, along with post hoc reference group comparisons on the significant main effect variables. Unlike the MANOVAs, only main effects were modeled (i.e., no interactions assumed) in the logistic regression because Hosmer and Lemeshow Goodness-of-Fit chi-square test statistics indicated good model fit with more parsimonious main-effects-only models. Thus, each logistic regression main effect was evaluated for significance ($p < .01$). If the respective logistic regression main effect was significant, reference groups for Research Question 1 post hoc comparisons among graduation rates for independent variable groups/categories included (a) group—AP course and exam, (b) ethnicity—white, and (c) gender—female. The AP course and exam group was also the reference group for the group variable in Research Question 2 analyses, but reference groups for other variables included (a) SAT rank category—highest rank (4) and (b) FRPL status—non-FRPL. For Research Question 3, SAT rank and FRPL status reference groups were the same as for Research Question 2, but the reference group for the AP group/grade variable was the AP course and exam grade 2 group because of interest in how well AP course and exam grade 2 students perform relative to non-AP groups, in particular. For Research Question 4, reference groups/categories included (a) number of AP Exams—4 or greater, (b) mean AP grade—4 to 5, and (c) number of courses—5 or greater. Wald 99 percent confidence limits were used to assess the significance of reference group comparisons.

For Research Question 1, a basic 5-group x 2-gender x 4-ethnic group, or 40-cell, design was employed for the MANOVA, related ANOVAs, and logistic regression analyses. However, the number of groups (3 to 5) and independent variables (2 to 3) varied across cohort years depending on the availability of dual enrollment data (2000–02 cohorts only) and the adequacy of the sample size (at least 10) for each cell in the design. Research Question 2 analyses used a 3-, 4-, or 5-group x 2-FRPL status x 4-SAT rank category design, while Research Question 3 used a 7-group x 2-FRPL status x 4-SAT rank category design. Last, Research Question 4 used a 4-AP mean grade category x 4-AP number of exams category x 4-AP number of courses category design, except when three categories of AP number of courses were used for the 1998-99 cohorts to assure sufficient *n*-sizes for each cell in the design. Within research questions, minor variations in groups/categories and number of independent variables used in analyzing different cohorts are evident in the Results section tables that follow.

Results

Results are organized by Phase 1 and Phase 2 research questions. In each section, overviews by year are provided for the statistically significant MANOVA, univariate ANOVA, and logistic regression effects for five college outcome variables: first- and fourth-year college GPAs, first- and fourth-year college credit hours earned, and baccalaureate (four-year) graduation rates. Least-square means for significant univariate ANOVA effects by outcome are presented, along with significant Tukey-Kramer post hoc comparisons. A significant univariate ANOVA effect is noted only if the corresponding MANOVA effect was significant. Then, significant logistic regression effects are provided with significant post hoc reference group comparisons.

Phase 1 Results for Research Question 1: Selected AP Exam Subjects

Ethnicity and gender comparisons were made within each of the seven sets of subject-specific AP and non-AP matched groups. Table 2 provides an overview by subject of significant MANOVA, univariate ANOVA, and logistic regression effects across college outcomes for each high

school graduate cohort year studied.

AP English Language and Composition

MANOVAs

Regarding the AP English Language and Composition Exam subject, statistically significant ($p < .01$) results were obtained for all three MANOVA main effects—group, ethnicity, and gender—with all cohorts (1998–2002) (see Table 2). MANOVA statistics for significant differences in multivariate means by group across cohorts included: (a) 1998–Wilks' $\Lambda = .9951$, $F(12, 24812) = 3.86$, $p < .0001$; (b) 1999–Wilks' $\Lambda = .9914$, $F(12, 33054) = 9.02$, $p < .0001$; (c) 2000–Wilks' $\Lambda = .9899$, $F(16, 53889) = 11.27$, $p < .0001$; (d) 2001–Wilks' $\Lambda = .9863$, $F(16, 63937), = 18.09$, $p < .0001$; and (e) 2002–Wilks' $\Lambda = .9904$, $F(8, 58914) = 35.64$, $p < .0001$). The group by ethnicity MANOVA interaction was significant for the last four cohorts

Table 2

Significant MANOVA, ANOVA, and Logistic Regression Effects for Seven AP Subjects*: AP and Non-AP Group Comparisons by Gender and Ethnicity

		Years Significant by High School Graduate Cohort Year					
		Multivariate Outcome Composite	*Univariate College Outcomes*				*Logistic Regression Outcome†*
*Relevant AP Subject Exam**	*Type of Effect*	*First- & Fourth-Year GPA and First- & Fourth-Year Credits*	*First-Year GPA*	*Fourth-Year GPA‡*	*First-Year Credit Hours Earned*	*Fourth-Year Credit Hours Earned‡*	*Four-Year Graduation Rate‡*
Eng Lang & Comp§,**	Group	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Ethnicity	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Gender	1998–2002	1998–2002	1998–2001	1999, 2001	1998–1999, 2001	1998–2001
	Group by Gender	2000	N.S.	N.S.	2000	N.S.	
	Group by Ethnicity	1999–2002	1999, 2001	2000–2001	2002	2000	
	Gender by Ethnicity	2000	N.S.	N.S.	2000	N.S.	
	Group by Gender by Ethnicity	2002	N.S.		N.S.		
Eng Lit & Comp§,**	Group	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Ethnicity	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Gender	1998–2002	1998–2002	1998–2001	1998	1998–1999, 2001	1998–2001
	Group by Gender	N.S.					
	Group by Ethnicity	1999–2001	2001	2000–2001	1999–2000	1999, 2001	
	Gender by Ethnicity	2000, 2002	2002	N.S.	2000	N.S.	
	Group by Gender by Ethnicity	N.S.					
Calc AB**	Group	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Ethnicity	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Gender	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Group by Gender	N.S.					
	Group by Ethnicity	1999-2002	2000-2002	1999-2001	1999-2002	2000-2001	
	Gender by Ethnicity	2002	2002		N.S.		
	Group by Gender by Ethnicity	2001	N.S.	N.S.	2001	N.S.	
Biology††	Group	1998–2002	1998–2002	1999, 2001	1998–2002	1998–1999, 2001	1998–2001
	Ethnicity	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Gender	1999–2002	1999–2002	1999–2001	2000	2000	1999–2001
	Group by Gender	N.S.					
	Group by Ethnicity	N.S.					
	Gender by Ethnicity	N.S.					
	Group by Gender by Ethnicity	N.S.					
Chem††	Group	2000–2002	2000–2002	2001	2000–2002	2000–2001	1999–2001
	Ethnicity	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Gender	1999–2002	1999–2002	1999–2001	N.S.	2001	1999–2001
	Group by Gender	N.S.					
	Group by Ethnicity	N.S.					
	Gender by Ethnicity	N.S.					
	Group by Gender by Ethnicity	N.S.					
Hist: US**	Group	1998–2002	1998–2002	1998, 2000–2001	1998–2002	1998–2001	1998–2001
	Ethnicity	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Gender	1998–2002	1998–2002	1998–2001	1999–2001	1998–2001	1998–2001
	Group by Gender	N.S.					
	Group by Ethnicity	2000, 2002	2000, 2002	2000	2002	N.S.	
	Gender by Ethnicity	1998, 2000, 2002	1998, 2000, 2002	2000	2000	N.S.	
	Group by Gender by Ethnicity	N.S.					

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Table 2

Significant MANOVA, ANOVA, and Logistic Regression Effects for Seven AP Subjects*: AP and Non-AP Group Comparisons by Gender and Ethnicity

		Years Significant by High School Graduate Cohort Year					
		Multivariate Outcome Composite	*Univariate College Outcomes*				*Logistic Regression Outcome*†
*Relevant AP Subject Exam**	*Type of Effect*	*First- & Fourth-Year GPA and First- & Fourth-Year Credits*	*First-Year GPA*	*Fourth-Year GPA*‡	*First-Year Credit Hours Earned*	*Fourth-Year Credit Hours Earned*‡	*Four-Year Graduation Rate*‡
Spanish Lang§,††,‡‡	Group	1998–2002	1998–2002	1998–2001	1999–2002	2000–2001	1998–2001
	Ethnicity	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998–2001
	Gender	1999–2002	1999–2000, 2002	1999–2001	N.S.	N.S.	1999–2001
	Group by Gender	N.S.					
	Group by Ethnicity	1999–2000, 2002	N.S.	N.S.	2002	1999–2000	
	Gender by Ethnicity	2000–2001	N.S.	N.S.	2000–2001	2001	
	Group by Gender by Ethnicity	N.S.					

Note: Significance level for α was $p < .01$. N.S. = nonsignificant effect for outcome in all cohort years studied. AP and non-AP groups included: AP course and exam, AP Exam only, AP course only, dual enrollment, and other course students. Dual enrollment data were unavailable for analysis prior to cohort year 2000. Ethnic groups included: Asian Americans, African Americans, Hispanics, and whites.

* AP Exam subjects included: English Language and Composition (Eng Lang & Comp), English Literature and Composition (Eng Lit & Comp), Calculus AB (Calc AB), Biology, Chemistry (Chem), United States History (Hist: US), and Spanish Language (Spanish Lang).

† Logistic regression models assumed no interactions.

‡ Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

§ For 1998–2002 cohort years for AP English Language and Composition, AP English Literature and Composition, and AP Spanish Language analyses only, AP and non-AP groups also included an AP Exam only group due to sufficient cell *n*'s for the full-factorial group by ethnicity by gender design.

** For 2000–2002 cohort years for AP English Language and Composition, AP English Literature and Composition, and AP Calculus AB and for 2002 AP U.S. History, AP and non-AP groups also included a dual enrollment group due to sufficient cell *n*'s for the full-factorial group by ethnicity by gender design.

†† Gender was excluded from the set of independent variables analyzed for the subjects relevant to AP Biology, AP Chemistry, and AP Spanish Language in the 1998 cohort year due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. This exclusion resulted in factorial analyses that included group and ethnicity only.

‡‡ For 1998–2002 cohort years for AP Spanish Language analyses only, African Americans were excluded due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design.

(1999–2002), while both the group by gender and gender by ethnicity interactions were significant for the 2000 cohort only. Although the group by gender by ethnicity interaction was significant with the 2002 cohort, none of the corresponding ANOVAs were significant.

ANOVA Main Effects and Post Hoc Comparisons

The main effects of group and ethnicity were significant for all outcomes and cohorts—first-year GPA and first-year credit hours earned (1998–2002) and fourth-year GPA and fourth-year credit hours (1998–2001)—for AP English Language and Composition ANOVAs (see Table 2). The gender main effect was significant for first-year GPA (1998–2002), first-year credit hours (1998–2001), fourth-year GPA (1999 and 2001), and fourth-year credit hours (1998, 1999, and 2001). For each main effect, Table 3 lists least-square means for each of the outcomes by cohort year.

Group main effects. Based on the Tukey-Kramer post hoc comparisons depicted in Table 3 for the group main effect, both the AP English Language and Composition course and exam group and the exam only group significantly outperformed all the other groups on first-year GPA (1999–2002), first-year credit hours (2000–01), and fourth-year GPA (1999–2001) outcomes. This advantage also held for fourth-year credit hours earned by the 1998–2001 cohorts, except in comparison to the AP course only group for the 1998 and 1999 cohorts.

Ethnicity main effects. For post hoc comparisons among ethnic groups, Asian American and white students posted significant and consistently higher mean first- and fourth-year GPAs than Hispanic and African American students (see Table 3). Asian Americans always cumulated a significantly higher mean number of first- and fourth-year credit hours than Hispanic, African American, and white students. Otherwise, white and African American students earned a significantly greater number of 1998 and 2000 first-year and 1998–2001 fourth-year credit hours than Hispanic students.

Gender main effects. For post hoc comparisons based on gender, Table 3 lists significantly higher means for females versus males across college GPA and credit hours earned outcomes. The only exceptions were nonsignificant differences between females and males in mean 2000 fourth-year credits and in mean 1998, 2000, and 2002 first-year credit hours earned.

ANOVA Interactions and Post Hoc Comparisons

The group by ethnicity ANOVA interaction emerged as significant in at least two of the 1999–2002 cohorts for AP English Language and Composition for at least two

Table 3

Least-Square Means by Outcome for Significant ANOVA Main Effects for AP English Language and Composition: Group, Ethnicity, and Gender

Main Effect & High School Graduation Cohort Year	*Main Effect Groups*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
Group/1998†	AP Course/Exam	2.90	2.90	28.31	103.27_{a}
	AP Course Only	2.82	2.83_{a}	27.21_{a}	103.69
	AP Exam Only	2.93	2.94_{b}	28.63_{b}	107.33_{b}
	Other Course	2.81	2.81_{a}	27.37_{a}	101.90_{a}
Group/1999†	AP Course/Exam	2.93_{a}	2.93_{a}	28.00_{a}	104.64_{a}
	AP Course Only	2.79_{b}	2.79_{b}	27.31_{c}	103.43_{a}
	AP Exam Only	2.97_{a}	2.95_{a}	$28.45_{d,e}$	104.65_{a}
	Other Course	2.74_{b}	2.76_{b}	$26.57_{b,f}$	99.36_{b}
Group/2000	AP Course/Exam	2.97_{a}	2.97_{a}	28.22_{a}	105.72_{a}
	AP Course Only	2.79_{b}	2.78_{b}	26.90_{b}	101.53_{b}
	AP Exam Only	2.92_{a}	2.92_{a}	28.34_{a}	106.18_{a}
	Dual Enrollment	2.72_{b}	2.78_{b}	26.78_{b}	100.56_{b}
	Other Course	2.77_{b}	2.78_{b}	26.02_{b}	99.59_{b}
Group/2001	AP Course/Exam	3.01_{a}	2.98_{a}	28.13_{a}	105.13_{a}
	AP Course Only	2.78_{b}	2.78_{b}	26.86_{b}	$100.89_{b,c}$
	AP Exam Only	2.93_{a}	2.92_{a}	28.41_{a}	105.42_{a}
	Dual Enrollment	2.66_{b}	2.71_{b}	26.33_{b}	99.56_{b}
	Other Course	2.75_{b}	2.76_{b}	26.14_{b}	$98.13_{b,d}$
Group/2002‡	AP Course/Exam	2.88_{a}	--	25.00_{a}	--
	AP Course Only	2.64_{b}	--	23.76_{b}	--
	AP Exam Only	2.88_{a}	--	24.86_{c}	--
	Dual Enrollment	2.65_{b}	--	24.18	--
	Other Course	2.59_{b}	--	$23.12_{b,d}$	--
Ethnicity/1998	Asian American	3.07_{a}	3.02_{a}	30.37_{a}	109.28_{a}
	African American	2.69_{b}	2.67_{b}	$27.51_{b,c}$	$103.85_{b,c}$
	Hispanic	2.71_{b}	2.75_{b}	$25.82_{b,d}$	$97.51_{b,d}$
	White	2.99_{a}	3.04_{a}	$27.82_{b,c}$	$105.55_{b,c}$
Ethnicity/1999	Asian American	3.04_{a}	3.01_{a}	30.52_{a}	110.26_{a}
	African American	2.70_{b}	2.65_{b}	$26.24_{b,c}$	$101.51_{b,c}$
	Hispanic	2.70_{b}	2.74_{b}	$25.98_{b,c}$	$97.27_{b,d}$
	White	2.99_{a}	3.02_{a}	$27.60_{b,d}$	$103.04_{b,c}$
Ethnicity/2000	Asian American	2.99_{a}	3.00_{a}	30.08_{a}	109.48_{a}
	African American	2.66_{b}	$2.63_{b,c}$	$26.57_{b,c}$	$102.73_{b,c}$
	Hispanic	2.70_{b}	$2.74_{b,d}$	$25.11_{b,d}$	$95.57_{b,d}$
	White	2.98_{a}	3.01_{a}	$27.25_{b,c}$	$103.09_{b,c}$
Ethnicity/2001	Asian American	2.98_{a}	2.98_{a}	29.89_{a}	108.12_{a}
	African American	$2.63_{b,c}$	$2.60_{b,c}$	$26.07_{b,c}$	$100.87_{b,c}$
	Hispanic	$2.73_{b,d}$	$2.74_{b,d}$	$25.27_{b,c}$	$95.36_{b,d}$
	White	2.97_{a}	3.00_{a}	$27.46_{b,d}$	$102.95_{b,c}$
Ethnicity/2002‡	Asian American	2.98_{a}	--	27.91_{a}	--
	African American	$2.48_{b,c}$	--	23.12_{b}	--
	Hispanic	$2.56_{b,c}$	--	$22.22_{b,c}$	--
	White	$2.88_{b,d}$	--	$23.50_{b,d}$	--
Gender/1998	Females	2.94_{a}	2.96_{a}	27.99§	105.54_{a}
	Males	2.79_{b}	2.78_{b}	27.77§	102.55_{b}
Gender/1999	Females	2.95_{a}	2.97_{a}	27.97_{a}	105.44_{a}
	Males	2.77_{b}	2.74_{b}	27.20_{b}	100.59_{b}
Gender/2000	Females	2.93_{a}	2.96_{a}	27.45§	103.56§
	Males	2.74_{b}	2.73_{b}	27.05§	101.88§
Gender/2001	Females	2.90_{a}	2.93_{a}	27.47_{a}	103.29_{a}
	Males	2.76_{b}	2.73_{b}	26.87_{b}	100.37_{b}

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Table 3

Least-Square Means by Outcome for Significant ANOVA Main Effects for AP English Language and Composition: Group, Ethnicity, and Gender

Main Effect & High School Graduation Cohort Year	*Main Effect Groups*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
Gender/2002‡	Females	2.84_a	--	24.39§	--
	Males	2.62_b	--	23.98§	--

Note: Significance level for α was $p < .01$. Within the same main effect/cohort year and same outcome (column), means with specific non-matching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly.
* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.
† Dual enrollment data were unavailable before the 2000 cohort year.
‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.
§ Nonsignificant effect for outcome within cohort year.

of the four GPA and credit years outcomes, similar to AP English Literature and Composition and AP Calculus AB (see Table 2). However, both the group by gender and gender by ethnicity interactions were significant for only one outcome—first-year credit hours—with only one cohort (2000), and thus are not presented.

Group by ethnicity interaction. Table 4 includes least-square means by outcome and year and, within each ethnic group, significant Tukey-Kramer post hoc comparisons among groups. Except for Hispanics, 2001 mean first- and fourth-year GPAs were significantly higher for those in the AP English Language and Composition course and exam group than for those in the AP English Language and Composition course only, dual enrollment, and other course groups. However, Hispanics in the 2001 AP English Language and Composition course and exam group earned significantly higher mean first-year GPAs than Hispanics in the other course group. While the overall Asian American and white first- and fourth-year GPA advantages persisted within the group by ethnicity interactions, African American and Hispanic students in the AP course and exam group generally performed at levels more closely comparable to Asian Americans and whites in the AP course only, dual enrollment, and other course groups. Otherwise, 2002 African American, Hispanic, and white AP English Language course and exam students significantly

Table 4

Least-Square Means by Outcome for Significant ANOVA Interactions for AP English Language and Composition: Group by Ethnicity

College Outcome	*High School Graduation Cohort Year*	*Ethnicity*	*Group*				
			AP Course and Exam	*AP Course Only*	*AP Exam Only*	*Dual Enrollment*	*Other Course*
First-Year GPA	1999*	Asian American	3.13_a	2.85_b	3.23_a	--	2.97
		African American	2.74	2.69	2.82	--	2.54
		Hispanic	2.77	2.74	2.74	--	2.56
		White	3.06_a	2.89_b	3.10_a	--	2.90_b
	2001	Asian American	3.18_a	2.94_b	3.05	2.80_b	2.92_b
		African American	2.90_a	2.58_b	2.78_c	$2.30_{b,d}$	2.58_b
		Hispanic	2.84_a	2.71	2.76	2.70	2.65_b
		White	3.10_a	2.89_b	3.12_a	2.86_b	2.86_b
Fourth-Year GPA	2000	Asian American	3.13_a	2.90_b	3.20_a	2.87	2.88_b
		African American	2.85_a	2.58	2.57	2.59	2.57_b
		Hispanic	2.79	2.68	2.79	2.71	2.71
		White	3.11_a	2.95_b	3.12_a	2.94_b	2.94_b
	2001	Asian American	3.17_a	2.93_b	3.04	2.83_b	2.93_b
		African American	2.83_a	2.56_b	2.72	2.36_b	2.52_b
		Hispanic	2.80	2.71	2.79	2.71	2.70
		White	3.12_a	2.93_b	3.12_a	2.93_b	2.90_b
First-Year Credit Hours	2002†‡	Asian American	28.15	26.32_a	30.06_b	28.04	26.95
		African American	24.87_a	23.16	23.27	22.73	21.55_b
		Hispanic	23.21_a	22.36	22.30	22.09	21.13_b
		White	23.77_a	23.20	23.80	23.85_a	22.87_b
Fourth-Year Credit Hours	2000	Asian American	110.92	110.26	114.12	104.76	107.36
		African American	107.03	99.97	106.96	101.52	98.17
		Hispanic	100.25_a	94.09_b	98.50_c	94.18	$90.82_{b,d}$
		White	104.68_a	101.80	105.15	101.79_b	102.01_b

Note: Significance level for α was $p < .01$. Within the same outcome, year, and row, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*) differed significantly. A number of other significant mean differences by outcome and year are not shown above.
* Dual enrollment data were unavailable before the 2000 cohort year.
† Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.
‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

exceeded their peers in the other course group in first-year credits earned. The 2000 Hispanic and white course and exam cohorts earned significantly more fourth-year credits versus counterparts in the other course group.

Logistic Regression Analyses

Consistent with MANOVA main effects for AP English Language and Composition displayed in Table 2, significant group, ethnicity, and gender main effects were also identified from the logistic regression analyses of baccalaureate (four-year) graduation rates for the 1998–2001 cohorts. No interactions were assumed in the logistic regression analyses, and model fit was determined to be adequate based on the Hosmer and Lemeshow Goodness-of-Fit chi-square test statistic.

Table 5 lists baccalaureate graduation rates for main effects for the 1998–2001 cohorts. Graduation rates for the AP English Language and Composition course and exam group (2000: 44.49 percent) significantly surpassed rates achieved by students in the other groups analyzed (e.g., 2000: AP course only, 30.25 percent; dual enrollment, 36.33 percent; and other course, 26.63 percent), with the exception of the AP Exam only group (2000: 42.39 percent). Asian Americans consistently had the highest graduation rates, followed by whites and African Americans, while Hispanics generally had the lowest rates (e.g., 2000: Asian Americans, 41.20 percent; whites, 38.34 percent; African Americans, 26.04 percent; and Hispanics, 22.62 percent). Females also graduated at rates significantly higher than males (e.g., 2000: females, 41.66 percent; and males, 27.84 percent).

Table 5

Four-Year Graduation Rates* for Significant Logistic Regression Main Effects for AP English Language and Composition: Group, Ethnicity, and Gender

High School Graduation Cohort Year	*Group (N-size)*	*Graduation Rate (%) (n-size)*	*Ethnicity (n-size)*	*Graduation Rate (%) (n-size)*	*Gender (n-size)*	*Graduation Rate (%) (n-size)*
1998†	AP Course/Exam *(2,574)*	41.34$_a$ *(1,064)*	Asian American *(877)*	39.57 *(347)*	Female *(5,343)*	40.95$_a$ *(2,188)*
	AP Course Only *(2,013)*	31.45$_b$ *(633)*	African American *(391)*	29.41$_b$ *(115)*	Male *(4,070)*	28.70$_b$ *(1,168)*
	AP Exam Only *(2,257)*	40.67 *(918)*	Hispanic *(1,145)*	23.84$_b$ *(273)*		
	Other Course *(2,569)*	28.84$_b$ *(741)*	White *(7,000)*	37.44$_a$ *(2,621)*		
1999†	AP Course/Exam *(3,676)*	41.35$_a$ *(1,520)*	Asian American *(1,161)*	43.41 *(504)*	Female *(7,045)*	40.84$_a$ *(2,877)*
	AP Course Only *(2,874)*	29.23$_b$ *(840)*	African American *(586)*	25.09$_b$ *(147)*	Male *(5,483)*	26.57$_b$ *(1,457)*
	AP Exam Only *(2,394)*	41.98 *(1,005)*	Hispanic *(1,662)*	23.71$_b$ *(394)*		
	Other Course *(3,584)*	27.04$_b$ *(969)*	White *(9,119)*	36.07$_a$ *(3,289)*		
2000	AP Course/Exam *(5,190)*	44.49$_a$ *(2,309)*	Asian American *(1,505)*	41.20 *(620)*	Female *(9,971)*	41.66$_a$ *(4,154)*
	AP Course Only *(3,716)*	30.25$_b$ *(1,124)*	African American *(845)*	26.04$_b$ *(220)*	Male *(7,711)*	27.84$_b$ *(2,147)*
	AP Exam Only *(2,163)*	42.39 *(917)*	Hispanic *(2,653)*	22.62$_b$ *(600)*		
	Dual Enrollment *(1,960)*	36.33$_b$ *(712)*	White *(12,679)*	38.34$_a$ *(4,861)*		
	Other Course *(4,653)*	26.63$_b$ *(1,239)*				
2001	AP Course/Exam *(6,698)*	40.68$_a$ *(2,725)*	Asian American *(1,792)*	39.45 *(707)*	Female *(11,723)*	38.81$_a$ *(4,550)*
	AP Course Only *(4,420)*	30.32$_b$ *(1,340)*	African American *(1,198)*	23.21$_b$ *(278)*	Male *(9,248)*	26.48$_b$ *(2,449)*
	AP Exam Only *(1,604)*	42.06 *(689)*	Hispanic *(3,551)*	21.40$_b$ *(760)*		
	Dual Enrollment *(2,399)*	34.26$_b$ *(822)*	White *(14,430)*	36.41$_a$ *(5,254)*		
	Other Course *(5,850)*	24.32$_b$ *(1,423)*				

Note: Significance level for α was $p < .01$. Within the same year and column, rates with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Dual enrollment data were unavailable before the 2000 cohort year.

AP English Literature and Composition

MANOVAs

For AP English Literature and Composition, multivariate means differed significantly with all three main effects—group, ethnicity, and gender—across all 1998–2002 cohorts (see Table 2). No interactions were significant for the 1998 cohort, while group by ethnicity was significant for 1999–2001 cohorts and gender by ethnicity was significant only for the 2000 and 2002 cohorts. Typical among cohorts, MANOVA statistics for significant main effects and interactions for the 2000 cohort included: (a) *group*—Wilks' $\Lambda = .9884$, $F(16, 50058) = 12.02$, $p < .0001$; (b) *ethnicity*—Wilks' $\Lambda = .9624$, $F(12, 43351) = 52.78$, $p < .0001$; and (c) *gender*—Wilks' $\Lambda = .9930$, $F(4, 16385) = 29.04$, $p < .0001$; (d) *group by ethnicity*—Wilks' $\Lambda = .9936$, $F(48, 63119)$, $= 2.19$, $p < .0001$; and (e) *ethnicity by gender*—Wilks' $\Lambda = .9978$, $F(12, 43351) = 3.07$, $p < .0002$.

ANOVA Main Effects and Post Hoc Comparisons

Group and ethnicity ANOVA main effects were significant for all GPA and credit hours outcomes for all AP English Literature and Composition cohorts (see Table 2). The same held true for the gender effect across all years of available GPA and credits outcomes, except that gender was significant only for first-year credit hours earned in the 1998 cohort and nonsignificant in 2000 and 2002 for fourth-year credit hours. For each significant main effect, Table 6 includes least-square means for each of the outcomes by cohort year.

Group main effects. In general and similar to AP English Language and Composition results, both the AP English Literature and Composition course and exam group and the exam only group almost always cumulated significantly higher mean first-year GPAs (1998–2002), fourth-year GPAs (1998–2001), first-year credits (1999 and 2001), and fourth-year credits (1999–2001) than all other groups (see Table 6). Both groups earned significantly more first-year credits (1998–2002) and fourth-year credits (1998–2001) than the other course group. The AP course only group also significantly exceeded the other course group in 1998–2001 first-year credits and in 1998 and 2001 fourth-year credits earned.

Ethnicity main effects. Similar to AP English Language and Composition, post hoc ethnic group comparisons for AP English Literature and Composition cohorts showed that Asian Americans and whites achieved higher mean first-year GPAs (1998–2002) and fourth-year GPAs (1998–2001) than Hispanics and African Americans (see Table 6). While Asian Americans still cumulated a significantly greater number of first-year credit hours (1998–2002) and fourth-year credit hours (1998–2001) than the other ethnic groups, African American and white differences were not significant, except for first-year credit hours in the 2000 cohort. Hispanics also earned significantly fewer first-year (1998–2002) and fourth-year (1998–2001) credit hours than whites and significantly fewer fourth-year credits than 1999 and 2001 African American cohorts.

Gender main effects. For post hoc comparisons by gender, mean GPA and fourth-year credit hour differences favored females over males in the AP English Literature and Composition ANOVAs (see Table 6). Except for the 1998 cohort, differences between males and females were nonsignificant for first-year credit hours earned. Male and female differences were also nonsignficant for fourth-year credit hours earned in 2000.

ANOVA Interactions and Post Hoc Comparisons

The group by ethnicity interaction was significant most consistently for fourth-year GPA (2000–01), first-year credits (1999–2000), and fourth-year credits (1999 and 2001) outcomes (see Table 2). Group by ethnicity was significant for first-year GPA only in 2001. The gender-by-ethnicity interaction was significant only for first-year GPA in 2002 and for first-year credit hours in 2000 and, thus, is not presented.

Group by ethnicity interaction. Table 7 provides by outcome and year least-square means for the group by ethnicity interaction and indicates significant Tukey-Kramer post hoc comparisons among groups within ethnicity. Students in the AP English Literature and Composition course and exam group usually outperformed their ethnic group counterparts in the AP course only, dual enrollment, and other course groups. For the 2001 cohort, comparisons between the AP English Literature and Composition course and exam and the other course group were statistically significant across all ethnic groups on first- and fourth-year GPAs and fourth-year credits for all ethnic groups, except for Asian Americans, on fourth-year credits. In addition, Hispanics and whites in the 2001 AP English Literature and Composition course and exam group earned a significantly greater number of fourth-year credits than their counterparts in the AP course only group.

Logistic Regression Analyses

Consistent with the MANOVA, the main effects of group, ethnicity, and gender were significant in the logistic regression analyses of baccalaureate (four-year) graduation rates for all 1998–2001 AP English Literature and Composition cohorts (see Table 2). Sufficient model fit was achieved in a logistic regression analysis that assumed no interactions.

Table 8 provides four-year graduation rates in the AP English Literature and Composition analyses for each of the group, ethnicity, and gender main effects by cohort year. Similar to rates achieved by AP English Language and Composition course and exam group students, 1998–2001 students who had taken both the AP English Literature and Composition course and exam graduated at higher rates (exceeding 41 percent) than students in the AP English Literature and Composition course only (no higher than

Table 6

Least-Square Means by Outcome for Significant ANOVA Main Effects for AP English Literature and Composition: Group, Ethnicity, and Gender

Main Effect & High School Graduation Cohort Year	*Main Effect Groups*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
Group/1998†	AP Course/Exam	2.94$_{a}$	2.92$_{a}$	28.20$_{a}$	104.27$_{a}$
	AP Course Only	2.78$_{b}$	2.79b	27.72$_{a}$	104.53$_{a}$
	AP Exam Only	3.03$_{a}$	2.99$_{a}$	28.81$_{a}$	107.14$_{a}$
	Other Course	2.77$_{b}$	2.79$_{b}$	26.54$_{b}$	100.06$_{b}$
Group/1999†	AP Course/Exam	3.01$_{a}$	2.97$_{a}$	28.28$_{a}$	105.41$_{a}$
	AP Course Only	2.80$_{b}$	2.80$_{b}$	27.24$_{b,c}$	101.84$_{b}$
	AP Exam Only	3.11$_{a}$	3.05$_{a}$	29.48$_{a}$	108.76$_{a}$
	Other Course	2.74$_{b}$	2.77$_{b}$	26.02$_{b,d}$	98.84$_{b}$
Group/2000	AP Course/Exam	2.98$_{a}$	2.96$_{a}$	28.06$_{a}$	104.79$_{a}$
	AP Course Only	2.81$_{b}$	2.81$_{b}$	26.88$_{b,c}$	101.77$_{b}$
	AP Exam Only	2.99$_{a}$	2.95$_{a}$	28.85$_{a,e}$	107.27$_{a}$
	Dual Enrollment	2.74$_{b}$	2.78$_{b}$	27.02$_{f}$	100.35$_{b}$
	Other Course	2.76$_{b}$	2.76$_{b}$	25.87$_{b,d}$	99.66$_{b}$
Group/2001	AP Course/Exam	3.02$_{a}$	2.99$_{a}$	28.51$_{a}$	105.93$_{a}$
	AP Course Only	2.82$_{b}$	2.83$_{b}$	27.10$_{b,c}$	101.83$_{b,c}$
	AP Exam Only	3.08$_{a}$	2.99$_{a}$	29.62$_{a}$	107.82$_{a}$
	Dual Enrollment	2.76$_{b}$	2.78$_{b}$	26.67$_{b}$	100.53$_{b}$
	Other Course	2.77$_{b}$	2.77$_{b}$	25.93$_{b,d}$	98.20$_{b,d}$
Group/2002‡	AP Course/Exam	2.93$_{a}$	--	25.14$_{a}$	--
	AP Course Only	2.72$_{b}$	--	24.02$_{b}$	--
	AP Exam Only	2.91$_{a}$	--	24.89$_{c}$	--
	Dual Enrollment	2.69$_{b}$	--	24.87$_{c}$	--
	Other Course	2.67$_{b}$	--	23.27$_{b,d}$	--
Ethnicity/1998	Asian American	3.10$_{a}$	3.05$_{a}$	30.36$_{a}$	110.05$_{a}$
	African American	2.71$_{b,c}$	2.67$_{b}$	26.88$_{b}$	102.35$_{b}$
	Hispanic	2.71$_{b,c}$	2.73$_{b}$	26.07$_{b,c}$	97.68$_{b,c}$
	White	3.00$_{b,d}$	3.05$_{a}$	27.96$_{b,d}$	105.91$_{b,d}$
Ethnicity/1999	Asian American	3.12$_{a}$	3.09$_{a}$	30.85$_{a}$	110.30$_{a}$
	African American	2.76$_{b,c}$	2.68$_{b}$	26.85$_{b}$	103.79$_{b,c}$
	Hispanic	2.75$_{b,c}$	2.76$_{b}$	25.54$_{b,c}$	97.09$_{b,d}$
	White	3.02$_{b,d}$	3.05$_{a}$	27.78$_{b,d}$	103.67$_{b,c}$
Ethnicity/2000	Asian American	3.06$_{a}$	3.04$_{a}$	30.36$_{a}$	110.07$_{a}$
	African American	2.63$_{b}$	2.59$_{b,c}$	26.20$_{b,c}$	101.03$_{b}$
	Hispanic	2.72$_{b}$	2.75$_{b,d}$	25.27$_{b,c}$	96.68$_{b,c}$
	White	3.01$_{a}$	3.03$_{a}$	27.52$_{b,d}$	103.30$_{b,d}$
Ethnicity/2001	Asian American	3.05$_{a}$	3.04$_{a}$	30.23$_{a}$	108.75$_{a}$
	African American	2.71$_{b}$	2.64$_{b,c}$	26.82$_{b}$	103.32$_{b,c}$
	Hispanic	2.79$_{b}$	2.77$_{b,d}$	25.53$_{b,c}$	95.90$_{b,d}$
	White	3.01$_{a}$	3.04$_{a}$	27.68$_{b,d}$	103.48$_{b,c}$
Ethnicity/2002‡	Asian American	3.08$_{a}$	--	28.12$_{a}$	--
	African American	2.50$_{b,c}$	--	23.41$_{b}$	--
	Hispanic	2.60$_{b,c}$	--	22.54$_{b,c}$	--
	White	2.95$_{b,d}$	--	23.68$_{b,d}$	--
Gender/1998	Females	2.95$_{a}$	2.97$_{a}$	28.18$_{a}$	105.95$_{a}$
	Males	2.81$_{b}$	2.78$_{b}$	27.46$_{b}$	102.05$_{b}$
Gender/1999	Females	2.99$_{a}$	3.01$_{a}$	28.11§	105.06$_{a}$
	Males	2.84$_{b}$	2.79$_{b}$	27.40§	102.37$_{b}$
Gender/2000	Females	2.92$_{a}$	2.96$_{a}$	27.44§	103.34§
	Males	2.78$_{b}$	2.75$_{b}$	27.23§	102.20§
Gender/2001	Females	2.95$_{a}$	2.96$_{a}$	27.75§	103.93$_{a}$
	Males	2.83$_{b}$	2.78$_{b}$	27.38§	101.80$_{b}$
Gender/2002‡	Females	2.89$_{a}$	--	24.44§	--
	Males	2.68$_{b}$	--	24.44§	--

Note: Significance level for α was $p < .01$. Within the same main effect/cohort year and same outcome (column), means with specific non-matching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Dual enrollment data were unavailable before the 2000 cohort year.

‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

§ Nonsignificant effect for outcome within cohort year.

Table 7

Least-Square Means by Outcome for Significant ANOVA Interactions for AP English Literature and Composition: Group by Ethnicity

College Outcome	*High School Graduation Cohort Year*	*Ethnicity*	*Group*				
			AP Course and Exam	*AP Course Only*	*AP Exam Only*	*Dual Enrollment*	*Other Course*
First-Year GPA	2001	Asian American	3.17$_{a}$	2.91$_{b,c}$	3.28$_{d}$	2.90$_{c}$	2.97$_{b,c}$
		African American	2.91$_{a}$	2.67	2.93	2.43$_{b}$	2.59$_{b}$
		Hispanic	2.85$_{a}$	2.75	2.88	2.81	2.65$_{b}$
		White	3.14$_{a}$	2.95$_{b,c}$	3.21$_{a}$	2.90$_{b}$	2.86$_{b,d}$
Fourth-Year GPA	2000	Asian American	3.18$_{a}$	2.90$_{b}$	3.22$_{a}$	2.93	2.95$_{b}$
		African American	2.70	2.57	2.62	2.58	2.49
		Hispanic	2.80$_{a}$	2.78	2.81	2.69	2.65$_{b}$
		White	3.16$_{a}$	3.00$_{b}$	3.14$_{a}$	2.94$_{b}$	2.93$_{b}$
	2001	Asian American	3.15$_{a}$	2.95$_{b}$	3.21$_{a}$	2.94	2.95$_{b}$
		African American	2.86$_{a}$	2.61$_{b}$	2.73	2.44$_{b}$	2.55$_{b}$
		Hispanic	2.82$_{a}$	2.75	2.83	2.79	2.67$_{b}$
		White	3.14$_{a}$	3.00$_{b,c}$	3.19$_{a}$	2.95$_{b}$	2.91$_{b,d}$
First-Year Credit Hours	1999*	Asian American	31.09	30.46	31.53	--	30.34
		African American	26.73$_{a}$	26.45	30.56$_{a}$	--	23.66$_{b}$
		Hispanic	26.72$_{a}$	24.75$_{b}$	27.34$_{c}$	--	23.34$_{b,d}$
		White	28.58$_{a}$	27.30$_{b}$	28.49$_{c}$	--	26.75$_{b,d}$
	2000	Asian American	31.20	29.62	31.18	30.34	29.46
		African American	26.98	25.51	27.59	26.23	24.69
		Hispanic	25.82$_{a}$	25.30$_{a}$	27.95$_{a}$	24.61	22.68$_{b}$
		White	28.24$_{a}$	27.09$_{b}$	28.69$_{a}$	26.92$_{b}$	26.65$_{b}$
Fourth-Year Credit Hours	1999*	Asian American	111.30	109.27	109.63	--	110.98
		African American	104.28	100.38	115.91$_{a}$	--	94.60$_{b}$
		Hispanic	100.43$_{a}$	95.17	103.74$_{a}$	--	89.02$_{b}$
		White	105.65$_{a}$	102.55$_{b}$	105.76$_{c}$	--	100.75$_{b,d}$
	2001	Asian American	110.76	108.47	111.11	106.51	106.91
		African American	106.50$_{a}$	100.75	113.69	98.14	97.50$_{b}$
		Hispanic	100.56$_{a}$	95.16$_{b,c}$	101.11$_{c}$	94.98$_{c}$	87.69$_{b,d}$
		White	105.89$_{a}$	102.93$_{b}$	105.38$_{c}$	102.52$_{b}$	100.70$_{b,d}$

Note: Significance level for α was $p < .01$. Within the same outcome, year, and row, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*) differed significantly. A number of other significant mean differences by outcome and year are not shown above.

* Dual enrollment data were unavailable before the 2000 cohort year.

32 percent), dual enrollment (no higher than 38 percent), and other course (no higher than 27 percent) groups. Also similar was the ordering of graduation rates by ethnic group (e.g., 2000: Asian American, 42.54 percent; white, 38.37 percent; African American, 23.83 percent; and Hispanic, 21.62 percent). Female graduation rates were significantly higher than male graduation rates across cohort years.

AP Calculus AB

MANOVAs

For AP Calculus AB, significant differences in multivariate means were obtained for all main effects—group, ethnicity, and gender—across all 1998–2002 cohorts (see Table 2). Due to small cell sizes, the AP Exam only group was excluded from analyses. The group by ethnicity interaction was significant in 1999–2002, gender by ethnicity was significant in 2002, and group by ethnicity by gender was significant in 2001. For an example of MANOVA statistics for significant main effects and interactions, those for the 1999 cohort included: (a) *group*—Wilks' $\Lambda = .9830$, $F(8, 15254) = 16.46$, $p < .0001$; (b) *ethnicity*—Wilks' $\Lambda = .9363$, $F(12, 20179) = 42.33$, $p < .0001$; (c) *gender*—Wilks' $\Lambda = .9853$, $F(4, 7627) = 28.40$, $p < .0001$; and (d) *group by ethnicity*—Wilks' $\Lambda = .9912$, $F(24, 26609), = 2.83$, $p < .0001$.

ANOVA Main Effects and Post Hoc Comparisons

ANOVA results indicated significant group, ethnicity, and gender main effects for all GPA and credit hours outcomes with all years of cohort data for AP Calculus AB (see Table 2).

Group main effects. Similar to results for both AP English Language and Composition and AP English Literature and Composition, Table 9 notes significant Tukey-Kramer post hoc mean differences in first- and fourth-year GPAs usually favoring the AP Calculus AB course and exam group (e.g., 2000 cohort: mean first-year GPA, 3.02) versus the AP Calculus AB course only (2.92), dual enrollment (2.61), and other course (2.79) groups. For both credit hours outcomes, means were significantly higher for the AP Calculus course and exam group than for dual enrollment and other course students.

Ethnicity main effects. Similar also to AP English Language and Composition and AP English Literature and Composition, post hoc ethnic group comparisons for AP Calculus AB showed significantly higher mean first- and fourth-year GPAs for Asian Americans and whites than for African Americans and Hispanics (see Table 9).

Table 8

Four-Year Graduation Rates* for Significant Logistic Regression Main Effects for AP English Literature and Composition: Group, Ethnicity, and Gender

High School Graduation Cohort Year	*Group (N-size)*	*Graduation Rate (%) (n-size)*	*Ethnicity (n-size)*	*Graduation Rate (%) (n-size)*	*Gender (n-size)*	*Graduation Rate (%) (n-size)*
1998†	AP Course/Exam *(3,087)*	41.76_a *(1,289)*	Asian American *(933)*	36.98 *(345)*	Female *(5,760)*	40.17_a *(2,314)*
	AP Course Only *(2,683)*	31.08_b *(834)*	African American *(448)*	27.90_b *(125)*	Male *(4,506)*	27.41_b *(1,235)*
	AP Exam Only *(1,483)*	43.49 *(645)*	Hispanic *(1,461)*	23.89_b *(349)*		
	Other Course *(3,013)*	25.92_b *(781)*	White *(7,424)*	36.77_a *(2,730)*		
1999†	AP Course/Exam *(3,968)*	41.58_a *(1,650)*	Asian American *(1,089)*	45.18 *(492)*	Female *(6,665)*	39.97_a *(2,664)*
	AP Course Only *(3,481)*	29.24_b *(1,018)*	African American *(579)*	24.70_b *(143)*	Male *(5,600)*	26.20_b *(1,467)*
	AP Exam Only *(1,019)*	44.65 *(455)*	Hispanic *(1,890)*	21.43_b *(405)*		
	Other Course *(3,797)*	26.55_b *(1,008)*	White *(8,707)*	35.50_a *(3,091)*		
2000	AP Course/Exam *(5,013)*	43.21_a *(2,166)*	Asian American *(1,408)*	42.54 *(599)*	Female *(9,233)*	41.29_a *(3,812)*
	AP Course Only *(3.912)*	31.65_b *(1,238)*	African American *(894)*	23.83_b *(213)*	Male *(7,195)*	27.55_b *(1,982)*
	AP Exam Only *(929)*	47.79 *(444)*	Hispanic *(2,613)*	21.62_b *(565)*		
	Dual Enrollment *(1,984)*	38.31_b *(760)*	White *(11,513)*	38.37_a *(4,417)*		
	Other Course *(4,590)*	25.84_b *(1,186)*				
2001	AP Course/Exam *(5,698)*	42.01_a *(2,394)*	Asian American *(1,604)*	40.84 *(655)*	Female *(10,275)*	39.79_a *(4,088)*
	AP Course Only *(4,143)*	30.75_b *(1,274)*	African American *(1,067)*	24.55_b *(262)*	Male *(8,175)*	27.83_b *(2,275)*
	AP Exam Only *(967)*	46.33 *(448)*	Hispanic *(3,118)*	21.71_b *(677)*		
	Dual Enrollment *(2,548)*	36.38_b *(927)*	White *(12,661)*	37.67_a *(4,769)*		
	Other Course *(5,094)*	25.91_b (1,320)				

Note: Significance level for α was $p < .01$. Within the same year and column, rates with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Dual enrollment data were unavailable before the 2000 cohort year.

Comparisons among both mean credit hours outcomes continued to show significantly higher means for Asian Americans generally than for the other ethnic groups and frequently showed Hispanics cumulating the fewest credit hours among groups.

Gender main effects. Similar again to the other AP subject-specific results, post hoc comparisons relevant to AP Calculus AB confirmed significantly higher mean GPAs and credit hours earned for females versus males (see Table 9).

ANOVA Interactions and Post Hoc Comparisons

Significant ANOVA interactions for AP Calculus AB included group by ethnicity for first-year GPA (2000–02), fourth-year GPA (1999–2001), first-year credit hours (1999–2002), and fourth-year credit hours (2000–01) (see Table 2). Thus, compared to analyses for all other subjects in the table, the group by ethnicity ANOVA interaction was significant most often for AP Calculus AB outcomes. The gender by ethnicity interaction was significant only for first-year GPA in 2002, and the three-way interaction was significant only for first-year credits in 2001; thus, neither is presented.

For the group by ethnicity interaction relevant to AP Calculus AB, Table 10 lists least-square means by outcome and cohort year, and significant Tukey-Kramer post hoc comparisons among groups within each ethnic group. Whites who were in the AP Calculus AB course and exam group posted significantly higher GPAs (first-year: 2000–2002 cohorts; fourth-year: 1999–2001) than whites in the AP Calculus AB course only, dual enrollment (as available), and other course groups. In addition, Hispanics and African Americans in the 2000–02 cohorts who were in the AP Calculus AB course and exam group averaged

Table 9

Least-Square Means by Outcome for Significant ANOVA Main Effects for AP Calculus AB: Group, Ethnicity, and Gender

Main Effect & High School Graduation Cohort Year	*Main Effect Groups*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
Group/1998†	AP Course/Exam	2.96_{a}	2.96_{a}	28.90_{a}	105.94_{a}
	AP Course Only	2.86	2.88	27.75	105.28_{a}
	Other Course	2.81_{b}	2.83_{b}	26.88_{b}	100.70_{b}
Group/1999†	AP Course/Exam	3.03_{a}	2.97_{a}	29.49_{a}	108.70_{a}
	AP Course Only	$2.91_{b,c}$	2.91_{a}	$28.43_{b,c}$	$105.40_{b,c}$
	Other Course	$2.78_{b,d}$	2.80_{b}	$26.40_{b,d}$	$98.35_{b,d}$
Group/2000	AP Course/Exam	3.02_{a}	2.98_{a}	29.10_{a}	108.11_{a}
	AP Course Only	$2.92_{b,c}$	$2.89_{b,c}$	$27.79_{b,c}$	$104.65_{b,c}$
	Dual Enrollment	$2.61_{b,d,e}$	$2.63_{b,d,e}$	$25.82_{b,d}$	$98.45_{b,d}$
	Other Course	$2.79_{b,d,f}$	$2.80_{b,d,f}$	$25.85_{b,d}$	$98.10_{b,d}$
Group/2001	AP Course/Exam	3.04_{a}	3.00_{a}	28.89_{a}	106.69_{a}
	AP Course Only	$2.88_{b,c}$	$2.88_{b,c}$	28.20_{a}	104.56_{a}
	Dual Enrollment	$2.65_{b,d}$	$2.69_{b,d}$	26.03_{b}	99.55_{b}
	Other Course	$2.83_{b,c}$	$2.85_{b,c}$	27.06_{b}	100.54_{b}
Group/2002‡	AP Course/Exam	2.99_{a}	--	25.70_{a}	--
	AP Course Only	$2.81_{b,c}$	--	25.09_{c}	--
	Dual Enrollment	$2.59_{b,d}$	--	24.12_{b}	--
	Other Course	$2.74_{b,c}$	--	$24.02_{b,d}$	--
Ethnicity/1998	Asian American	3.06_{a}	3.03_{a}	30.16_{a}	108.98_{a}
	African American	2.68_{b}	$2.68_{b,c}$	$26.59_{b,c}$	102.17_{b}
	Hispanic	2.71_{b}	$2.74_{b,c}$	$26.13_{b,c}$	$97.13_{b,c}$
	White	3.08_{a}	$3.11_{b,d}$	$28.50_{b,d}$	107.62_{d}
Ethnicity/1999	Asian American	3.11_{a}	3.05_{a}	30.57_{a}	110.21_{a}
	African American	2.67_{b}	$2.64_{b,c}$	27.19_{b}	$103.44_{b,c}$
	Hispanic	2.77_{b}	$2.78_{b,d}$	$26.44_{b,c}$	$98.44_{b,d}$
	White	3.08_{a}	3.10_{a}	$28.23_{b,d}$	$104.52_{b,c}$
Ethnicity/2000	Asian American	3.00_{a}	2.97_{a}	29.78_{a}	109.37_{a}
	African American	2.62_{b}	$2.56_{b,c}$	$26.11_{b,c}$	100.13_{b}
	Hispanic	2.69_{b}	$2.72_{b,d}$	$25.04_{b,c}$	$96.38_{b,c}$
	White	3.03_{a}	3.05_{a}	$27.64_{b,d}$	$103.43_{b,d}$
Ethnicity/2001	Asian American	3.00_{a}	3.00_{a}	29.68_{a}	108.66_{a}
	African American	2.66_{b}	$2.64_{b,c}$	$27.10_{b,c}$	$102.88_{b,c}$
	Hispanic	2.72_{b}	$2.75_{b,d}$	$25.64_{b,d}$	$96.30_{b,d}$
	White	3.02_{a}	3.04_{a}	$27.76_{b,c}$	$103.50_{b,c}$
Ethnicity/2002‡	Asian American	3.02_{a}	--	28.16_{a}	--
	African American	2.55_{b}	--	23.96_{b}	--
	Hispanic	2.59_{b}	--	23.10_{b}	--
	White	2.97_{a}	--	23.72_{b}	--
Gender/1998	Females	3.03_{a}	3.05_{a}	28.37_{a}	106.70_{a}
	Males	2.73_{b}	2.73_{b}	27.32_{b}	101.25_{b}
Gender/1999	Females	3.01_{a}	3.01_{a}	28.61_{a}	106.11_{a}
	Males	2.81_{b}	2.77_{b}	27.60_{b}	102.20_{b}
Gender/2000	Females	2.96_{a}	2.96_{a}	27.67_{a}	104.71_{a}
	Males	2.71_{b}	2.69_{b}	26.61_{b}	99.95_{b}
Gender/2001	Females	2.96_{a}	2.98_{a}	28.06_{a}	104.98_{a}
	Males	2.73_{b}	2.73_{b}	27.03_{b}	100.69_{b}
Gender/2002‡	Females	2.93_{a}	--	25.13_{a}	--
	Males	2.64_{b}	--	24.34_{b}	--

Note: Significance level for α was $p < .01$. Within the same main effect/cohort year and same outcome (column), means with specific non-matching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly. AP Exam only groups were excluded from the MANOVAs and univariate ANOVAs in all cohort years (1998–2002) due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Dual enrollment data were unavailable before the 2000 cohort year.

‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

Table 10

Least-Square Means by Outcome for Significant ANOVA Interactions for AP Calculus AB: Group by Ethnicity

College Outcome	High School Graduation Cohort Year	Ethnicity	Group*			
			AP Course and Exam	AP Course Only	Dual Enrollment†	Other Course
First-Year GPA	2000	Asian American	3.16_{a}	3.00	2.74_{b}	3.08
		African American	2.81_{a}	2.84_{a}	2.41	2.43_{b}
		Hispanic	2.88_{a}	2.77_{b}	2.47_{b}	2.65_{b}
		White	3.23_{a}	$3.10_{b,c}$	$2.81_{b,d,e}$	$2.98_{b,d,f}$
	2001	Asian American	3.16_{a}	2.95_{b}	$2.76_{b,c}$	3.12_{d}
		African American	2.92_{a}	2.78_{c}	$2.38_{b,d}$	2.58_{b}
		Hispanic	2.89_{a}	2.72_{b}	2.57_{b}	2.68_{b}
		White	3.18_{a}	$3.06_{b,c}$	$2.87_{b,d}$	$2.96_{b,d}$
	2002‡	Asian American	3.22_{a}	2.97_{b}	2.81_{b}	3.09
		African American	2.77_{a}	2.56	2.40_{b}	2.46_{b}
		Hispanic	2.80_{a}	2.71_{c}	$2.34_{b,d}$	2.53_{b}
		White	3.16_{a}	$3.01_{b,c}$	$2.82_{b,d}$	$2.89_{b,d}$
Fourth-Year GPA	1999	Asian American	3.15	3.00	--	3.00
		African American	2.64	2.78	--	2.50
		Hispanic	2.87	2.76	--	2.71
		White	3.22_{a}	$3.10_{b,c}$	--	$2.98_{b,d}$
	2000	Asian American	3.13_{a}	2.94_{b}	2.76_{b}	3.07
		African American	2.73_{a}	2.73_{a}	2.36	2.42_{b}
		Hispanic	2.83	2.77	2.55	2.70
		White	3.22_{a}	$3.11_{b,c}$	$2.86_{b,d,e}$	$3.02_{b,d,f}$
	2001	Asian American	3.12_{a}	2.96_{b}	$2.78_{b,c}$	3.13_{d}
		African American	2.81_{a}	2.73_{a}	2.44_{b}	2.58
		Hispanic	2.87_{a}	2.76	2.66	2.69_{b}
		White	3.18_{a}	$3.09_{b,c}$	$2.90_{b,d}$	$2.99_{b,d}$
First-Year Credit Hours	1999	Asian American	31.36	30.98	--	29.38
		African American	28.38	27.30	--	25.88
		Hispanic	28.83_{a}	27.09_{a}	--	23.40_{b}
		White	29.38_{a}	$28.36_{b,c}$	--	$26.96_{b,d}$
	2000	Asian American	31.67	29.77	27.95	29.74
		African American	27.72_{a}	27.19_{a}	25.87	23.65_{b}
		Hispanic	27.87_{a}	$25.99_{b,c}$	22.89_{b}	$23.40_{b,d}$
		White	29.16_{a}	$28.23_{b,c}$	26.58_{b}	$26.59_{b,d}$
	2001	Asian American	30.96_{a}	30.78_{a}	26.56_{b}	30.40_{a}
		African American	27.52	27.87	26.45	26.55
		Hispanic	27.77_{a}	25.71_{b}	24.48_{b}	24.60_{b}
		White	29.30_{a}	$28.43_{b,c}$	$26.62_{b,d}$	$26.68_{b,d}$
	2002‡	Asian American	28.73	27.80	27.88	28.22
		African American	25.12	24.33	22.99	23.38
		Hispanic	24.71_{a}	24.85_{a}	21.56_{b}	21.27_{b}
		White	24.23_{a}	23.39	24.04	23.22_{b}
Fourth-Year Credit Hours	2000	Asian American	113.68	107.88	107.30	108.63
		African American	107.50	105.98	95.18	91.86
		Hispanic	104.22_{a}	99.31_{c}	90.80_{b}	$91.20_{b,d}$
		White	107.04_{a}	105.42_{c}	100.53_{b}	$100.72_{b,d}$
	2001	Asian American	110.71	111.21	102.77	109.96
		African American	105.72	103.53	102.33	99.95
		Hispanic	103.36_{a}	$97.63_{b,c}$	92.32_{b}	$91.88_{b,d}$
		White	106.99_{a}	105.87_{a}	100.76_{b}	100.37_{b}

Note: Significance level for α was $p < .01$. Within the same outcome, year, and row, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly. A number of other significant mean differences for post hoc comparisons by outcome and year are not shown above.

* AP Exam only groups were excluded from the MANOVAs and univariate ANOVAs in all cohorts year (1998–2002) due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design.

† Dual enrollment data were unavailable before the 2000 cohort year.

‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

significantly higher first- year GPAs than counterparts in the other course group. Otherwise, Hispanics and whites in the AP Calculus AB course and exam group earned a greater mean number of 2000–01 first-year and fourth-year credit hours than Hispanics and whites in the dual enrollment and other course groups.

Logistic Regression Analyses

Consistent with the MANOVA, all main effects were significant in the logistic regression analyses of four-year graduation rates for 1998–2001 AP Calculus AB cohorts (see Table 2). All analyses assumed no interaction, and all resulted in adequate model fit.

Graduation rates of at least 39 percent for AP Calculus AB course and exam students were significantly higher

Table 11

Four-Year Graduation Rates* for Significant Logistic Regression Main Effects for AP Calculus AB: Group, Ethnicity, and Gender

High School Graduation Cohort Year	*Group† (N-size)*	*Graduation Rate (%) (n-size)*	*Ethnicity (n-size)*	*Graduation Rate (%) (n-size)*	*Gender (n-size)*	*Graduation Rate (%) (n-size)*
1998‡	AP Course/Exam (1,671)	39.02_a (652)	Asian American (724)	34.25 (248)	Female (2,390)	41.63_a (995)
	AP Course Only (1,642)	32.89_b (540)	African American (202)	27.23_b (55)	Male (2,594)	28.57_b (741)
	Other Course (1,671)	32.56_b (544)	Hispanic (705)	25.25_b (178)		
			White (3,353)	37.43_a (1,255)		
1999‡	AP Course/Exam (2,563)	40.34_a (1,034)	Asian American (868)	40.55 (352)	Female (3,669)	42.79_a (1,570)
	AP Course Only (2,528)	33.15_b (838)	African American (356)	24.72_b (88)	Male (3,985)	28.03_b (1,117)
	Other Course (2,563)	31.80_b (815)	Hispanic (1,102)	22.14_b (244)		
			White (5,328)	37.59_a (2.003)		
2000	AP Course/Exam (3,263)	40.85_a (1,333)	Asian American (1,234)	40.36 (498)	Female (5,081)	43.53_a (2,212)
	AP Course Only (3,070)	34.82_b (1,069)	African American (509)	24.75_b (126)	Male (5,068)	28.45_b (1,442)
	Dual Enrollment (555)	27.39_b (152)	Hispanic (1,582)	21.43_b (339)		
	Other Course (3,261)	33.73_b (1,100)	White (6,824)	39.43_a (2,691)		
2001	AP Course/Exam (3,884)	41.92_a (1,628)	Asian American (1,436)	40.60 (583)	Female (6,200)	42.87_a (2,658)
	AP Course Only (3,494)	35.72_b (1,248)	African American (699)	25.46_b (178)	Male (6,174)	29.40_b (1,815)
	Dual Enrollment (1,122)	31.37_b (352)	Hispanic (1,945)	23.86_b (464)		
	Other Course (3,874)	32.14_b (1,245)	White (8,294)	39.16_a (3,248)		

Note: Significance level for α was $p < .01$. Within the same year and column, rates with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† AP Exam only groups were excluded from the logistic regression analyses in all cohorts (1998–2001), as they were in the MANOVAs and ANOVAs, due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design.

‡ Dual enrollment data were unavailable before the 2000 cohort year.

than rates for the other groups across 1998–2001 cohorts and were comparable to their AP English Language and Composition and AP English Literature and Composition counterparts (see Table 11). Similarly, the relative ordering of graduation rates by ethnic group persisted (e.g., Asian Americans > whites > African Americans > Hispanics), as did the higher female-to-male rates with analyses for the other AP subjects.

AP Biology

MANOVAs

Group and ethnicity MANOVA main effects for 1998–2002 AP Biology cohorts were found to be significant, and the gender main effect was significant for 1999–2000 cohorts (see Table 2). Because of insufficient cell sizes, AP Exam only and dual enrollment groups were excluded from all analyses; gender was excluded in 1998 only. Significant MANOVA statistics for the 2001 cohort were very similar to those for the other cohorts: (a) *group*—Wilks' $\Lambda = .9904$, $F(8, 10752) = 6.53$, $p < .0001$; (b) *ethnicity*—Wilks' $\Lambda = .9369$, $F(12, 14224) = 29.57$, $p < .0001$; and (c) *gender*—Wilks' $\Lambda = .9906$, $F(4, 5376) = 12.69$, $p < .0001$.

ANOVA Main Effects and Post Hoc Comparisons

Group and ethnicity ANOVA main effects for AP Biology were significant for all GPA and credit hours earned outcomes across all cohorts, except for group with fourth-year GPA (1998 and 2000) and fourth-year credits (2000) (see Table 2). Gender was significant for all GPA outcomes across all available years of cohort data but was significant only for first- and fourth-year credits in the 2000 cohort. However, gender was excluded from the 1998 cohort due to cell sizes too small to support the three-way MANOVA. None of the MANOVA interactions was significant for any

Table 12

Least-Square Means by Outcome for Significant ANOVA Main Effects for AP Biology: Group, Ethnicity, and Gender

Main Effect & High School Graduation Cohort Year	*Main Effect Groups*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
Group/1998†	AP Course/Exam	2.96_{a}	2.93‡	28.40_{a}	105.70_{a}
	AP Course Only	2.78_{b}	2.82‡	27.19	101.80
	Other Course	2.80	2.80‡	25.98_{b}	100.09_{b}
Group/1999†	AP Course/Exam	2.99_{a}	2.96_{a}	28.98_{a}	106.43_{a}
	AP Course Only	2.84_{b}	2.81_{b}	27.31_{b}	102.44
	Other Course	2.77_{b}	2.78_{b}	26.41_{b}	98.58_{b}
Group/2000	AP Course/Exam	2.95_{a}	2.91‡	28.15_{a}	104.21‡
	AP Course Only	2.85	2.84‡	27.46	103.39‡
	Other Course	2.79_{b}	2.83‡	26.37_{b}	100.49‡
Group/2001	AP Course/Exam	3.00_{a}	2.96_{a}	29.11_{a}	106.38_{a}
	AP Course Only	2.82_{b}	2.83_{b}	27.26_{b}	101.04_{b}
	Other Course	2.80_{b}	2.85_{b}	27.28_{b}	100.91_{b}
Group/2002§	AP Course/Exam	3.00_{a}	--	25.74_{a}	--
	AP Course Only	2.79_{b}	--	24.99	--
	Other Course	2.77_{b}	--	23.89_{b}	--
Ethnicity/1998	Asian American	3.05_{a}	3.00_{a}	30.40_{a}	110.35_{a}
	African American	2.67_{b}	2.65_{b}	25.99_{b}	99.85_{b}
	Hispanic	2.66_{b}	2.72_{b}	$24.39_{b,c}$	$94.21_{b,c}$
	White	3.01_{a}	3.04_{a}	$27.99_{b,d}$	$105.72_{b,d}$
Ethnicity/1999	Asian American	3.09_{a}	3.03_{a}	30.36_{a}	108.97_{a}
	African American	2.65_{b}	2.60_{b}	$27.19_{b,c}$	102.02_{c}
	Hispanic	2.70_{b}	2.72_{b}	$24.89_{b,d}$	$95.01_{b,d,e}$
	White	3.03_{a}	3.05_{a}	$27.84_{b,c}$	$103.94_{b,f}$
Ethnicity/2000	Asian American	3.10_{a}	3.07_{a}	30.60_{a}	110.87_{a}
	African American	2.65_{b}	2.62_{b}	26.41_{b}	$102.87_{b,c}$
	Hispanic	2.67_{b}	2.71_{b}	$24.89_{b,c}$	$94.23_{b,d}$
	White	3.03_{a}	3.04_{a}	$27.41_{b,d}$	$102.81_{b,c}$
Ethnicity/2001	Asian American	3.09_{a}	3.09_{a}	30.69_{a}	110.01_{a}
	African American	2.66_{b}	2.64_{b}	27.05_{b}	$101.91_{b,c}$
	Hispanic	2.72_{b}	2.75_{b}	$26.16_{b,c}$	$95.71_{b,d}$
	White	3.02_{a}	3.04_{a}	$27.64_{b,d}$	$103.48_{b,c}$
Ethnicity/2002§	Asian American	3.16_{a}	--	28.47_{a}	--
	African American	$2.63_{b,c}$	--	24.49_{b}	--
	Hispanic	$2.65_{b,c}$	--	23.04_{b}	--
	White	$2.96_{b,d}$	--	23.50_{b}	--
Gender/1999	Females	2.94_{a}	2.95_{a}	27.88‡	103.59‡
	Males	2.80_{b}	2.75_{b}	27.26‡	101.38‡
Gender/2000	Females	2.97_{a}	2.98_{a}	27.85_{a}	104.66_{a}
	Males	2.75_{b}	2.74_{b}	26.80_{b}	100.73_{b}
Gender/2001	Females	2.96_{a}	2.97_{a}	28.00‡	104.02‡
	Males	2.79_{b}	2.79_{b}	27.77‡	101.54‡
Gender/2002§	Females	2.98_{a}	--	24.85‡	--
	Males	2.73_{b}	--	24.90‡	--

Note: Significance level for α was $p < .01$. Within the same main effect/cohort year and same outcome (column), means with specific non-matching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly. 1998–2002 AP Exam only and 2000–2002 dual enrollment cohort year groups were excluded from the MANOVAs and ANOVAs due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. Gender was excluded from the set of independent variables analyzed for the subjects relevant to AP Biology in cohort year 1998 due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. This resulted in factorial analyses that included group and ethnicity only in cohort year 1998.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Dual enrollment data were unavailable before the 2000 cohort year.

‡ Nonsignificant effect for outcome within cohort year.

§ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

cohort; thus, no ANOVA interactions were analyzed.

Group differences in the AP Biology analyses remained consistent with those in AP English Language and Composition, AP English Literature and Composition, and AP Calculus AB (see Table 12). That is, the AP Biology course and exam group was almost always significantly higher than the AP course only and/or the other course groups. Exceptions to this pattern occurred in 1998 for fourth-year GPA and in 2000 for both fourth-year GPA and credits. Patterns of significant post hoc differences in the outcomes among ethnic groups and between males and females also remained consistent with analyses for the other AP subjects.

Logistic Regression Analyses

Mirroring the MANOVAs, logistic regression main effects of

Table 13

Four-Year Graduation Rates* for Significant Logistic Regression Main Effects for AP Biology: Group, Ethnicity, and Gender

High School Graduation Cohort Year	*Group† (N-size)*	*Graduation Rate (%) (n-size)*	*Ethnicity (n-size)*	*Graduation Rate (%) (n-size)*	*Gender (n-size)*	*Graduation Rate (%) (n-size)*
1998‡	AP Course/Exam *(977)*	41.86_a *(409)*	Asian American *(407)*	39.80 *(162)*		
	AP Course Only *(893)*	33.48_b *(299)*	African American *(114)*	28.95 *(33)*		
	Other Course *(977)*	30.81_b *(301)*	Hispanic *(396)*	22.98_b *(91)*		
			White *(1,930)*	37.46_a *(723)*		
1999‡	AP Course/Exam *(1,394)*	45.34_a *(632)*	Asian American *(486)*	45.27 *(220)*	Female *(2,319)*	41.35_a *(959)*
	AP Course Only *(1,316)*	32.52_b *(428)*	African American *(199)*	26.13_b *(52)*	Male *(1,785)*	29.19_b *(521)*
	Other Course *(1,394)*	30.13_b *(420)*	Hispanic *(591)*	20.14_b *(119)*		
			White *(2,828)*	38.51_a *(1,089)*		
2000	AP Course/Exam *(1,895)*	42.80_a *(811)*	Asian American *(601)*	43.59 *(262)*	Female *(3,210)*	41.84_a *(1,343)*
	AP Course Only *(1,763)*	32.84_b *(579)*	African American *(305)*	25.25_b *(77)*	Male *(2,343)*	27.70_b *(649)*
	Other Course *(1,895)*	31.77_b *(602)*	Hispanic *(941)*	21.04_b *(198)*		
			White *(3,706)*	39.26_a *(1,455)*		
2001	AP Course/Exam *(1,873)*	42.93_a *(804)*	Asian American *(640)*	45.31 *(290)*	Female *(3,081)*	41.16_a *(1,268)*
	AP Course Only *(1,657)*	34.22_b *(567)*	African American *(292)*	21.92_b *(64)*	Male *(2,322)*	29.89_b *(694)*
	Other Course *(1,873)*	31.55_b *(591)*	Hispanic *(894)*	22.26_b *(199)*		
			White *(3,577)*	39.39_a *(1,409)*		

Note: Significance level for α was $p < .01$. Within the same year and column, rates with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions. 1998–2002 AP Exam only and 2000–02 dual enrollment cohort year groups were excluded from the MANOVAs and ANOVAs due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. Gender was excluded from the set of independent variables analyzed for the subjects relevant to AP Biology in cohort year 1998 due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. This resulted in factorial analyses that included group and ethnicity only in cohort year 1998.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† For AP Biology analyses, both the 1998–2001 AP Exam only and the 2000–01 dual enrollment groups were excluded due to some cell *n*'s < 10 in the full-factorial group by ethnicity and group by ethnicity by gender designs.

‡ Dual enrollment data were unavailable before the 2000 cohort year.

group and ethnicity for the 1998–2001 AP Biology cohorts were found to be significant, along with gender in 1999–2001 (see Table 13). Gender was excluded from logistic regression analyses in 1998 due to small cell sizes. For the 1999 cohort, the graduation rate was 45.34 percent for the AP Biology course and exam group compared to 32.52 percent and 30.13 percent, respectively, for the AP Biology course only and the other course groups. Within the same cohort, the graduation rate for Asian Americans was 45.27 percent, 38.51 percent for whites, 26.13 percent for African Americans, and 20.14 percent for Hispanics. Rates for Hispanics and African Americans differed significantly from the rate for whites. Females also graduated at a significantly higher rate (1999: 41.35 percent) than males (1999: 29.19 percent).

AP Chemistry

MANOVAs

While the group and gender MANOVA main effects were significant for 2000–02 and 1999–2002 AP Chemistry cohorts, respectively, ethnicity was found to be significant for all AP Chemistry cohorts (1998–2002) (see Table 2). Due to small cell sizes, neither AP Exam only nor dual enrollment groups were analyzed; gender was excluded from analyses in 1998 only. MANOVA statistics for the 2000 cohort are comparable to those for most cohorts: (a) *group*—Wilks' $\Lambda = .9876$, $F(8, 6424) = 5.03$, $p < .0001$; (b) *ethnicity*—Wilks' $\Lambda = .9128$, $F(12, 8498.4) = 24.86$, $p < .0001$; and (c) *gender*—Wilks' $\Lambda = .9867$, $F(4, 3212) = 10.79$, $p < .0001$.

ANOVA Main Effects and Post Hoc Comparisons

Ethnicity was the only ANOVA main effect for AP Chemistry that was significant for both GPA and credit hours outcomes across all available years of cohort data (see Table 2). However, group was significant in 2000–02 for both first-year GPA and first-year credits, and in 2000–01 for fourth-year credits, but was significant only in 2001 for fourth-year GPA. In addition, gender was significant in 1999–2002 for first-year GPA and in 1999–2001 for fourth-year GPA, but was significant only in 2001 for fourth-year credits.

AP Chemistry course and exam group students earned significantly higher first-year GPAs than the other course students in 2000–02 and were significantly higher than AP course only students in 2001–02 (see Table 14). They also compiled more first-year credits (2000–02) and fourth-year credits (2000–01) than other course students. However, in 2001 and 2002 they also earned significantly higher first-year GPAs and 2001 fourth-year GPAs than the AP Chemistry course only students. AP course only students tallied significantly more first-year credit hours in 2001 and fourth-year credit hours in 2000–01 than other course students. Mean differences on the outcomes among ethnic groups and between males and females were very comparable to those observed with results for the other AP subjects

Table 14

Least-Square Means by Outcome for Significant ANOVA Main Effects for AP Chemistry: Group, Ethnicity, and Gender

Main Effect & High School Graduation Cohort Year	*Main Effect Groups*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
Group/2000†	AP Course/Exam	3.05_{a}	2.98‡	29.79_{a}	107.99_{a}
	AP Course Only	3.02	2.95‡	28.24	105.52_{a}
	Other Course	2.89_{b}	2.86‡	26.81_{b}	99.99_{b}
Group/2001†	AP Course/Exam	3.13_{a}	3.06_{a}	29.88_{a}	108.02_{a}
	AP Course Only	2.92_{b}	2.87_{b}	29.16_{a}	105.62_{a}
	Other Course	2.87_{b}	2.87_{b}	27.15_{b}	100.63_{b}
Group/2002†§	AP Course/Exam	3.04_{a}	--	26.26_{a}	--
	AP Course Only	2.87_{b}	--	25.03	--
	Other Course	2.85_{b}	--	24.30_{b}	--
Ethnicity/1998	Asian American	3.23_{a}	3.16_{a}	31.62_{a}	112.98_{a}
	African American	2.62_{b}	2.68_{b}	27.44_{b}	101.18_{b}
	Hispanic	2.83_{b}	2.80_{b}	$26.59_{b,c}$	$96.79_{b,c}$
	White	3.15_{a}	3.15_{a}	$28.88_{b,d}$	108.30_{d}
Ethnicity/1999	Asian American	3.24_{a}	3.13_{a}	31.64_{a}	112.19_{a}
	African American	2.74_{b}	2.60_{b}	26.40_{b}	100.45_{b}
	Hispanic	2.76_{b}	2.77_{b}	27.16_{b}	$99.69_{b,c}$
	White	3.14_{a}	3.13_{a}	28.61_{b}	$104.92_{b,d}$
Ethnicity/2000	Asian American	3.22_{a}	3.14_{a}	31.73_{a}	111.84_{a}
	African American	2.75_{b}	2.64_{b}	27.01_{b}	104.96_{c}
	Hispanic	2.81_{b}	2.79_{b}	$26.01_{b,c}$	$96.60_{b,d}$
	White	3.16_{a}	3.16_{a}	$28.37_{b,d}$	104.61_{b}
Ethnicity/2001	Asian American	3.22_{a}	3.18_{a}	31.65_{a}	111.90_{a}
	African American	2.71_{b}	$2.58_{b,c}$	28.17_{b}	101.53_{b}
	Hispanic	2.85_{b}	$2.86_{b,d}$	$26.37_{b,c}$	$100.18_{b,c}$
	White	3.11_{a}	3.11_{a}	$28.74_{b,d}$	$105.42_{b,d}$
Ethnicity/2002§	Asian American	3.25_{a}	--	28.32_{a}	--
	African American	$2.60_{b,c}$	--	24.74_{b}	--
	Hispanic	$2.75_{b,c}$	--	23.78_{b}	--
	White	$3.09_{b,d}$	--	23.94_{b}	--
Gender/1999	Females	3.08_{a}	3.04_{a}	28.35‡	104.88‡
	Males	2.86_{b}	2.78_{b}	28.55‡	103.74‡
Gender/2000	Females	3.08_{a}	3.05_{a}	28.67‡	106.02‡
	Males	2.89_{b}	2.81_{b}	27.89‡	102.98‡
Gender/2001	Females	3.07_{a}	3.05_{a}	28.97‡	106.60_{a}
	Males	2.88_{b}	2.82_{b}	28.50‡	102.91_{b}
Gender/2002§	Females	3.05_{a}	--	24.86‡	--
	Males	2.80_{b}	--	25.53‡	--

Note: Significance level for α was $p < .01$. Within the same main effect/cohort year and same outcome (column), means with specific non-matching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*) differed significantly. 1998–2002 AP Exam only and 2000-02 dual enrollment cohort year groups were excluded from the MANOVAs and ANOVAs due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. Gender was excluded from the set of independent variables analyzed for the subjects relevant to AP Chemistry in cohort year 1998 due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. This resulted in factorial analyses that included group and ethnicity only in cohort year 1998.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Dual enrollment data were unavailable before the 2000 cohort year.

‡ Nonsignificant effect for outcome within cohort year.

§ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

Table 15

Four-Year Graduation Rates* for Significant Logistic Regression Main Effects for AP Chemistry: Group, Ethnicity, and Gender

High School Graduation Cohort Year	*Group† (N-size)*	*Graduation Rate (%) (n-size)*	*Ethnicity (n-size)*	*Graduation Rate (%) (n-size)*	*Gender (n-size)*	*Graduation Rate (%) (n-size)*
1998‡,§	AP Course/Exam *(531)*	43.31 *(230)*	Asian American *(272)*	43.75 *(119)*		
	AP Course Only *(484)*	37.40 *(181)*	African American *(58)*	20.69_{b} *(12)*		
	Other Course *(531)*	36.16 *(192)*	Hispanic *(150)*	26.00_{b} *(39)*		
			White *(1,066)*	40.62_{a} *(433)*		
1999‡	AP Course/Exam *(770)*	42.34_{a} *(326)*	Asian American *(366)*	46.17 *(169)*	Female *(1,035)*	42.61_{a} *(441)*
	AP Course Only *(694)*	32.28_{b} *(224)*	African American *(93)*	23.66_{b} *(22)*	Male *(1,199)*	29.69_{b} *(356)*
	Other Course *(770)*	32.08_{b} *(247)*	Hispanic *(251)*	20.72_{b} *(52)*		
			White *(1,524)*	36.35_{a} *(554)*		
2000	AP Course/Exam *(1,121)*	42.91_{a} *(481)*	Asian American *(473)*	45.45 *(215)*	Female *(1.568)*	45.73_{a} *(717)*
	AP Course Only *(997)*	35.51^{b} *(354)*	African American *(144)*	22.22_{b} *(32)*	Male *(1.671)*	31.18_{b} *(521)*
	Other Course *(1,121)*	35.95^{b} *(403)*	Hispanic *(422)*	20.62_{b} *(87)*		
			White *(2,200)*	41.09_{a} *(904)*		
2001	AP Course/Exam *(1,230)*	43.33_{a} *(533)*	Asian American *(530)*	46.42 *(246)*	Female *(1,616)*	45.54_{a} *(736)*
	AP Course Only *(1,031)*	35.69_{b} *(368)*	African American *(136)*	22.79_{b} *(31)*	Male *(1,875)*	33.87_{b} *(635)*
	Other Course *(1,230)*	38.21_{b} *(470)*	Hispanic *(493)*	23.12_{b} *(114)*		
			White *(2,332)*	42.02_{a} *(980)*		

Note: Significance level for α was $p < .01$. Within the same year and column, rates with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions. Gender was excluded from the set of independent variables analyzed for the subjects relevant to AP Chemistry in cohort year 1998 due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. This resulted in analyses that included group and ethnicity only in cohort year 1998.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† For Chemistry analyses, both the 1998–2001 AP Exam only and the 2000-01 dual enrollment groups were excluded due to some cell *n*'s < 10 in the full-factorial group by ethnicity and group by ethnicity by gender designs.

‡ Dual enrollment data were unavailable before the 2000 cohort year.

§ Group effect was nonsignificant in the 1998 cohort year.

examined. Both mean first-year credits (1999–2002) and fourth-year credits (1999–2000) differed nonsignificantly between males and females.

Logistic Regression Analyses

Results from logistic regression analyses of four-year graduation rates for AP Chemistry indicated that the main effect of ethnicity was significant across 1998–2001 cohorts, while group and gender were significant from 1999–2001 (see Table 15). Gender was excluded from logistic regression analyses in 1998 due to small cell sizes. Graduation rates of at least 42 percent for AP Chemistry course and exam group students outpaced rates for students in all other groups across all cohorts. Rates never exceeded 38 percent for AP Chemistry course only students and were lowest for the other course group in 1999 (below 33 percent). Asian Americans continued to graduate at rates (e.g., 2000: 45.45 percent) higher than whites (2000: 41.09 percent), while either African American (2000: 22.22 percent) or Hispanic graduation rates (2000: 20.62 percent) were lowest across 1998–2001 cohorts. Female graduation rates (e.g., 2000: 45.73 percent) also exceeded those for males (2000: 31.18 percent).

AP U.S. History

MANOVAs

Group, ethnicity, and gender MANOVA main effects were found to be significant across 1998–2002 cohorts in the MANOVAs for AP U.S. History (see Table 2). Except for inclusion of the dual enrollment group in 2002, AP Exam only and dual enrollment groups were excluded from analyses due to insufficient cell sizes. The gender by ethnicity interaction was significant in 1998, 2000, and 2002, while group by ethnicity was significant in 2000 and

2002. MANOVA statistics for the 2000 cohort are similar to those in other years: (a) *group*—Wilks' $\Lambda = .9926$, $F(8, 20154) = 9.41$, $p < .0001$; (b) *ethnicity*–Wilks' $\Lambda = .9379$, $F(12, 26662) = 54.53$, $p < .0001$; (c) *gender*—Wilks' $\Lambda = .9820$, $F(4, 10077) = 46.28$, $p < .0001$; (d) *group by ethnicity*—Wilks' $\Lambda = .9948$, $F(24, 35156) = 2.18$, $p < .0007$; and (e) *gender by ethnicity*—Wilks' $\Lambda = .9972$, $F(12, 26662) = 2.35$, $p < .0053$.

ANOVA Main Effects, Interactions, and Post Hoc Comparisons

ANOVA results for AP U.S. History showed that group and ethnicity were significant across all GPA outcomes for all cohorts, except for the group with fourth-year GPA in 1999 (see Table 2). Gender was significant across all outcomes and cohorts, except first-year credits in 1998 and 2002. Both the group by ethnicity and the gender by ethnicity

Table 16

Least-Square Means by Outcome for Significant ANOVA Main Effects for AP U.S. History: Group, Ethnicity, and Gender

Main Effect & High School Graduation Cohort Year	*Main Effect Groups*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
Group/1998†	AP Course/Exam	2.99_{a}	2.98_{a}	29.11_{a}	107.90_{a}
	AP Course Only	2.79_{b}	2.84_{b}	27.83	105.60
	Other Course	2.83_{b}	2.81_{b}	27.22_{b}	102.49_{b}
Group/1999†	AP Course/Exam	2.94_{a}	2.90‡	28.28_{a}	105.19_{a}
	AP Course Only	2.81_{b}	2.82‡	26.88_{b}	101.10_{b}
	Other Course	2.91	2.89‡	27.63	100.97_{b}
Group/2000	AP Course/Exam	2.99_{a}	2.96_{a}	28.15_{a}	104.69_{a}
	AP Course Only	2.80_{b}	2.78_{b}	27.02_{b}	101.52_{b}
	Other Course	2.80_{b}	2.80_{b}	26.80_{b}	100.65_{b}
Group/2001	AP Course/Exam	2.99_{a}	2.97_{a}	28.29_{a}	104.85_{a}
	AP Course Only	2.82_{b}	2.82_{b}	26.79_{b}	101.57_{b}
	Other Course	2.82_{b}	2.82_{b}	27.04_{b}	99.90_{b}
Group/2002§	AP Course/Exam	2.91_{a}	--	24.93_{a}	--
	AP Course Only	$2.67_{b,c}$	--	24.12	--
	Dual Enrollment	$2.56_{b,d}$	--	23.55_{b}	--
	Other Course	$2.70_{b,c}$	--	23.67_{b}	--
Ethnicity/1998	Asian American	3.03_{a}	3.00_{a}	30.19_{a}	109.77_{a}
	African American	2.76_{b}	2.69_{b}	28.02	106.51
	Hispanic	2.71_{b}	2.77_{b}	$26.25_{b,c}$	$99.58_{b,c}$
	White	2.99_{a}	3.03_{a}	$27.77_{b,d}$	$105.46_{b,d}$
Ethnicity/1999	Asian American	3.08_{a}	3.05_{a}	30.99_{a}	110.54_{a}
	African American	2.76_{b}	2.66_{b}	26.06_{b}	99.80_{b}
	Hispanic	2.71_{b}	2.73_{b}	$25.69_{b,c}$	$96.17_{b,c}$
	White	3.01_{a}	3.03_{a}	$27.66_{b,d}$	$103.16_{b,d}$
Ethnicity/2000	Asian American	3.06_{a}	3.02_{a}	30.38_{a}	109.58_{a}
	African American	2.64_{b}	$2.56_{b,c}$	26.22_{b}	99.79_{b}
	Hispanic	2.74_{b}	$2.76_{b,d}$	$25.28_{b,c}$	$96.80_{b,c}$
	White	3.02_{a}	3.04_{a}	$27.43_{b,d}$	$102.97_{b,d}$
Ethnicity/2001	Asian American	3.04_{a}	3.02_{a}	30.22_{a}	108.10_{a}
	African American	2.69_{b}	$2.66_{b,c}$	26.43_{b}	$101.73_{b,c}$
	Hispanic	2.77_{b}	$2.78_{b,d}$	$25.43_{b,c}$	$95.56_{b,d}$
	White	3.00_{a}	3.03_{a}	$27.42_{b,d}$	$103.03_{b,c}$
Ethnicity/2002§	Asian American	2.97_{a}	--	27.43_{a}	--
	African American	2.45_{b}	--	22.84_{b}	--
	Hispanic	2.54_{b}	--	$22.44_{b,c}$	--
	White	2.89_{a}	--	$23.56_{b,d}$	--
Gender/1998	Females	2.96_{a}	2.99_{a}	28.30‡	108.06_{a}
	Males	2.79_{b}	2.76_{b}	27.81‡	102.61_{b}
Gender/1999	Females	2.99_{a}	3.00_{a}	28.13_{a}	104.74_{a}
	Males	2.78_{b}	2.74_{b}	27.07_{b}	100.10_{b}
Gender/2000	Females	2.97_{a}	2.98_{a}	27.93_{a}	104.81_{a}
	Males	2.76_{b}	2.71_{b}	26.73_{b}	99.76_{b}
Gender/2001	Females	2.96_{a}	2.98_{a}	27.80_{a}	103.78_{a}
	Males	2.79_{b}	2.77_{b}	26.95_{b}	100.44_{b}
Gender/2002§	Females	2.83_{a}	--	24.31‡	--
	Males	2.59_{b}	--	23.83‡	--

Note: Significance level for α was $p < .01$. Within the same main effect/cohort year and same outcome (column), means with specific non-matching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*) differed significantly. 1998–2002 AP Exam only and 2000–01 dual enrollment cohort year groups were excluded from the MANOVAs, ANOVAs, and logistic regression analyses due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Dual enrollment data were unavailable before the 2000 cohort year.

‡ Nonsignificant effect for outcome within cohort year.

§ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

interactions were significant for all but one outcome (fourth-year credits), but only one outcome, first-year GPA, was significant for more than one cohort (group by ethnicity: 2000 and 2002; gender by ethnicity: 1998, 2000, and 2002). Thus, these interactions are not presented.

Tukey-Kramer post hoc comparisons showed significantly higher mean GPA and credit hours earned by the AP U.S. History course and exam students than by those in the AP U.S. History course only and other course groups in 2000–01, as well as for mean GPAs in 1998 (see Table 16). For the 1999 cohort, mean GPAs and first-year credit hours differed nonsignificantly between the AP U.S. History course and exam and the other course students. In 2002, mean first-year GPA for AP course and exam students was significantly higher than means for AP course only, dual enrollment, and other course students. Otherwise, generally similar patterns of significant mean differences existed among ethnic groups and between males and females as in other AP subjects analyzed (see Table 16). Exceptions were nonsignificant differences between males and females in 1998 and 2002 on first-year credits.

Logistic Regression Analyses

Logistic regression analyses regarding AP U.S. History indicated significant group, ethnicity, and gender main effect differences in graduation rates across 1998–2001 cohorts (see Table 17). Course and exam students graduated at rates significantly higher (e.g., 2000: 43.40 percent) than course only (30.94 percent) and other course (33.74 percent) students. Ethnic and gender differences in graduation rates were consistent with other AP subjects analyzed.

AP Spanish Language

MANOVAs

The MANOVAs for AP Spanish Language identified significant main effects for group and ethnicity in 1998–2002 and for gender in 1999–2002 (see Table 2). Gender was excluded from analyses in 1998, as were African Americans in 1998–2002 and dual enrollment students in 2000–02,

Table 17

Four-Year Graduation Rates* for Significant Logistic Regression Main Effects for AP U.S. History: Group, Ethnicity, and Gender

High School Graduation Cohort Year	*Group† (N-size)*	*Graduation Rate (%) (n-size)*	*Ethnicity (n-size)*	*Graduation Rate (%) (n-size)*	*Gender (n-size)*	*Graduation Rate (%) (n-size)*
1998‡	AP Course/Exam (1,681)	43.07$_a$ (724)	Asian American (604)	37.58 (227)	Female (2,453)	42.60$_a$ (1,045)
	AP Course Only (1,360)	33.46$_b$ (455)	African American (155)	30.32 (47)	Male (2,269)	29.70$_b$ (674)
	Other Course (1,681)	32.12$_b$ (540)	Hispanic (451)	24.83$_b$ (112)		
			White (3,512)	37.96$_a$ (1,333)		
1999‡	AP Course/Exam (2,258)	40.92$_a$ (924)	Asian American (756)	42.33 (320)	Female (3,208)	42.49$_a$ (1,363)
	AP Course Only (1,784)	32.17$_b$ (574)	African American (236)	28.39$_b$ (67)	Male (3,091)	27.63$_b$ (854)
	Other Course (2,257)	31.86$_b$ (719)	Hispanic (778)	21.34$_b$ (166)		
			White (4,529)	36.74$_a$ (1,664)		
2000	AP Course/Exam (3,689)	43.40$_a$, (1,601)	Asian American (1,088)	41.08 (447)	Female (5,246)	43.06$_a$ (2,259)
	AP Course Only (2,770)	30.94$_b$ (857)	African American (474)	24.47$_b$ (116)	Male (4,858)	29.42$_b$ (1,429)
	Other Course (3,645)	33.74$_b$ (1,230)	Hispanic (1,445)	23.88$_b$ (345)		
			White (7,097)	39.17$_a$ (2,780)		
2001	AP Course/Exam (4,306)	41.59$_a$ (1,791)	Asian American (1,250)	40.96 (512)	Female (6,034)	40.79$_a$ (2,461)
	AP Course Only (3,113)	30.52$_b$ (950)	African American (589)	24.96$_b$ (147)	Male (5,647)	28.44$_b$ (1,606)
	Other Course (4,262)	31.11$_b$ (1,326)	Hispanic (1,855)	21.78$_b$ (404)		
			White (7,987)	37.61$_a$ (3,004)		

Note: Significance level for α was $p < .01$. Within the same year and column, rates with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† 1998–2002 AP Exam only and 2000-01 dual enrollment cohort year groups were excluded from the MANOVAs, ANOVAs, and logistic regression analyses due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design.

‡ Dual enrollment data were unavailable before the 2000 cohort year.

due to cell sizes too small to support a three-way factorial MANOVA. However, like the AP English Language and Composition and AP English Literature and Composition analyses but unlike the other AP subject analyses, the AP Spanish Language analyses included the AP Exam only group. Group by ethnicity was significant for 1999–2000 and 2002 cohorts, while gender by ethnicity was significant for 2000–01 cohorts. MANOVA statistics for the 1999 cohort were similar to other years: (a) *group*—Wilks' Λ = .9833, $F(12, 6162.2) = 3.27$, $p < .0001$, (b) *ethnicity*—Wilks' Λ = .8835, $F(8, 4658) = 37.20$, $p < .0001$; (c) *gender*—Wilks' Λ = .9830, $F(4, 2329) = 10.05$, $p < .0001$; and (d) *group by ethnicity*—Wilks' Λ = .9758, $F(24, 8126.1) = 2.39$, $p < .0002$.

ANOVA Main Effects and Post Hoc Comparisons

Group and ethnicity main effects from the ANOVA analyses for AP Spanish Language were significant for all available cohorts for all GPA and credit hours outcomes, except for

Table 18

Least-Square Means by Outcome for Significant ANOVA Main Effects for AP Spanish Language: Group, Ethnicity, and Gender

Main Effect & High School Graduation Cohort Year	*Main Effect Groups*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
Group/1998†	AP Course/Exam	3.05_{a}	3.08_{a}	28.21‡	101.83‡
	AP Course Only	2.90	2.91_{b}	27.29‡	102.04‡
	AP Exam Only	3.04_{a}	3.04_{c}	28.02‡	103.38‡
	Other Course	2.75_{b}	$2.81_{b,d}$	26.52‡	99.34‡
Group/1999†	AP Course/Exam	3.01_{a}	3.01_{a}	28.59_{a}	102.66‡
	AP Course Only	2.91	2.93	27.64	101.34‡
	AP Exam Only	3.06_{a}	3.07_{a}	28.12	103.83‡
	Other Course	2.79_{b}	2.84_{b}	26.17_{b}	99.86‡
Group/2000	AP Course/Exam	3.04_{a}	3.07_{a}	28.48_{a}	103.81_{a}
	AP Course Only	2.91	2.91_{b}	27.42_{a}	102.22
	AP Exam Only	3.01	2.98	27.41	101.22
	Other Course	2.82_{b}	2.84_{b}	25.61_{b}	97.16_{b}
Group/2001	AP Course/Exam	3.05_{a}	3.06_{a}	28.64_{a}	103.94_{a}
	AP Course Only	2.95	2.94_{c}	27.93_{a}	101.94
	AP Exam Only	3.15_{a}	3.14_{d}	27.56	103.81
	Other Course	2.89_{b}	$2.91_{b,c}$	26.06_{b}	97.18_{b}
Group/2002§	AP Course/Exam	3.08_{a}	--	25.48_{a}	--
	AP Course Only	$2.86_{b,c}$	--	24.37_{a}	--
	AP Exam Only	3.09_{a}	--	25.85_{a}	--
	Other Course	$2.66_{b,d}$	--	22.60_{b}	--
Ethnicity/1998**	Asian American	3.15_{a}	3.12_{a}	30.42_{a}	107.57_{a}
	Hispanic	2.61_{b}	2.65_{b}	$24.19_{b,c}$	93.03_{b}
	White	3.05_{a}	3.10_{a}	$27.91_{b,d}$	104.34_{a}
Ethnicity/1999**	Asian American	3.13_{a}	3.13_{a}	30.61_{a}	109.62_{a}
	Hispanic	2.63_{b}	2.66_{b}	$24.41_{b,c}$	$92.79_{b,c}$
	White	3.06_{a}	3.10_{a}	$27.87_{b,d}$	$103.35_{b,d}$
Ethnicity/2000**	Asian American	3.16_{a}	3.11_{a}	30.33_{a}	108.87_{a}
	Hispanic	2.59_{b}	2.63_{b}	$23.68_{b,c}$	$91.33_{b,c}$
	White	3.08_{a}	3.10_{a}	$27.68_{b,d}$	$103.11_{b,d}$
Ethnicity/2001**	Asian American	3.25_{a}	3.21_{a}	30.45_{a}	109.19_{a}
	Hispanic	2.68_{b}	2.70_{b}	$24.20_{b,c}$	92.00_{b}
	White	3.11_{a}	3.13_{a}	$27.98_{b,d}$	103.97_{a}
Ethnicity/2002§,**	Asian American	3.25_{a}	--	28.72_{a}	--
	Hispanic	$2.49_{b,c}$	--	$21.25_{b,c}$	--
	White	$3.02_{b,d}$	--	$23.75_{b,d}$	--
Gender/1999	Females	3.05_{a}	3.08_{a}	27.87‡	103.17‡
	Males	2.83_{b}	2.85_{b}	27.39‡	100.68‡
Gender/2000	Females	3.02_{a}	3.04_{a}	27.54‡	102.20‡
	Males	2.88_{b}	2.86_{b}	26.92‡	100.00‡
Gender/2001	Females	3.06‡	3.09_{a}	27.99‡	103.32‡
	Males	2.96‡	2.94_{b}	27.11‡	100.12‡
Gender/2002§	Females	2.97_{a}	--	24.34‡	--
	Males	2.87_{b}	--	23.80‡	--

Note: Significance level for α was $p < .01$. Within the same main effect/cohort year and same outcome (column), means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*) differed significantly. 2000–02 dual enrollment cohort year groups were excluded from the MANOVAs, ANOVAs, and logistic regression analyses due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. Gender was excluded from the set of independent variables analyzed for the subjects relevant to AP Spanish Language in the 1998 cohort year due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. This resulted in factorial analyses that included group and ethnicity only.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Dual enrollment data were unavailable before the 2000 cohort year.

‡ Nonsignificant effect for outcome within cohort year.

§ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

** For all 1998–2002 AP Spanish Language cohort year analyses, African Americans were excluded due to some cell *n*'s < 10 in the full-factorial group by ethnicity and group by ethnicity by gender designs.

group on first-year credits in 1998 and fourth-year credits in 1998-99 (see Table 2). While gender was excluded from analysis in 1998, it was significant for first-year GPA in 1999, 2000, and 2002 and for fourth-year GPA in 1999–2001. The group by ethnicity interaction was only significant for first-year credits in 2002 and fourth-year credits in 1999–2000, while the gender by ethnicity interaction was only significant for first-year credits in 2000–01 and fourth-year credits in 2001. Thus, means for these interactions are not presented.

In all available cohort years across outcomes, except for first-year credits in 1998 and fourth-year credits in 1998–99, the AP Spanish Language course and exam group had significantly higher means on the outcomes than the other course group (see Table 18). AP Spanish Language exam only group means on GPA and credit hours outcomes never differed significantly from the AP Spanish Language course and exam group means, but they frequently were significantly higher than mean GPAs and first-year credits for the other course only group. Differences in means among ethnic groups and between females and males generally mirrored those observed for the other AP subjects; however, all mean first- and fourth-year credit hour differences between females and males were nonsignificant.

Logistic Regression Analyses

Significant group, ethnicity, and gender main effects emerged from the logistic regression analyses of four-year graduation rates for AP Spanish Language (see Table 19). Gender was excluded from the 1998 analysis. Consistent with AP Spanish Language ANOVA group main effects, AP Spanish Language Exam only graduation rates never differed significantly from the AP Spanish Language course and exam group. Otherwise, AP Spanish Language course and exam graduation rates were significantly higher than rates for the AP Spanish Language course only and other course groups. Significant differences in graduation rates by ethnic group and gender mirrored those found in the other subjects.

Phase 2 Results: Aggregated AP Subjects

Phase 2 addressed college outcome comparisons among groups of students with varying types of AP and non-AP experiences aggregated across all AP Exams and AP and non-AP courses (Research Question 2). Also addressed were comparisons among four AP mean grade categories of the AP course and exam group relative to the other AP and non-AP groups (Research Question 3). Finally, for the AP course and exam group only, additional analyses were conducted to evaluate effects of the number of AP courses, number of AP Exams, and average AP Exam grade category on college outcomes (Research Question 4). Results related to Research Questions 2 and 4 are provided for each of five high school graduate cohorts (1998–2002), while Research Question 3 analyzed the 2001 cohort only.

Research Question 2 Results: Group Comparisons by SAT® Rank and FRPL Participation

Students with various types of aggregated AP experiences—any AP course and exam, any AP course but no exam, any AP Exam but no course—were separately grouped, as were non-AP students who took any dual enrollment course and students who took other courses only. College outcomes comparisons were made among the five possible groups, using SAT rank and FRPL participation to control for preexisting differences in ability/college readiness and family income status, respectively, which were related to the outcomes.

MANOVAs

The MANOVA main effects of group, SAT rank, and FRPL participation status were found to be statistically significant ($p < .01$) for each of the 1998–2002 high school graduate cohorts on the multivariate composite of four college outcomes—first- and fourth-year GPAs and first- and fourth-year credit hours earned (see Table 20). In 2000, AP Exam only and dual enrollment groups were excluded from analyses due to small cell sizes. Statistically significant differences in multivariate means by group included: (a) *1998*—Wilks' $\Lambda = .9880$, $F(12, 102846) = 39.35$, $p < .0001$; (b) *1999*—Wilks' $\Lambda = .9840$, $F(12, 105505) = 53.82$, $p < .0001$; (c) *2000*—Wilks' $\Lambda = .9858$, $F(8, 80182) = 71.74$, $p < .0001$; (d) *2001*—Wilks' $\Lambda = .9855$, $F(16, 128789), = 38.64$, $p < .0001$; and (e) *2002*—Wilks' $\Lambda = .9871$, $F(8, 118980) = 96.84$, $p < .0001$). The most consistent, significant interaction was the group by SAT rank interaction (1999–2002), followed by the group by FRPL status interaction (1999–2000 and 2002). The FRPL status by SAT rank interaction was significant only for the 1998 cohort. The three-way interaction was never significant.

ANOVA Main Effects and Post Hoc Comparisons

The three ANOVA main effects of group, FRPL participation status, and SAT rank were significant for all 1998–2002 first-year and 1998–2001 fourth-year GPA and credit hours outcomes, except that FRPL status was significant only in 2002 for first-year GPA (see Table 20).

Group main effects. Table 21 shows least-square means for each of the outcomes by group for each cohort year and Tukey-Kramer post hoc comparisons. Most notably, the AP course and exam group significantly outperformed the AP course only and other courses groups for all cohort years and outcomes. In addition, the

Table 19

Four-Year Graduation Rates* for Significant Logistic Regression Main Effects for AP Spanish Language: Group, Ethnicity, and Gender

High School Graduation Cohort Year	*Group (N-size)*	*Graduation Rate (%) (n-size)*	*Ethnicity† (n-size)*	*Graduation Rate (%) (n-size)*	*Gender (n-size)*	*Graduation Rate (%) (n-size)*
1998‡	AP Course/Exam *(478)*	38.08_a *(182)*	Asian American *(170)*	44.71 *(76)*		
	AP Course Only *(446)*	31.17_b *(139)*	Hispanic *(684)*	20.61_b *(141)*		
	AP Exam Only *(451)*	37.92 *(171)*	White *(999)*	38.44_a *(384)*		
	Other Course (478)	22.80_b *(109)*				
1999‡	AP Course/Exam *(616)*	38.31_a *(236)*	Asian American *(218)*	50.00 *(109)*	Female *(1,396)*	38.11_a *(532)*
	AP Course Only *(546)*	32.42_b *(177)*	Hispanic *(945)*	19.47_b *(184)*	Male *(960)*	26.56_b *(255)*
	AP Exam Only *(578)*	37.54 *(217)*	White *(1,193)*	41.41_a *(494)*		
	Other Course *(616)*	25.49_b *(157)*				
2000	AP Course/Exam *(1,021)*	$38.69_{a,}$ *(395)*	Asian American (289)	51.56 *(149)*	Female *(2,137)*	35.75_a *(764)*
	AP Course Only *(809)*	34.36_b *(278)*	Hispanic (1,459)	18.44_b *(269)*	Male *(1,334)*	28.41_b *(379)*
	AP Exam Only *(620)*	28.71 *(178)*	White (1,723)	42.08_a *(725)*		
	Other Course *(1,021)*	28.60_b *(292)*				
2001	AP Course/Exam *(1,154)*	40.12_a *(463)*	Asian American *(315)*	50.48 *(159)*	Female *(2,255)*	37.83_a *(853)*
	AP Course Only *(796)*	35.55_b *(283)*	Hispanic *(1,659)*	22.06_b *(366)*	Male *(1,499)*	29.02_b *(435)*
	AP Exam Only *(650)*	33.54 *(218)*	White *(1,780)*	42.87_a *(763)*		
	Other Course *(1,154)*	28.08_b *(324)*				

Note: Significance level for α was $p < .01$. Within the same year and column, rates with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions. 2000-01 dual enrollment cohort year groups were excluded from the logistic regression analyses due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. Gender was excluded from the set of independent variables analyzed for the subjects relevant to AP Spanish Language in the 1998 cohort year due to some cell *n*'s < 10 in the full-factorial group by ethnicity by gender design. This resulted in a logistic regression analysis for 1998 that included group and ethnicity only.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† For 1998–2001 cohort years for Spanish Language analyses, African Americans were excluded due to some cell *n*'s < 10 in the full-factorial group by ethnicity and group by ethnicity by gender designs.

‡ Dual enrollment data were unavailable before the 2000 cohort year.

Table 20

Significant MANOVA, ANOVA, and Logistic Regression Effects: Aggregated Groups*

	Years Significant by High School Graduate Cohort Year					
	Multivariate Outcome Composite	*Univariate College Outcomes*				*Logistic Regression Outcome†*
Type of Effect	*First- & Fourth-Year GPA and First- & Fourth-Year Credits*	*First-Year GPA*	*Fourth-Year GPA‡*	*First-Year Credit Hours Earned*	*Fourth-Year Credit Hours Earned‡*	*Four-Year Graduation Rate‡*
SAT Rank	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998-2001
FRPL Status	1998–2002	2002	1998–2001	1998–2002	1998–2001	1998-2001
Group	1998–2002	1998–2002	1998–2001	1998–2002	1998–2001	1998-2001
Group by SAT Rank	1999–2002	1999–2002	N.S.	1999, 2002	N.S.	
Group by FRPL Status	1999–2000, 2002	N.S.	N.S.	1999, 2002	1999–2000	
FRPL Status by SAT Rank	1998	N.S.	N.S.	1998	N.S.	
Group by FRPL Status by SAT Rank	N.S.					

Note: Significance level for α ($p < .01$). N.S. = nonsignificant effect for outcome in all cohort years studied.

* Aggregated groups were exclusively formed by including students who had: (a) completed both an AP course and exam in any AP subject, (b) taken an AP Exam only in any AP subject; (c) completed an AP course only in any subject; (d) completed a dual enrollment course only in any subject equivalent to an AP subject; and (d) completed only other courses from the regular high school curriculum.

† Logistic regression models assumed no interactions.

‡ Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

Table 21

Least-Square Means by Outcome for the Significant ANOVA Effect: Group

High School Graduation Cohort Year	*Group (N-size)*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
1998†	AP Course and Exam *(8,178)*	$2.77_{a,c}$	$2.79_{a,c}$	$26.38_{a,c}$	$100.97_{a,c}$
	AP Course Only *(8,772)*	$2.62_{a,d}$	$2.68_{a,d}$	$25.12_{a,d}$	$96.98_{a,d}$
	AP Exam Only *(1,922)*	$2.74_{a,c}$	$2.78_{a,c}$	25.75_{a}	100.11_{a}
	Other Courses *(20,035)*	2.51_{b}	2.57_{b}	23.52_{b}	90.43_{b}
1999†	AP Course and Exam *(10,712)*	$2.77_{a,c}$	$2.79_{a,c}$	$26.52_{a,c}$	$101.14_{a,c}$
	AP Course Only *(11,945)*	$2.61_{a,d}$	$2.66_{a,d}$	$24.70_{b,c}$	$94.58_{a,d}$
	AP Exam Only *(550)*	$2.78_{a,c}$	$2.80_{a,c}$	$24.35_{b,c}$	95.99_{a}
	Other Courses *(16,705)*	2.51_{b}	2.59_{b}	$22.67_{b,d}$	87.99_{b}
2000‡	AP Course and Exam *(13,129)*	2.79_{a}	2.81_{a}	26.04_{a}	100.23_{a}
	AP Course Only *(11,828)*	$2.66_{b,c}$	$2.69_{b,c}$	$24.41_{b,c}$	$95.07_{b,c}$
	Other Courses *(15,161)*	$2.53_{b,d}$	$2.59_{b,d}$	$22.21_{b,d}$	$87.70_{b,d}$
2001	AP Course and Exam *(14,888)*	2.81_{a}	2.82_{a}	26.46_{a}	100.51_{a}
	AP Course Only *(10,530)*	$2.66_{b,c}$	$2.70_{b,c}$	$24.60_{b,c}$	$95.11_{b,c}$
	AP Exam Only *(388)*	2.67	2.71	$24.44_{b,c}$	92.65_{b}
	Other Courses *(14,911)*	$2.55_{b,d}$	$2.60_{b,d}$	$22.65_{b,d}$	$88.04_{b,d}$
	Dual Enrollment *(1,482)*	2.64_{b}	2.66_{b}	$24.84_{b,c}$	93.19_{b}
2002§	AP Course and Exam *(19,223)*	2.71_{a}	--	23.56_{a}	--
	AP Course Only *(12,969)*	$2.49_{b,c}$	--	$22.09_{b,c}$	--
	AP Exam Only *(1,175)*	$2.57_{b,c}$	--	21.45_{b}	--
	Other Courses *(23,848)*	$2.36_{b,d}$	--	$20.25_{b,d}$	--
	Dual Enrollment *(2,316)*	$2.53_{b,c}$	--	22.34_{c}	--

Note: Significance level for α was $p < .01$. Within the same year and column, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*) differed significantly.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Dual enrollment data were unavailable before the 2000 cohort year.

‡ Dual enrollment and AP Exam only groups were excluded from the MANOVA in cohort year 2000 due to some cell *n*'s < 10.

§ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

AP course only group significantly exceeded the other courses group in all cohort years on all outcomes. Means for the AP course and exam group generally exceeded means of the two remaining groups—AP Exam only and dual enrollment. In fact, means for the AP course and exam group were significantly greater than (a) dual enrollment group means across all outcomes in 2001 and for first-year GPA in 2002 and (b) AP Exam only group means for first- and fourth-year credit hours in 2001 and for first-year GPA and first-year credit hours in 2002. In general, all three types of AP groups and the dual enrollment group outperformed the other courses group on all outcomes.

FRPL status main effects. Non-FRPL participants significantly outperformed FRPL participants in terms of: (a) fourth-year GPAs and fourth-year credit hours earned (1998–2001), (b) 2002 first-year GPA, and (c) first-year credit hours earned (1998–2002) (see Table 22). FRPL status was nonsignificant for 1998–2001 first-year GPA.

SAT rank main effects. Table 23 shows that students in the top SAT rank 4 category (SAT total score of 1090 or above) earned significantly higher mean first-year and fourth-year GPAs than students in the lower three categories in all years according to the Tukey-Kramer tests. Similarly, this pattern held for each lower SAT rank category with respect to the categories or category below it. For example, mean first-year and fourth-year GPAs were higher for students in the SAT rank (3) category (SAT total scores of 980–1080) than in the categories below rank (3). However, this same pattern was somewhat less consistent regarding mean first- and fourth-year credit hours earned, although students in the SAT rank

Table 22

Least-Square Means by Outcome for the Significant ANOVA Effect: FRPL Status

High School Graduation Cohort Year	*FRPL Status (N-size)*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
1998	FRPL *(5,423)*	2.65†	2.68_{a}	24.71_{a}	94.90_{a}
	Non-FRPL *(33,484)*	2.66†	2.73_{b}	25.58_{b}	98.44_{b}
1999	FRPL *(5,603)*	2.65†	2.68_{a}	24.05_{a}	93.00_{a}
	Non-FRPL *(34,309)*	2.69†	2.74_{b}	24.98_{b}	96.39_{b}
2000	FRPL *(5,581)*	2.65†	2.68_{a}	23.63_{a}	92.05_{a}
	Non-FRPL *(34,537)*	2.68†	2.72_{b}	24.81_{b}	96.60_{b}
2001	FRPL *(6,107)*	2.64†	2.66_{a}	24.03_{a}	90.55_{a}
	Non-FRPL *(36,092)*	2.69†	2.73_{b}	25.16_{b}	97.25_{b}
2002‡	FRPL *(10,054)*	2.47_{a}	--	21.56_{a}	--
	Non-FRPL *(49,477)*	2.59_{b}	--	22.31_{b}	--

Note: Significance level for α was $p < .01$. Within the same year and column, means with nonmatching subscripts differed significantly.
* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.
† Nonsignificant effect for outcome within cohort year.
‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

Table 23

Least-Square Means by Outcome for the Significant ANOVA Effect: SAT Rank

High School Graduation Cohort Year	*SAT Rank (N–size)*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA**	*First-Year Credit Hours*	*Fourth-Year Credit Hours**
1998	(1) SAT≤850 *(7,681)*	2.39_{a}	2.43_{a}	21.02_{a}	87.05_{a}
	(2) SAT: 860–970 *(9,109)*	$2.56_{b,c}$	$2.63_{b,c}$	$24.86_{b,c}$	$96.18_{b,c}$
	(3) SAT: 980–1080 *(9,020)*	$2.76_{b,d,e}$	$2.80_{b,d,e}$	$26.82_{b,d,e}$	$101.85_{b,d}$
	(4) SAT≥1090 *(13,097)*	$2.92_{b,d,f}$	$2.97_{b,d,f}$	$28.06_{b,d,f}$	$103.42_{b,d}$
1999	(1) SAT≤850 *(7,865)*	2.39_{a}	2.43_{a}	20.12_{a}	84.14_{a}
	(2) SAT: 860–970 *(9,237)*	$2.62_{b,c}$	$2.66_{b,c}$	$24.29_{b,c}$	$94.96_{b,c}$
	(3) SAT: 980–1080 *(9,184)*	$2.74_{b,d,e}$	$2.79_{b,d,e}$	$26.67_{b,d}$	$100.27_{b,d}$
	(4) SAT≥1090 *(13,626)*	$2.93_{b,d,f}$	$2.96_{b,d,f}$	$27.16_{b,d}$	$100.33_{b,d}$
2000	(1) SAT≤850 *(7,810)*	2.40_{a}	2.45_{a}	20.74_{a}	85.13_{a}
	(2) SAT: 860–970 *(9,217)*	$2.58_{b,c}$	$2.63_{b,c}$	$24.10_{b,c}$	$94.46_{b,c}$
	(3) SAT: 980–1080 *(9,034)*	$2.76_{b,d,e}$	$2.79_{b,d,e}$	$25.38_{b,d,e}$	$98.11_{b,d}$
	(4) SAT≥1090 *(14,057)*	$2.90_{b,d,f}$	$2.92_{b,d,f}$	$26.65_{b,d,f}$	$99.62_{b,d}$
2001	(1) SAT≤850 *(8,475)*	2.40_{a}	2.42_{a}	21.10_{a}	84.23_{a}
	(2) SAT: 860–970 *(9,736)*	$2.59_{b,c}$	$2.64_{b,c}$	$24.41_{b,c}$	$94.52_{b,c}$
	(3) SAT: 980–1080 *(9,769)*	$2.76_{b,d,e}$	$2.78_{b,d,e}$	$26.11_{b,d}$	97.66_{b}
	(4) SAT≥1090 *(14,219)*	$2.92_{b,d,f}$	$2.94_{b,d,f}$	$26.77_{b,d}$	$99.20_{b,d}$
2002†	(1) SAT≤850 *(14,215)*	2.22_{a}	--	18.53_{a}	--
	(2) SAT: 860–970 *(13,903)*	$2.49_{b,c}$	--	$22.14_{b,c}$	--
	(3) SAT: 980–1080 *(12,946)*	$2.59_{b,d,e}$	--	$22.89_{b,c}$	--
	(4) SAT≥1090 (18,467)	$2.83_{b,d,f}$	--	$24.18_{b,d}$	--

Note: Significance level for α was $p < .01$. Within the same year and column, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly.
* Fourth-year college outcome measures were unavailable for analysis in 2002.
† 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

Table 24

Least-Square Means for 1999–2002 First-Year GPA for the Significant ANOVA Interaction: Group by SAT Rank

High School Graduation Cohort Year	*SAT Rank (N-size)*	*Group*				
		AP Course and Exam	*AP Course Only*	*AP Exam Only**	*Other Courses*	*Dual Enrollment†*
1999	(1) SAT≤850 *(7,865)*	2.43	2.34	2.50	2.30	--
	(2) SAT: 860–970 *(9,237)*	2.70_{a}	$2.54_{b,c}$	2.80_{e}	$2.44_{b,d,f}$	--
	(3) SAT: 980–1080 *(9,184)*	2.87_{a}	$2.72_{b,c}$	2.80	$2.58_{b,d}$	--
	(4) SAT≥1090 *(13,626)*	3.08_{a}	2.86_{b}	3.04	2.72_{b}	--
2000	(1) SAT≤850 *(7,810)*	2.47_{a}	2.43_{c}	--	$2.30_{b,d}$	--
	(2) SAT: 860–970 *(9,217)*	2.71_{a}	$2.59_{b,c}$	--	$2.46_{b,d}$	--
	(3) SAT: 980–1080 *(9,034)*	2.88_{a}	2.74_{b}	--	2.66_{b}	--
	(4) SAT≥1090 *(14,057)*	3.10_{a}	2.90_{b}	--	2.71_{b}	--
2001	(1) SAT≤850 *(8,475)*	2.51_{a}	2.47_{c}	2.32	$2.35_{b,d}$	2.37
	(2) SAT: 860–970 *(9,736)*	2.75_{a}	$2.62_{b,c}$	2.63	$2.50_{b,d}$	2.44_{b}
	(3) SAT: 980–1080 *(9,769)*	2.88_{a}	2.74_{b}	2.84	2.63_{b}	2.72
	(4) SAT≥1090 *(14,219)*	3.09_{a}	2.84_{b}	2.90	2.72_{b}	3.03
2002‡	(1) SAT≤850 *(14,215)*	2.37_{a}	2.25_{c}	2.24	$2.11_{b,d}$	2.13
	(2) SAT: 860–970 *(13,903)*	2.62_{a}	$2.44_{b,c}$	2.59_{e}	$2.30_{b,d,f}$	2.48
	(3) SAT: 980–1080 *(12,946)*	2.79_{a}	$2.57_{b,c}$	2.54	$2.41_{b,d}$	2.66
	(4) SAT≥1090 *(18,467)*	3.05_{a}	2.71_{b}	2.92_{b}	2.61_{b}	2.84

Note: Significance level for α was $p < .01$. Within the same year and row, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly. A number of other significant mean differences for post hoc comparisons by outcome and year are not shown above.
* AP Exam only and dual enrollment groups were excluded from the MANOVA in cohort year 2000 due to some cell *n*'s < 10.
† No dual enrollment group data were available prior to 2000.
‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

(1) category (SAT total scores of 850 or below) always earned significantly fewer mean credit hours than those with higher SAT ranks. Students in the SAT rank (2) category (SAT total scores of 860–970) earned fewer mean credit hours than those with higher SAT ranks, except for fourth-year credit hours earned by the 2001 cohort.

ANOVA Interactions and Post Hoc Comparisons

The most frequent ANOVA interaction was group by SAT rank—four years (1999–2001) for first-year GPA and two

Table 25

Least-Square Means for First-Year Credit Hours for Significant ANOVA Interaction: Group by SAT Rank

High School Graduation Cohort Year	*SAT Rank (N-size)*	*Group*				
		AP Course and Exam	*AP Course Only*	*AP Exam Only*	*Other Courses*	*Dual Enrollment**
1999	(1) SAT≤850 *(7,865)*	22.83_{a}	$21.20_{b,c}$	$17.60_{b,d}$	$18.86_{b,d}$	--
	(2) SAT: 860–970 *(9,237)*	26.09_{a}	$24.50_{b,c}$	24.11	$22.46_{b,d}$	--
	(3) SAT: 980–1080 *(9,184)*	27.95_{a}	$25.95_{b,c}$	28.43_{e}	$24.35_{b,d,f}$	--
	(4) SAT≥1090 *(13,626)*	29.19_{a}	$27.16_{b,c}$	27.27	$25.02_{b,d}$	--
2002†	(1) SAT≤850 *(14,215)*	20.87_{a}	$19.24_{b,c}$	17.28_{b}	$16.26_{b,d,e}$	18.98_{f}
	(2) SAT: 860–970 *(13,903)*	23.66_{a}	22.70_{c}	21.21_{b}	$20.11_{b,d,e}$	23.04_{f}
	(3) SAT: 980–1080 *(12,946)*	24.44_{a}	22.95_{b}	22.56	21.74_{b}	22.76
	(4) SAT≥1090 *(18,467)*	25.25_{a}	23.45_{b}	24.73	22.91_{b}	24.58

Note: Significance level for α was $p < .01$. Within the same year and row, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly. A number of other significant mean differences for post hoc comparisons by outcome and year are not shown above.
* No dual enrollment group data were available prior to 2000.
† 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

Table 26

Least-Square Means by Outcome for the Significant ANOVA Interaction: Group by FRPL Status

College Outcomes	*High School Graduation Cohort Year*	*FRPL Status (N-size)*	*Group*				
			AP Course and Exam	*AP Course Only*	*AP Exam Only*	*Other Courses*	*Dual Enrollment**
First-Year Credit Hours	1999	FRPL *(5,603)*	26.38_{a}	$24.08_{b,c}$	23.87	$21.84_{b,d}$	--
		Non-FRPL *(34,309)*	26.65_{a}	$25.32_{b,c}$	24.83_{b}	$23.50_{b,d}$	--
	2002†,‡	FRPL *(10,054)*	23.66_{a}	$21.67_{b,c}$	21.15_{b}	$19.71_{b,d}$	21.59
		Non-FRPL *(49,477)*	23.45_{a}	$22.50_{b,c}$	21.74_{b}	$20.79_{b,d}$	23.09
Fourth-Year Credit Hours	1999	FRPL *(5,603)*	100.35_{a}	$91.68_{b,c}$	95.56_{e}	$84.40_{b,d,f}$	--
		Non-FRPL *(34,309)*	100.90_{a}	$97.48_{b,c}$	96.42	$91.58_{b,d}$	--
	2000§	FRPL *(5,581)*	99.07_{a}	$92.66_{b,c}$	--	$84.43_{b,d}$	--
		Non-FRPL *(34,537)*	101.38_{a}	$97.47_{b,c}$	--	$90.97_{b,d}$	--

Note: Significance level for α was $p < .01$. Within the same outcome, year, and row, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly. A number of other significant mean differences for post hoc comparisons by outcome and year are not shown above.

* Dual enrollment data were unavailable before the 2000 cohort year.

† Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

§ Dual enrollment and AP Exam only groups were excluded from the MANOVA in cohort year 2000 due to some cell *n*'s < 10.

years (1999 and 2002) for first-year credit hours earned (see Table 20). The next most frequent interaction was group by FRPL status—two years (1999 and 2002) for first-year credit hours earned and two years (1999–2000) for fourth-year credit hours earned. The FRPL status by SAT rank interaction was significant in 1998 only for first-year credit hours earned.

Group by SAT rank interactions for first-year GPA. Table 24 includes mean first-year GPAs by group and SAT rank for 1999–2002 cohorts and significant Tukey-Kramer post hoc comparisons among group means within each SAT rank category. Except in the lowest SAT rank category, students in the AP course and exam group obtained significantly higher first-year GPAs than those in the AP course only and other courses groups. For 2000–02 cohorts, moreover, AP course and exam students in the lowest SAT rank group posted significantly higher first-year GPAs than their peers in the other courses group. Thus, in terms of first-year GPA, the advantage of the AP course and exam experience over experiences of the AP course only and other courses groups generally held across the four SAT rank categories despite GPA differences related to SAT rank.

Group by SAT rank interactions for first-year credit hours. Table 25 provides mean first-year credit hours earned for the group by SAT rank ANOVA interaction in 1999 and 2002 and significant Tukey-Kramer post hoc comparisons among groups within SAT rank category. Within each SAT rank, students in the AP course and exam group generally averaged a significantly greater number of first-year credits than those in the AP course only and other courses groups. The one exception was a nonsignificant difference between the AP course and exam and AP course only groups within the next to lowest SAT rank category (860–970) in the 2002 cohort. Thus, for first-year credits, the AP course and exam advantage over the AP course only and other courses experiences generally extended across SAT rank categories.

Group by FRPL status interactions for credit hours outcomes. Table 26 includes both 1999 and 2002 mean first-year and 1999–2000 mean fourth-year credit hours earned for the significant group by FRPL status ANOVA interactions and significant Tukey-Kramer post hoc

Table 27

Least-Square Means for First-Year Credit Hours Earned for the Significant ANOVA Interaction: SAT Rank by FRPL Status

FRPL Status (N-size)	*SAT Rank*			
	(1) SAT≤850	*(2) SAT: 860–970*	*(3) SAT: 980–1080*	*(4) SAT≥1090*
1998				
FRPL *(5,423)*	19.84_{a}	24.30	26.53	28.15
Non-FRPL *(44,922)*	22.21_{b}	25.42	27.12	27.97

Note: Significance level for α was $p < .01$. Within the same column, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*) differed significantly. A number of other significant mean differences for post hoc comparisons by outcome and year are not shown above.

comparisons among groups within FRPL and non-FRPL statuses. Regardless of FRPL status, AP course and exam students earned significantly more first- and fourth-year credits than AP course only and other courses students. AP course only students also earned significantly more first- and fourth-year credits than other courses students within both FRPL and non-FRPL groups.

SAT rank by FRPL status interaction. Both FRPL and non-FRPL students in the 1998 cohort earned a higher number of credit hours in the first year as their SAT rank went up, but FRPL students at the lowest SAT rank earned significantly fewer credit hours than non-FRPL students (see Table 27).

Logistic Regression Analyses

Significant SAT rank, FRPL status, and group logistic regression main effects matched the MANOVA results of 1998–2001 (see Table 20). However, inclusion of the SAT rank by group interaction beyond the three main effect predictors failed to substantially improve model fit, so only the main effects model was used (no interactions assumed).

Group main effects. In all four years (1998–2001), four-year graduation rates for the AP course and exam group surpassed 36 percent, significantly above rates achieved by the AP course only, dual enrollment, or other courses groups (see Table 28). Graduation rates for the other courses group were lowest among groups in all four years, failing to exceed 14 percent.

FRPL status main effects. Table 28 notes four-year graduation rates by FRPL participation status. For the 1998–2001 cohorts, rates for non-FRPL participants were significantly higher than those for FRPL participants (e.g., 13.17 percent for the FRPL group versus 25.72 percent for the non-FRPL group in 2001).

SAT rank main effects. Compared to group and FRPL status, Table 28 displays the most marked disparities in four-year graduation rates based on SAT rank categories.

Table 28

Four-Year Graduation Rates* for Significant Logistic Regression Main Effects: Group, FRPL Status, and SAT Rank

High School Graduation Cohort Year	*Group (N-size)*	*Graduation Rate (%) (n-size)*	*FRPL Status (n-size)*	*Graduation Rate (%) (n-size)*	*SAT Rank†* *(n-size)*	*Graduation Rate (%) (n-size)*
1998‡	AP Course/Exam *(8,178)*	37.38_a *(3,057)*	FRPL *(5,423)*	12.63_b *(685)*	*(1)* *(7,681)*	7.59_b *(583)*
	AP Course Only *(8,772)*	22.73_b *(1,994)*	Non-FRPL *(33,484)*	23.34_a *(7,815)*	*(2)* *(9,109)*	15.47_b *(1,409)*
	AP Exam Only *(1,922)*	33.14 *(637)*			*(3)* *(9,020)*	22.58_b *(2,037)*
	Other Courses *(20,035)*	14.04_b *(2,812)*			*(4)* *(13,097)*	34.14_a *(4,471)*
1999‡	AP Course/ Exam *(10,712)*	37.14_a *(3,978)*	FRPL *(5,603)*	12.31_b *(690)*	*(1)* *(7,865)*	7.51_b *(591)*
	AP Course Only *(11,945)*	21.65_b *(2,586)*	Non-FRPL *(34,309)*	23.79_a *(8,163)*	*(2)* *(9,237)*	14.73_b *(1,361)*
	AP Exam Only *(550)*	28.00 *(154)*			*(3)* *(9,184)*	23.38_b *(2,147)*
	Other Courses *(16,705)*	12.78_b *(2,135)*			*(4)* *(13,626)*	34.89_a *(4,754)*
2000§	AP Course/Exam *(13,129)*	38.00_a *(4,989)*	FRPL *(5,581)*	12.78_b *(713)*	*(1)* *(7,810)*	7.66_b *(598)*
	AP Course Only *(11,828)*	22.67_b *(2,681)*	Non-FRPL *(34,537)*	25.50_a *(8,806)*	*(2)* *(9,217)*	15.96_b *(1,471)*
	Other Courses *(15,161)*	12.20_b *(1,849)*			*(3)* *(9,034)*	23.84_b *(2,154)*
					(4) *(14,057)*	37.68_a *(5,296)*
2001	AP Course/Exam *(14,888)*	36.96_a *(5,503)*	FRPL *(6,107)*	13.17_b *(804)*	*(1)* *(8,475)*	7.62_b *(646)*
	AP Course Only *(10,530)*	22.94_b *(2,416)*	Non-FRPL *(36,092)*	25.72_a *(9,284)*	*(2)* *(9,736)*	15.93_b *(1,551)*
	AP Exam Only *(388)*	25.00 *(97)*			*(3)* *(9,769)*	24.61_b *(2,404)*
	Other Courses *(14,911)*	11.48_b *(1,712)*			*(4)* *(14,219)*	38.59_a *(5,487)*
	Dual Enrollment *(1,482)*	24.29_b *(360)*				

Note: Significance level for α was $p < .01$. Within the same year and column, rates with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† SAT rank categories included: (1) SAT Total score ≤ 850, (2) SAT: 860–970, (3) SAT: 980–1080, (4) SAT ≥ 1090.

‡ Dual enrollment data were unavailable before the 2000 cohort year.

§ Dual enrollment and AP Exam only groups were excluded from the 2000 logistic regression in keeping with the 2000 MANOVA design due to some cell *n*'s < 10.

Four-year graduation rates for students in the bottom SAT rank 1 group hovered just above 7.5 percent, while those in the upper SAT rank 4 group exceeded 34 percent for 1998–2001 cohorts. Graduation rates for the top SAT rank 4 group were significantly above rates obtained in each of the three lower SAT rank 1–3 groups.

Research Question 3 Results: Group/AP Grade Comparisons by SAT Rank and FRPL Participation

Similar to Research Question 2, students with the various types of aggregated AP experiences were examined again, but new groups were created by using four rounded mean AP grade categories (1, 2, 3, 4–5) to subdivide the AP course and exam group in Research Question 3 analyses. Small sample size prevented a similar subdivision of the AP Exam only group; thus, it was excluded from analyses. Then, controlling for SAT rank and FRPL participation, college outcomes were compared among seven groups—four AP course and exam grade groups and the AP courses only, dual enrollment courses only, and the other courses only groups. Analyses used the 2001 cohort only.

MANOVA

Even with a reconstituted group, or AP grade groups (group/AP grade) variable, significant MANOVA effects—group/AP grade, FRPL status, and SAT rank—were parallel to significant effects for the Research Question 2 2001 MANOVA. Significant MANOVA statistics for the 2001 group/AP grade results included: (a) *group/AP grade*—Wilks' $\Lambda = .9840$, $F(24, 145657) = 28.08$, $p < .0001$; (b) *FRPL status*—Wilks' $\Lambda = .9991$, $F(4, 41752) = 9.135$, $p < .0001$; (c) *SAT rank*—Wilks' $\Lambda = .9842$, $F(12, 110466) = 55.55$, $p < .0001$; and (d) *group/AP grade by SAT rank interaction*—Wilks' $\Lambda = .9962$, $F(72, 164182) = 2.22$, $p < .0001$.

ANOVA Main Effects and Post Hoc Comparisons

As in the related MANOVA, similar significant effects—group{/AP grade}, FRPL status, SAT rank, and the SAT rank by group{/AP grade} interaction—were found in the ANOVAs for three college outcomes (fourth-year GPA and first- and fourth-year credit hours earned). Except for FRPL status, ANOVA effects were also significant for first-year GPA. In addition, a number of Tukey-Kramer post hoc comparisons were statistically significant.

Group/AP grade main effect. The AP course and

Table 29

Least-Square Means for the Significant Univariate Main Effects: 2001 Group/AP Grade Analysis

Type of Main Effect (N-size)	*Independent Variable Groups/Categories (N-size)*	*College Outcomes*			
		*First-Year GPA**	*Fourth-Year GPA*	*First-Year Credit Hours*	*Fourth-Year Credit Hours*
Group/AP Grade†,‡,§	AP Course & Exam (1) *(2,572)*	2.61_{a}	2.65_{a}	$25.45_{a,e}$	98.10_{c}
	AP Course & Exam (2) *(5,318)*	$2.83_{b,c,e,g}$	$2.85_{b,c,e,g}$	$26.87_{b,c,e,g}$	$101.31_{a,c,e}$
	AP Course & Exam (3) *(4,475)*	$2.88_{b,c,e,g}$	$2.89_{b,c,e,g}$	$26.46_{c,e}$	$100.48_{a,c,e}$
	AP Course & Exam (4) *(2,523)*	$2.96_{b,c,e,g}$	$2.95_{b,c,e,g}$	25.45_{e}	97.33_{c}
	AP Course Only *(10,530)*	$2.66_{d,e}$	$2.70_{d,e}$	$24.60_{d,e}$	$95.11_{b,c}$
	Other Courses *(14,911)*	2.55_{f}	2.60_{f}	22.65_{f}	88.04_{d}
	Dual Enrollment *(1,482)*	2.64_{h}	2.66_{h}	24.84_{h}	93.19_{f}
FRPL Status	FRPL *(5,983)*	2.71	2.73_{a}	24.88_{a}	94.09_{a}
	Non-FRPL *(35,828)*	2.76	2.78_{b}	25.50_{b}	98.36_{b}
SAT Rank	(1) SAT≤850 *(8,373)*	2.49_{a}	2.51_{a}	21.76_{a}	87.63_{a}
	(2) SAT: 860–970 *(9,651)*	$2.67_{b,c}$	$2.71_{b,c}$	$24.83_{b,c}$	$95.82_{b,c}$
	(3) SAT: 980–1080 *(9,679)*	$2.80_{b,d,e}$	$2.84_{b,d,e}$	$26.70_{b,d}$	$99.54_{b,d}$
	(4) SAT≥1090 *(14,108)*	$2.96_{b,d,f}$	$2.96_{b,d,f}$	$27.47_{b,d}$	$101.90_{b,d}$

Note: Significance level for α was $p < .01$. Within the same main effect and outcome (column), means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*, *g* vs. *h*) differed significantly.

* Nonsignificant FRPL status main effect for first-year GPA.

† The AP course and exam group was subdivided by rounded mean AP Exam grade categories so comparisons could be made to the AP course only, other courses, and dual enrollment groups.

‡ Rounded mean grades of 4–5 were combined for one of the AP course and exam grade/groups due to some cell *n*'s < 10.

§ The AP Exam only group was excluded from the MANOVA due to some cell *n*'s < 10.

exam groups with rounded mean AP grades of 2, 3, and 4–5 earned mean first- and fourth-year college GPAs that were significantly higher than the AP course and exam group with a mean AP grade of 1 and the AP course only, dual enrollment, and other courses groups (see Table 29). The AP course only group also posted significantly higher mean first- and fourth-year GPAs than the other courses group. In terms of first- and fourth-year credits, the AP course only and all AP course and exam groups significantly exceeded the other courses group. Moreover, the AP course and exam group with AP mean grades of 2 earned a significantly greater number of first-year college credits than the AP course and exam/mean grade 1 group and the AP course only and dual enrollment groups. In addition, the AP course and exam/mean grade 3 group significantly exceeded the AP course only and other courses group in first-year credits earned. AP course and exam/mean grade 2 and 3 groups also significantly outpaced the AP course only and dual enrollment groups in the mean number of fourth-year credits earned.

FRPL status main effect. FRPL participants earned significantly lower fourth-year GPAs and significantly fewer first- and fourth-year credit hours than non-FRPL students (see Table 29).

SAT rank main effect. All GPA and credit hours outcome means rose with SAT rank category (see Table 29). Also, all SAT rank groups differed significantly from all the other rank groups in terms of first- and fourth-year college GPAs. Except for nonsignificant differences between the fourth (highest) and third (next highest) SAT rank groups, all other SAT rank groups differed significantly in the mean number of first- and fourth-year credit hours earned.

ANOVA Interactions and Post Hoc Comparisons

The group/AP grade by SAT rank interaction was significant for all four 2001 ANOVA outcomes (see Table 30 for means for significant interactions by outcome). By comparison, the group by SAT rank interaction for Research Question 2 was significant only for first-year GPA in 2001 (see Table 20). Most likely, the use of the seven-group, group/AP grade variable in this analysis, rather than the five-group variable, contributed to these differences.

Group/AP grade by SAT rank interactions for GPA outcomes. Both first- and fourth-year GPAs rose generally with SAT rank regardless of students' group/AP grade category (see Table 30). Except within the lowest SAT rank for first-year GPA, the first- and fourth-year GPA means for the AP course and exam grade 1 group were always significantly lower than the other AP course and exam grade 2 group means. Within the top SAT rank group, moreover, mean first- and fourth-year GPAs for the AP course and exam grade 1 group were significantly less than all higher AP course and exam grade 2, 3, and 4–5 group means. Across SAT ranks, the least separation in mean GPAs occurred in

Table 30

Least-Square Means for the Significant Univariate ANOVA Interactions of Group by SAT Rank: 2001 Group/AP Grade Analysis

College Outcomes	*SAT Rank†* *(N-size)*	*Group/AP Grade**						
		Course & Exam(1)	*Course & Exam(2)*	*Course & Exam(3)*	*Course & Exam(4)*	*Course Only*	*Other Courses*	*Dual Enrollment*
First-Year GPA	1) 400–850 *(8,373)*	2.42	2.61_{a}	2.55	2.68	2.47_{c}	$2.35_{b,d}$	2.37
	2) 860–970 *(9,651)*	2.63_{a}	$2.83_{b,c}$	2.85_{e}	2.83_{g}	$2.62_{d,i}$	$2.50_{d,f,h,j}$	$2.44_{d,f,h}$
	3) 980–1080 *(9,679)*	2.70_{a}	$2.91_{b,c}$	$2.98_{b,e}$	2.95	$2.74_{d,f}$	$2.63_{d,f}$	2.72
	4) 1090+ *(14,108)*	2.68_{a}	$2.96_{b,c}$	$3.15_{b,d,e}$	$3.37_{b,d,f,g}$	$2.84_{b,f,h}$	$2.72_{d,f,h}$	3.03
Fourth-Year GPA	1) 400–850	2.45_{a}	$2.67_{b,c}$	2.61	2.65_{e}	$2.47_{d,g}$	$2.37_{d,f,h}$	2.35_{d}
	2) 860–970	2.67_{a}	$2.84_{b,c}$	2.81_{e}	2.86_{g}	2.65_{d}	$2.57_{d,f,h}$	$2.54_{d,h}$
	3) 980–1080	2.76_{a}	$2.92_{b,c}$	$2.99_{b,e}$	3.00_{g}	$2.81_{f,i}$	$2.68_{d,f,h,j}$	2.76
	4) 1090+	2.70_{a}	$2.96_{b,c}$	$3.14_{b,d,e}$	$3.30_{b,d,g}$	$2.86_{f,h}$	$2.78_{f,h}$	2.99
First-Year Credits	1) 400–850	23.29_{a}	23.87_{c}	21.86	20.90	21.63_{e}	$18.87_{b,d,f}$	21.87
	2) 860–970	25.52_{a}	26.76_{c}	25.70_{e}	25.33	$24.32_{d,g}$	$22.46_{b,d,f,h}$	23.70_{d}
	3) 980–1080	26.51_{a}	28.18_{c}	28.86_{e}	26.53	$25.82_{d,f}$	$24.45_{b,d,f}$	26.56
	4) 1090+	26.47_{a}	28.68_{c}	$29.42_{b,e}$	29.05_{g}	$26.64_{d,f,h}$	$24.83_{d,f,h}$	27.21
Fourth-Year Credits	1) 400–850	92.25_{a}	90.68_{c}	90.46_{e}	86.50	87.57_{g}	$78.01_{b,d,f,h}$	87.94
	2) 860–970	99.56_{a}	$102.73_{b,c}$	98.60_{e}	95.35	$94.72_{d,g}$	$88.84_{b,d,f,h}$	90.96_{d}
	3)980–1080	99.41_{a}	105.65_{c}	105.49_{e}	101.06	$99.19_{d,g}$	$91.81_{b,d,f,h}$	94.17
	4) 1090+	101.17	106.19_{a}	107.37_{c}	106.43_{e}	$98.96_{b,d}$	$93.52_{b,d,f}$	99.68

Note: Significance level for α was $p < .01$. *N*-sizes by row were the same within outcomes. Within the same outcome and row, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*, *g* vs. *h*, *i* vs. *j*) differed significantly. A number of other significant mean differences for post hoc comparisons by outcome and year are not shown above.

* Group/AP grade included the AP course and exam group subdivided by four AP rounded mean grade categories [(1) mean grade = 1, (2) mean grade = 2, (3) mean grade = 3, and (4) mean grade either 4 or 5], so comparisons could be made to the AP course only, other courses, and dual enrollment course groups.

† SAT rank categories included: (1) SAT Total score ≤ 850, (2) SAT: 860–970, (3) SAT: 980–1080, (4) SAT ≥ 1090.

the AP course and exam grade 1 group. Within the top SAT rank, the AP course and exam grade 4–5 group posted the highest GPAs among all group/AP grade and SAT rank combinations. Interestingly, the AP course and exam grade 2 group almost always achieved significantly higher mean GPAs than the other courses group, regardless of SAT rank.

Group/AP by SAT rank interaction for credit hours outcomes. In general, all AP and other non-AP groups earned increasing mean numbers of first- and fourth-year credits as their SAT ranks rose (see Table 30). Regardless of SAT rank, the AP course and exam grade 1 and 2 groups generally earned a significantly greater number of mean credits than the other courses group. Moreover, the AP course and exam grade 2 group generally averaged a significantly greater number of credits than the AP course only group across SAT rank groups. Regardless of group, the greatest separation in mean credit hours earned nearly always appeared between the SAT rank 1 and 2 groups rather than between higher adjacent rank groups. Within the highest SAT rank group, the AP course and exam grade 3 group averaged the most first- and fourth-year credit hours earned in comparison to the other groups, followed closely by the course and exam grade 4–5 and grade 2 groups.

Logistic Regression Results

Parallel to Research Question 2 MANOVA results for 2001, Table 31 contains equivalent significant main effects—group/AP grade, FRPL status, and SAT rank—from the logistic regression analysis of baccalaureate graduation. No interactions were assumed in this model.

Table 31 further shows that four-year college graduation rates for the AP course and exam/mean grade 1 (20.61 percent), AP course only (22.94 percent), dual enrollment (24.29 percent), and other courses (11.48 percent) groups were lower and differed significantly from the AP course and exam/mean grade 2 reference group (32.46 percent). While graduation rates for the AP course and exam/mean grade 3 and grade 4–5 groups were not significantly different from the AP course and exam/mean grade 2 designated reference group, they were higher at 44.13 and 50.42 percent, respectively. Other main effects showed non-FRPL participants graduating at significantly higher rates (25.69 percent) than FRPL participants (13.17 percent). Graduation rates also increased as SAT rank

Table 31

Four-Year Graduation Rates for the Significant Logistic Regression Main Effects: 2001 Group/AP Grade Analysis

Type of Main Effect	*Independent Variable Groups/Categories (N-size)*	*Number of Graduates*	*Graduation Rate (%)*
Group/AP Grade*,†,‡	AP Course & Exam (1) *(2,572)*	530	20.61_b
	AP Course & Exam (2) *(5,318)*	1,726	32.46_a
	AP Course & Exam (3) *(4,475)*	1,975	44.13
	AP Course & Exam (4) *(2,523)*	1,272	50.42
	AP Course Only *(10,530)*	2,416	22.94_b
	Other Courses *(14,911)*	1,712	11.48_b
	Dual Enrollment *(1,482)*	360	24.29_b
FRPL Status	FRPL *(5,983)*	788	13.17_b
	Non-FRPL *(35,828)*	9,203	25.69_a
SAT Rank§	(1) SAT ≤ 850 *(8,373)*	636	7.60_b
	(2) SAT: 860–970 *(9,651)*	1,538	15.94_b
	(3) SAT: 980–1080 *(9,679)*	2,378	24.57_b
	(4) SAT ≥ 1090 *(14,108)*	5,439	38.55_a

Note: Significance level for α was $p < .01$. Within the same outcome and column, means with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions.

* AP Group/Grade included the AP course and exam group subdivided by four AP rounded mean grade categories of (1) mean grade = 1, (2) mean grade = 2, (3) mean grade = 3, and (4) mean grade either 4 or 5, so comparisons could be made to the AP course only, other courses, and dual enrollment course groups.

† Rounded mean grades of 4–5 were combined for one of the AP course and exam grade/groups due to some cell *n*'s < 10.

‡ The AP Exam only group was excluded from the MANOVA due to some cell *n*'s < 10.

§ SAT rank categories included: (1) SAT Total score ≤850, (2) SAT: 860–970, (3) SAT: 980–1080, (4) SAT ≥ 1090.

category went up and each of the three lower SAT rank categories had significantly lower graduation rates (3: 24.57 percent, 2: 15.94 percent, 1: 7.60 percent) than those in the top category (38.55 percent).

Research Question 4 Results: Quality and Intensity of the AP Experience

Research Question 4 analyses compared college outcomes in relationship to both quality and intensity of the AP course and exam experience. This was done by examining students' rounded mean AP grade categories across exams and the numbers of AP courses and exams they took.

MANOVAs

Four significant multivariate effects emerged from MANOVAs executed with the 1998–2002 high school graduate cohorts for the composite college GPA and credits earned outcome (see Table 32). For example, significant differences appeared among multivariate means by rounded mean AP grade category [1998 cohort: Wilks' Λ = .9505, $F(12, 21502) = 34.72$, $p < .0001$; 1999 cohort: Wilks' Λ = .9411, $F(12, 28207) = 54.55$, $p < .0001$; 2000 cohort: Wilks' Λ = .9477, $F(12, 34559) = 59.09$, $p < .0001$; 2001 cohort: Wilks' Λ = .9512, $F(12, 39213) = 62.44$, $p < .0001$; 2002 cohort: Wilks' Λ = .9588, $F(6, 38316) = 96.84$, $p < .0001$)]. For 1998–2002 cohorts, all main effects—number of AP Exams taken, mean AP Exam grade, and number of AP courses completed—were significant, except for number of AP courses in the 1998 cohort. The number of AP Exams by AP grade interaction was also significant for all cohorts; however, no other interactions were significant.

ANOVA Main Effects and Post Hoc Comparisons

Two of the three ANOVA main effects—number of AP Exams taken and mean AP Exam grade—were significant across all high school graduate cohort years for all GPA outcomes (see Table 32). For first-year credit hours, mean AP grade and the number of exams main effects were statistically significant for all cohorts, except for first-year credits in the 2002 cohort. For fourth-year credits, mean AP grade was significant for all cohorts, except in 1999, while the number of exams was significant only for 1999–2000 cohorts. The third main effect, number of AP courses completed, was significant most often in 1999–2001 cohorts with fourth-year GPA and in 1999–2002 with first-year credit hours earned.

Number of AP Exams taken main effect. Table 33 presents least-square means for each of the outcomes by four categories of the number of AP Exams taken—1, 2, 3, and 4 or above (4+). Post hoc comparisons indicated that significantly higher first- and fourth-year GPAs were earned by those who had taken at least three AP Exams compared to those who had taken only one or two exams. In comparison, significantly different post hoc comparisons were more variable in terms of first-year credit hours earned across 1998–2001 cohorts but generally favored those who had taken at least three AP Exams versus fewer exams.

Mean AP grade main effect. Table 34 lists least-square means for four outcomes by four rounded mean AP grade categories—1, 2, 3, and 4–5. Mean first-year GPAs for 1998–2002 cohorts and mean fourth-year

Table 32

Significant MANOVA, ANOVA, and Logistic Regression Effects: AP Course and Exam Group Aggregate*

	Years Significant by High School Graduation Cohort					
	Multivariate Outcome Composite	*Univariate College Outcomes*				*Logistic Regression Outcome†*
Type of Effect	*First- & Fourth- Year GPA, First- & Fourth-Year Credits*	*First-Year GPA*	*Fourth-Year GPA‡*	*First-Year Credit Hours Earned*	*Fourth-Year Credit Hours Earned†*	*Fourth-Year Graduation Rate†*
Number of AP Exams	1998–2002	1998–2002	1998–2001	1998–2001	1999–2000	1998—2001
Mean AP Exam Grade	1998–2002	1998–2002	1998–2001	1998–2002	1998, 2000-01	1998—2001
Number of AP Courses	1999–2002	1999–2000	1999–2001	1999–2002	1999, 2001	1999—2001
Number of AP Exams by Mean AP Grade	1998–2002	1998–2002	1998–2001	2000-01	N.S.	
Number of AP Exams by Num. of AP Courses	N.S.					
Number of AP Courses by Mean AP Grade	N.S.					
Number of AP Exams by Mean AP Grade by Num. of AP Courses	N.S.					

Note: Significance level for α ($p < .01$). N.S. = nonsignificant effect for outcome in all cohort years studied.
* AP course and exam groups included students who had completed both an AP course and exam in any subject.
† Logistic regression models assumed no interactions.
‡ Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

Table 33

Least-Square Means by Outcome for Significant Univariate Effect: Number of AP Exams

High School Graduation Cohort Year	*Number of AP Exams* (N-size)*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA†*	*First-Year Credit Hours‡*	*Fourth-Year Credit Hours†,§*
1998	1 *(3,325)*	2.88_{a}	2.94_{a}	27.66_{a}	105.59
	2 *(2,005)*	2.90_{a}	2.92_{a}	27.48_{a}	104.35
	3 *(1,114)*	3.03_{b}	3.05_{b}	27.91_{a}	107.59
	4+ *(1,734)*	3.08_{b}	3.07_{b}	29.50_{b}	108.10
1999	1 *(3,944)*	2.92_{a}	2.94_{a}	27.39_{a}	103.28_{a}
	2 *(2,695)*	$2.95_{a,c}$	2.97	28.34_{b}	105.98
	3 *(1,535)*	3.04_{b}	3.02_{b}	28.43_{b}	107.35_{b}
	4+ *(2,538)*	$3.06_{b,d}$	3.03_{b}	29.08_{b}	106.25
2000	1 *(4,612)*	2.92_{a}	2.94_{a}	26.98_{a}	103.43_{a}
	2 *(3,046)*	2.93_{a}	2.95_{a}	$27.64_{a,c}$	104.02
	3 *(1,969)*	3.02_{b}	3.02_{b}	27.87_{b}	104.14
	4+ *(3,502)*	3.09_{b}	3.09_{b}	$28.80_{b,d}$	106.94_{b}
2001	1 *(4,906)*	2.91_{a}	2.92_{a}	27.25_{a}	102.99
	2 *(3,420)*	2.93_{a}	$2.96_{a,c}$	$27.44_{a,c}$	103.09
	3 *(2,259)*	3.02_{b}	3.01_{b}	28.21_{b}	104.42
	4+ *(4,303)*	3.04_{b}	$3.05_{b,d}$	$28.50_{b,d}$	104.19
2002**	1 *(6,034)*	2.86_{a}	--	23.77	--
	2 *(4,404)*	2.86_{a}	--	23.86	--
	3 *(2,950)*	2.98_{b}	--	24.34	--
	4+ *(5,835)*	3.01_{b}	--	24.22	--

Note: Significance level for α was $p < .01$. Within the same year and column, means with specific nonmatching subscript pairs (*a* vs. *b*, *c* vs. *d*) differed significantly.

* Numbers of AP Exams 4 and above were merged due to some cell *n*'s < 10.

† Fourth-year college outcomes were unavailable in 2002.

‡ Nonsignificant main effect for first-year credit hours in 2002.

§ Nonsignificant main effect for fourth-year credit hours in 1998 and 2001.

** 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

GPAs for 1998–2001 cohorts went up as average AP Exam grades increased, and all paired comparisons of higher versus lower AP Exam grade categories were significantly different. Students who had average AP Exam grades of 1 earned significantly fewer first- and fourth-year college credits than those who had AP Exam grade averages of 2 or above, with some exceptions in the 1999 cohort.

Number of AP courses main effect. For the 1999 cohort, post hoc mean comparisons revealed that students who had completed at least five AP courses earned significantly higher mean GPAs and credit hours than those who had completed three or fewer AP courses (see Table 35). Similar types of mean differences were evident but less consistent in the subsequent 2000-02 cohort years for students who had completed one or two AP courses versus those who had completed at least four or at least five courses.

ANOVA Interactions and Post Hoc Comparisons

The only significant MANOVA interaction was the number of AP Exams by mean AP grade interaction, which was significant for only three of the ANOVA outcomes—first- and fourth-year GPAs (1998–2002 and 1998–2001 cohorts, respectively) and first-year credit hours earned (2000-01 cohorts) (see Table 32).

Number of AP Exams by mean grade interaction for

Table 34

Least-Square Means by Outcome for Significant Univariate Effect: Mean AP Grade

High School Graduation Cohort Year	*Rounded Mean AP Grade* (N-size)*	*College Outcomes*			
		First-Year GPA	*Fourth-Year GPA†*	*First-Year Credit Hours*	*Fourth-Year Credit Hours†,‡*
1998	1 *(1,044)*	2.63_{a}	2.68_{a}	26.31_{a}	100.91_{a}
	2 *(2,585)*	$2.90_{b,c}$	$2.93_{b,c}$	28.46_{b}	108.14_{b}
	3 *(2,729)*	$3.07_{b,d,e}$	$3.08_{b,d,e}$	28.64_{b}	108.01_{b}
	4-5 *(1,820)*	$3.30_{b,d,f}$	$3.29_{b,d,f}$	29.14_{b}	108.57_{b}
1999	1 *(1,397)*	2.66_{a}	2.69_{a}	27.24_{a}	104.51
	2 *(3,533)*	$2.86_{b,c}$	$2.90_{b,c}$	28.34	105.70
	3 *(3,471)*	$3.12_{b,d,e}$	$3.12_{b,d,e}$	28.98_{b}	107.02
	4-5 *(2,311)*	$3.29_{b,d,f}$	$3.26_{b,d,f}$	28.67_{b}	105.63
2000	1 *(1,910)*	2.66_{a}	2.70_{a}	26.08_{a}	100.13_{a}
	2 *(4,531)*	$2.88_{b,c}$	$2.90_{b,c}$	28.06_{b}	105.78_{b}
	3 *(4,072)*	$3.08_{b,d,e}$	$3.09_{b,d,e}$	28.41_{b}	106.06_{b}
	4-5 *(2,616)*	$3.33_{b,d,f}$	$3.30_{b,d,f}$	28.74_{b}	106.56_{b}
2001	1 *(2,572)*	2.60_{a}	2.66_{a}	26.12_{a}	99.88_{a}
	2 *(5,318)*	$2.92_{b,c}$	$2.93_{b,c}$	28.20_{b}	105.83_{b}
	3 *(4,475)*	$3.09_{b,d,e}$	$3.09_{b,d,e}$	28.39_{b}	105.30_{b}
	4-5 *(2,523)*	$3.29_{b,d,f}$	$3.25_{b,d,f}$	28.70_{b}	103.69_{b}
2002§	1 *(3,298)*	2.54_{a}	--	23.12_{a}	--
	2 *(6,980)*	$2.84_{b,c}$	--	24.14_{b}	--
	3 *(5,772)*	$3.08_{b,d,e}$	--	24.40_{b}	--
	4-5 *(3,173)*	$3.24_{b,d,f}$	--	24.53_{b}	--

Note: Significance level for α was $p < .01$. Within the same year and column, means with nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly.

* Rounded mean grades 4–5 were merged due to some cell *n*'s < 10.

† Fourth-year college outcomes were unavailable in 2002.

‡ Nonsignificant main effect for fourth-year credit hours in 1999.

§ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

GPA outcomes. For the number of AP Exams by mean AP grade ANOVA interaction, Tables 36 and 37 show that students with mean AP grades of 1 derived the least first- or fourth-year GPA benefit from taking an increasing number of AP Exams, when compared to students with mean AP grades of 2–5. Students with mean 4–5 AP grades derived the greatest boosts in GPA as the number of AP Exams they took increased (cf. mean first-year GPA of 3.54 for cohort year 2000 students with 4–5 AP grade averages who had taken 4+ AP Exams). For those who took only one AP Exam, 1998–2002 first-year GPAs and 1998–2001 fourth-year GPAs were always statistically lower for those with a mean 1 AP grade than for those with mean 2–5 AP grades; this also was a frequent pattern for those taking more than one AP Exam, especially after the 1999 cohort year.

Number of AP Exams by mean grade interaction for first-year credits. Although interaction patterns were similar to patterns summarized above for first- and fourth-year GPAs, they were observed to a lesser degree. However, 2000-01 students who took only one AP Exam and who earned mean 1 AP grades completed significantly fewer first-year credit hours than students with mean 2 AP grades who took only one AP Exam (see Table 38). In addition, students who earned mean 1 AP grades *and* who took three AP Exams in cohort 2000 *or* who took two AP Exams in cohort 2001 compiled fewer mean first-year credits than those with higher mean AP Exam grades.

Logistic Regression Analyses

Significant main effect results from the logistic regression analyses of four-year baccalaureate graduation rates mirrored those obtained from the MANOVAs for the other four college outcomes (see Table 32). The number of AP Exams and the mean AP Exam grade main effects were significant for all years of available graduation rate data

Table 35

Least-Square Means by Outcome for Significant Univariate Effect: Number of AP Courses

High School Graduation Cohort Year	*Number of AP Courses*,†,‡ (N-size)*	*College Outcomes*			
		First-Year GPA§	*Fourth-Year GPA***	*First-Year Credit Hours*	*Fourth-Year Credit Hours*,††*
1999	1–3 *(5,692)*	2.96_a	2.96_a	27.62_a	103.31_a
	4 *(1,713)*	2.97	2.98	28.39	105.68
	5+ *(3,307)*	3.03_b	3.03_b	28.91_b	108.15_b
2000	1–2 *(4,095)*	2.91_a	2.96_a	27.14_a	103.40
	3 *(2,144)*	3.00	2.98	27.77	103.92
	4 *(2,069)*	3.02_b	3.04_b	28.02	105.73
	5+ *(4,821)*	3.02_b	3.01	28.37_b	105.48
2001	1–2 *(4,625)*	2.94	2.96	27.35_a	102.71
	3 *(2,429)*	2.98	2.98	27.83	103.15
	4 *(2,223)*	2.97	2.97	27.81	103.53
	5+ *(5,611)*	3.02	3.02	28.41_b	105.30
2002‡‡	1–2 *(6,914)*	2.89	--	23.61_a	--
	3 *(3,007)*	2.92	--	24.05	--
	4 *(2,670)*	2.95	--	23.98	--
	5+ *(6,632)*	2.95	--	24.55_b	--

Note: Significance level for α was $p < .01$. Within the same year and column, means with nonmatching subscripts differed significantly.
* Numbers of courses 1–3 were merged for 1998 and 1999 high school graduate cohorts due to some cell *n*'s < 10.
† Numbers of courses 5 and above were merged for 1998–2002 high school graduate cohorts due to some cell *n*'s < 10.
‡ Numbers of courses 1–2 were merged for 2000-02 high school graduate cohorts due to some cell *n*'s < 10.
§ Nonsignificant main effect for first-year GPA in 2001-02.
** Fourth-year college outcomes were unavailable in 2002.
†† Nonsignificant main effect for fourth-year credit hours in 2000-01.
‡‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

(1998–2001 cohort years), while the number of AP courses main effect was significant only for 1999–2001 high school graduate cohorts. Examination of Hosmer and Lemeshow Goodness-of-Fit chi-square test statistics indicated good model fit for using only three independent variables as main effects with 1999–2001 cohort data in the logistic regression analyses. Only two main effect variables—number of AP Exams and mean AP Exam grade—were used in the logistic regression with 1998 cohort data. Thus, no interactions were assumed in all logistic regression analyses.

Number of AP Exams and mean grade main effects. Table 39 lists four-year baccalaureate graduation rates by number of AP Exams taken and by mean AP Exam grades, respectively, across 1998–2001 cohorts. Graduation rates rose as the number of AP Exams taken went up and as mean AP grades increased. In all 1998–2001 cohort years, graduation rates for those reference students taking at least four exams were significantly higher (e.g., 1998: 51.27 percent) than for those who took a lower number of AP Exams (3 exams, 39.41 percent; 2 exams, 37.01 percent; 1 exam, 29.68 percent). Similarly, 1998–2001 reference group students who averaged 4–5 for AP grades graduated at significantly higher rates (e.g., 2001: 50.42 percent) than those with 1–3 average AP grades (3, 44.13 percent; 2, 32.46 percent; 1, 20.61 percent).

Number of courses main effect. Table 39 summarizes four-year baccalaureate graduation rates across cohort years 1999–2001 by the number of AP courses taken. Despite showing a pattern of graduation rates rising as the number of AP courses taken increased (e.g., 2000: 1–2, 29.18 percent; 3, 35.91 percent; 4, 39.00 percent; 5+, 45.99 percent), none of the post hoc comparisons with the reference group of at least five AP courses taken was significantly different. However, the number of AP courses main effect was statistically significant for all three years.

Discussion

This statewide study provided an extensive comparison of students' performance on several college outcomes—first- and fourth-year GPAs, first- and fourth-year credit hours earned, and four-year (baccalaureate)

Table 36

Least-Square Means for First-Year GPA for Significant Univariate Interaction: Rounded Mean AP Grade by Number of AP Exams

High School Graduation Cohort Year	*Number of AP Exams* (N-size)*	*Rounded Mean AP Grade*			
		1	*2*	*3*	*4–5*†
1998	1 *(3,325)*	2.57_{a}	$2.88_{b,c}$	2.94_{b}	$3.11_{b,d}$
	2 *(2,005)*	2.51_{a}	2.83_{a}	$3.02_{b,c}$	$3.25_{b,d}$
	3 *(1,114)*	2.76_{a}	2.90_{a}	3.17_{b}	3.31_{b}
	4+ *(1,734)*	2.68_{a}	2.97	$3.16_{b,c}$	$3.51_{b,d}$
1999	1 *(3,944)*	2.67_{a}	$2.86_{b,c}$	$3.06_{b,d}$	$3.08_{b,d}$
	2 *(2,695)*	2.65_{a}	2.83_{a}	$3.06_{b,c}$	$3.25_{b,d}$
	3 *(1,535)*	2.62_{a}	$2.89_{b,c}$	$3.19_{b,d}$	$3.36_{b,d}$
	4+ *(2,538)*	2.70_{a}	2.87_{a}	$3.19_{b,c}$	$3.48_{b,d}$
2000	1 *(4,612)*	2.72_{a}	$2.86_{b,c}$	$3.01_{b,d}$	$3.08_{b,d}$
	2 *(3,046)*	2.61_{a}	$2.85_{b,c}$	$3.03_{b,d,e}$	$3.22_{b,d,f}$
	3 *(1,969)*	2.53_{a}	$2.91_{b,c}$	$3.14_{b,d,e}$	$3.48_{b,d,f}$
	4+ *(3,502)*	2.78_{a}	$2.91_{b,c}$	$3.15_{b,d,e}$	$3.54_{b,d,f}$
2001	1 *(4,906)*	2.66_{a}	2.94_{b}	3.03_{b}	3.02_{b}
	2 *(3,420)*	2.55_{a}	$2.90_{b,c}$	$3.04_{b,d,e}$	$3.25_{b,d,f}$
	3 *(2,259)*	2.67_{a}	$2.91_{b,c}$	$3.13_{b,d,e}$	$3.38_{b,d,f}$
	4+ *(4,303)*	2.52_{a}	$2.95_{b,c}$	$3.19_{b,d,e}$	$3.50_{b,d,f}$
2002‡	1 *(6,034)*	2.59_{a}	$2.83_{b,c}$	$3.01_{b,d}$	$3.01_{b,d}$
	2 *(4,404)*	2.48_{a}	$2.76_{b,c}$	$3.00_{b,d,e}$	$3.18_{b,d,f}$
	3 *(2,950)*	2.58_{a}	$2.88_{b,c}$	$3.13_{b,d}$	$3.32_{b,d}$
	4+ *(5,835)*	2.51_{a}	$2.90_{b,c}$	$3.19_{b,d,e}$	$3.44_{b,d,f}$

Note: Significance level for α was $p < .01$. Within the same row, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly. A number of other significant mean differences for post hoc comparisons by outcome and year are not shown above.

* Numbers of AP Exams 4 and above were merged due to some cell *n*'s < 10.

† Rounded mean grades 4–5 were merged due to some cell *n*'s < 10.

‡ 2002 means based on all first-year enrollees; means for prior years based only on those with both first- and fourth-year data.

graduation status—by the various types of AP and non-AP experiences they had in high school. Students with AP experiences were subdivided into AP course and exam, AP course only, and AP Exam only groups, while those with non-AP experience were placed into dual enrollment only or other course only groups. Thus, the study provided a further examination of the types of AP and non-AP experiences analyzed in relationship to a variety of college outcomes, and the results were found to support the findings of previous studies (e.g., Dodd et al., 2002; Dougherty et al., 2006; Geiser and Santelices, 2004; Morgan and Maneckshana, 2000). Phase 1 of the study compared the AP and non-AP student groups on the college outcome measures related to seven AP Exams in five academic subject areas (English, mathematics, sciences, social sciences, and foreign language). Phase 2 made comparisons among aggregated groups based on students' experiences across one or more AP Exams, AP courses, and non-AP courses.

Key Findings

Research Questions 1–3 in Phases 1 and 2 addressed AP and non-AP group comparisons on the college outcomes, differing only on the independent variables analyzed for each question. Research Question 4 in Phase 2 addressed only comparisons within AP course and exam/AP mean grade groups with other independent variables.

Phase 1–Matched Group Comparisons Within Seven AP Subjects

Group main effects

With AP and non-AP groups matched on SAT rank and FRPL status, group main effects were statistically significant in the preponderance of Phase 1 MANOVA,

Table 37

Least-Square Means for Fourth-Year GPA for Significant Univariate Interaction: Rounded Mean AP Grade by Number of AP Exams

High School Graduation Cohort Year	*Number of AP Exams* (N-size)*	*Rounded Mean AP Grade*			
		1	*2*	*3*	*4–5*†
1998	1 *(3,325)*	2.64_{a}	$2.95_{b,c}$	3.00_{b}	$3.16_{b,d}$
	2 *(2,005)*	2.60_{a}	2.84_{a}	$3.03_{b,c}$	$3.22_{b,d}$
	3 *(1,114)*	2.80_{a}	2.92_{a}	3.16_{b}	3.34_{b}
	4+ *(1,734)*	$2.69_{a,c}$	3.02_{a}	$3.14_{a,d}$	3.45_{b}
1999	1 *(3,944)*	2.70_{a}	$2.90_{b,c}$	$3.07_{b,d}$	$3.07_{b,d}$
	2 *(2,695)*	2.71_{a}	2.87_{a}	$3.06_{b,c}$	$3.26_{b,d}$
	3 *(1,535)*	2.68_{a}	$2.96_{b,c}$	$3.18_{b,d}$	$3.27_{b,d}$
	4+ *(2,538)*	2.66_{a}	2.86_{a}	$3.17_{b,c}$	$3.43_{b,d}$
2000	1 *(4,612)*	2.75_{a}	$2.90_{b,c}$	$3.03_{b,d}$	$3.07_{b,d}$
	2 *(3,046)*	2.67_{a}	$2.87_{b,c}$	$3.04_{b,d,e}$	$3.21_{b,d,f}$
	3 *(1,969)*	2.60_{a}	$2.90_{b,c}$	$3.12_{b,d,e}$	$3.44_{b,d,f}$
	4+ *(3,502)*	2.76_{a}	2.95_{a}	$3.16_{b,c}$	$3.49_{b,d}$
2001	1 *(4,906)*	2.72_{a}	2.97_{b}	3.02_{b}	2.99_{b}
	2 *(3,420)*	2.61_{a}	2.91_{b}	3.06_{b}	3.25_{b}
	3 *(2,259)*	2.68_{a}	$2.91_{b,c}$	$3.12_{b,d,e}$	$3.32_{b,d,f}$
	4+ *(4,303)*	2.63_{a}	$2.94_{b,c}$	$3.16_{b,d,e}$	$3.46_{b,d,f}$

Note: Significance level for α was $p < .01$. Within the same row, means with specific nonmatching subscript pairs (e.g., *a* vs. *b*, *c* vs. *d*, *e* vs. *f*) differed significantly. A number of other significant mean differences for post hoc comparisons by outcome and year are not shown above.
* Numbers of AP Exams 4 and above were merged due to some cell *n*'s < 10.
† Rounded mean grades 4–5 were merged due to some cell *n*'s < 10.

Table 38

Least-Square Means for First-Year Credit Hours for Significant Univariate Interaction: Rounded Mean AP Grade by Number of AP Exams

High School Graduation Cohort Year	*Number of AP Exams* (N-size)*	*Rounded Mean AP Grade*			
		1	*2*	*3*	*4–5*†
2000	1 (4,612)	26.01_{a}	27.56_{b}	27.56	26.79
	2 (3,046)	26.56	27.39	27.89	28.71
	3 (1,969)	25.28_{a}	28.28_{b}	28.51_{b}	29.41_{b}
	4+ (3,502)	26.48	29.00	29.67	30.06
2001	1 (4,906)	26.00_{a}	28.27_{b}	27.40	27.32
	2 (3,420)	25.42_{a}	27.93_{b}	28.24_{b}	28.17_{b}
	3 (2,259)	26.28_{a}	28.05	28.72_{b}	29.81_{b}
	4+ (4,303)	26.79	28.54	29.19	29.49

Note: Significance level for α was $p < .01$. Within the same row, means with nonmatching subscripts differed significantly. A number of other significant mean differences for post hoc comparisons by outcome and year are not shown above.
* Numbers of AP Exams 4 and above were merged due to some cell *n*'s < 10.
† Rounded mean grades 4–5 were merged due to some cell *n*'s < 10.

Table 39

Four-Year Graduation Rates* for Significant Logistic Regression Main Effects: Number of AP Exams, Mean AP Grade, and Number of AP Courses

High School Graduation Cohort Year	*Number of AP Exams*† *(N-size)*	*Graduation Rate (%) (n-size)*	*Mean AP Grade*‡ *(n-size)*	*Graduation Rate (%) (n-size)*	*Number of AP Courses*§,**,†† *(n-size)*	*Graduation Rate (%)*‡‡ *(n-size)*
1998†	1 *(3,325)*	29.68_b *(987)*	1 *(1,044)*	20.31_b *(212)*		
	2 *(2,005)*	37.01_b *(742)*	2 *(2,585)*	32.22_b *(833)*		
	3 *(1,114)*	39.41_b *(439)*	3 *(2,729)*	40.56_b *(1,107)*		
	4+ *(1,734)*	51.27_a *(889)*	4–5 *(1,820)*	49.73_a *(905)*		
1999†	1 *(3,944)*	29.06_b *(1,146)*	1 *(1,397)*	20.04_b *(280)*	1–3 *(5,692)*	31.76 *(1,808)*
	2 *(2,695)*	35.77_b *(964)*	2 *(3,533)*	31.25_b *(1,104)*	4 *(1,713)*	38.30 *(656)*
	3 *(1,535)*	39.02_b *(599)*	3 *(3,471)*	41.80_b *(1,451)*	5+ *(3,307)*	45.78 *(1,514)*
	4+ *(2,538)*	50.00_a *(1,269)*	4–5 *(2,311)*	49.46_a *(1,143)*		
2000	1 *(4,612)*	29.42_b *(1,357)*	1 *(1,910)*	20.21_b *(386)*	1–2 *(4,095)*	29.18 *(1,195)*
	2 *(3,046)*	34.93_b *(1,064)*	2 *(4,531)*	32.49_b *(1,472)*	3 *(2,144)*	35.91 *(770)*
	3 *(1,969)*	39.26_b *(773)*	3 *(4,072)*	44.97_b *(1,831)*	4 *(2,069)*	39.00 *(807)*
	4+ *(3,502)*	51.26_a *(1,795)*	4–5 *(2,616)*	49.69_a *(1,300)*	5+ *(4,821)*	45.99 *(2,217)*
2001	1 *(4,906)*	28.74_b *(1,410)*	1 *(2,572)*	20.61_b *(530)*	1–2 *(4,625)*	28.97 *(1,340)*
	2 *(3,420)*	34.91_b *(1,194)*	2 *(5,318)*	32.46_b *(1,726)*	3 *(2,429)*	35.86 *(871)*
	3 *(2,259)*	37.32_b *(843)*	3 *(4,475)*	44.13_b *(1,975)*	4 *(2,223)*	37.43 *(1,391)*
	4+ *(4,303)*	47.78_a *(2,056)*	4-5 *(2,523)*	50.42_a *(1,272)*	5+ *(5,611)*	43.84 *(3,151)*

Note: Significance level for α was $p < .01$. Within the same year and column, rates with nonmatching subscripts differed significantly. The subscript "a" denotes the reference group used for comparisons. Logistic regression models assumed no interactions.

* Fourth-year college outcome measures were unavailable for analysis in the 2002 cohort year.

† Numbers of AP Exams 4 and above were merged in the logistic regressions in keeping with MANOVA designs due to some cell *n*'s < 10.

‡ Rounded mean grades 4–5 were merged in the logistic regressions in keeping with MANOVA designs due to some cell *n*'s < 10.

§ Numbers of courses 1–3 were merged in 1999 logistic regressions in keeping with MANOVA designs due to some cell *n*'s < 10.

** Numbers of courses 5 and above were merged in 1999–2001 Logistic Regressions in keeping with MANOVA designs due to some cell *n*'s < 10.

†† Numbers of courses 1–2 were merged in 2000-01 in the Logistic Regression in keeping with MANOVA design due to some cell *n*'s < 10.

‡‡ Within any year above, none of the rates for number of courses differed significantly from the 5+ courses reference group.

follow-up ANOVA, and logistic regression analyses within each subject. Exceptions were a number of nonsignificant group main effects in the AP Chemistry analyses for the 1998-99 cohorts.

For Phase 1 analyses with group, gender, and ethnicity as independent variables, the AP course and exam group generally outperformed the AP course and other course only groups on the outcomes. This pattern was consistent for first- and fourth-year GPAs for the 1999–2002 and 1999–2001 cohorts, respectively, in the AP English Language and Composition, AP English Literature and Composition (also in 1998), AP Calculus AB (except for fourth-year GPA in 1999), AP Biology (except in 2000), AP Chemistry (in 2001 and 2002 only), and AP U.S. History (also in 1998 but not 1999) analyses. The AP course and exam group also earned higher mean GPAs than the dual enrollment group for 2000–02 analyses in which there were a sufficient number of these students—AP English Language and Composition; AP English Literature and Composition; AP Calculus AB; and AP U.S. History (analyzed in 2002 only). When there was a sufficient number, AP Exam only students achieved significantly higher mean GPAs than other course only students in AP English Language and Composition (except on 1998 first-year GPA); AP English Literature and Composition; and AP Spanish Language (except in 2000). Otherwise, the AP Spanish Language course and exam group earned significantly higher GPAs than the other course group, never differed significantly from the AP Exam only group, and only differed significantly from the AP course only group on first-year GPA in 2002 and fourth-year GPA in 1998 and 2000. To a slightly lesser extent, findings for credit hours outcomes were consistent with those observed for the GPA outcomes across the AP subject-

specific analyses, especially regarding the greater number of mean credits earned by AP course and exam versus the other course students.

Also for Phase 1, AP course and exam students graduated at significantly higher rates within four years than students in the AP course only and the other course groups in almost all of the subject-specific logistic regression analyses of graduation for 1998–2001 cohorts. The only exception was in the 1998 AP Chemistry analysis (nonsignificant group differences). In analyses with a sufficient number of students (AP English Language and Composition, AP English Literature and Composition, and AP Calculus AB), AP course and exam students also graduated at significantly higher rates than dual enrollment students (2000–01). Graduation rates for AP Exam only students, when their numbers were sufficient for the analyses (AP English Language and Composition, AP English Literature and Composition, and AP Spanish Language), were closely comparable and differed nonsignificantly from rates for AP course and exam students.

Group interactions with ethnicity and gender

For Phase 1, the group by ethnicity interaction was significant for more than one cohort in the MANOVAs and for more than one cohort within more than one outcome in the ANOVAs for AP English Language and Composition (MANOVAs: 1999–2002), AP English Literature and Composition (1999–2001), and AP Calculus AB (1999–2002). Even in the significant ANOVA interactions for specific outcomes in these subjects, students within ethnic groups in the AP course and exam group outperformed, in general, other students of the same ethnic group in the AP course only, dual enrollment (when available), and other course groups despite performance gaps among some ethnic groups overall.

The pattern of significantly higher first- and fourth-year GPAs for the AP course and exam group over the AP course only, dual enrollment, and other course groups was most consistent across ethnic groups in the 2001 cohort within AP English Language and Composition, English Literature and Composition, and Calculus AB subject-specific analyses. For 2001–02 cohorts as well, AP Calculus AB course and exam students were consistent in earning first-year GPAs significantly above those of the dual enrollment group, regardless of ethnicity.

Across ethnicity and cohorts, the pattern of significantly higher first- and fourth-year credits for AP course and exam students versus the course only, dual enrollment, and/or other course groups appeared most frequently for Hispanics and whites. For example in 2001, Hispanic and white AP Calculus AB course and exam students posted more first-year credits than Hispanics and whites in the AP Calculus AB course only, dual enrollment, and other course groups, while Asian American course and exam students outperformed peers in the dual enrollment group. Slightly less consistently across ethnicity in 2001, Hispanic and white AP English Literature and Composition course and exam students generally earned more fourth-year credits than Hispanics and whites in the AP English Literature and Composition course only and other course groups. Otherwise, Hispanic and white AP Calculus AB course and exam students earned significantly more first-year and fourth-year credits in 2000–01 than their dual enrollment and other course counterparts.

In addition, group by ethnicity interactions were significant for more than one cohort in the MANOVAs for AP U.S. History (2000 and 2002) and AP Spanish Language (1999–2000 and 2002) but were only significant for more than one cohort on just one outcome in the ANOVAs. Thus, for five of the seven sets of subject-specific analyses, the group by ethnicity interaction was significant more frequently in the later cohort years. For that reason, it appears worthwhile to follow future cohorts to examine whether this interaction persists or changes in nature as growth in the AP Program continues.

The group by gender interaction for Phase 1 analyses was significant for only one MANOVA cohort (2000) and for only one ANOVA outcome—first-year credits earned—with only AP English Language and Composition. Thus, this interaction merits further study only if it persists in this AP subject or arises in others, especially in regard to subject-specific gender relationships and growth in the AP Program in general.

Phase 2–Aggregated AP Subjects

Group main effects

With subject-aggregated AP and non-AP group comparisons controlled by FRPL status and SAT rank (Research Question 2), the group main effect was significant in all MANOVAs (1998–2002), all ANOVAs for all outcomes (first-year GPA and credits: 1998–2002; fourth-year GPA and credits: 1998–2001), and in all logistic regression analyses of graduation rates (1998–2001). For all outcomes and in all cohorts for Research Question 2 analyses, the AP course and exam group significantly surpassed the AP course only and other courses groups, with the AP course only group performing significantly above the other courses group as well. While not always significant, AP course and exam group means on the outcomes were higher, in general, than means for the AP Exam only and dual enrollment groups. Most consistently, 2000-02 AP course and exam cohorts significantly outperformed all other groups on all GPA and credit hours outcomes, except for the AP Exam only group on 2001 GPA outcomes. Across cohorts, AP course and exam students had significantly higher four-

year graduation rates (1998–2001, exceeding 36 percent) than the AP course only (1998–2001, under 23 percent), dual enrollment (analyzed in 2001 only, 24.29 percent), and other courses only groups (1998–2001, no more than 14 percent).

Regarding Research Question 3 (which addressed the 2001 cohort only), the AP grade group main effect comparisons, controlled by FRPL status and SAT rank in the ANOVA analyses, were statistically significant for all GPA and credit hours outcomes. The AP course and exam/mean grade 2, 3, and 4–5 groups earned significantly higher GPAs than the AP course and exam/mean grade 1, AP course only, dual enrollment, and other courses groups. Furthermore, all AP course and exam/mean grade 1–5 and AP course only students earned more first- and fourth-year credits than the other courses group. Moreover, AP course and exam/mean grade 2 students tallied a significantly higher number of first-year and fourth-year credits than dual enrollment only students, as did course and exam grade 3 students on fourth-year credits, and significantly more first-year credits than AP course only students. Although AP course and exam/grade 4–5 students posted nonsignificantly different but fewer fourth-year credits, in particular, than those in the 1–3 grade groups, this pattern does not generalize to graduation rates. In the logistic regression comparisons, the AP course and exam/mean grade 2 students as the reference group had significantly higher four-year graduation rates (32.46 percent) than AP course and exam/mean grade 1 (20.61 percent), AP course only (22.94 percent), dual enrollment (24.29 percent), and other courses (11.48 percent) students. However, AP course and exam/mean grade 3 and 4–5 students had the highest graduation rates at 44.13 and 50.42 percent, respectively. Since the AP mean grade 3–5 students more likely earned credit by examination or placed out of AP equivalent courses for their higher AP Exam grades, the fact that such credits are unavailable for this study's credit hours outcomes may be playing a role in the number of credits obtained.

Note that Texas graduation rates are lower than the national average, as Texas students are taking longer to graduate. Many AP and other students eventually graduate within five or six years, and the four-year rate used in this study aligns with the more stringent, traditional standard promoted by many policy leaders. Thus, overall graduation rate levels found in this study are lower than those in other studies following students over longer time periods and, in some instances, a broader pool of students (e.g., Adelman, 1999, 2006). Nevertheless, the general finding of higher graduation rates for AP versus non-AP students in this study agrees with those of others (e.g., Dougherty et al., 2006; Morgan and Maneckshana, 2000).

Group by SAT rank interactions

In Research Question 2, the group by SAT rank ANOVA interaction was significant for first-year GPA (1999–2002) and first-year credit hours earned (1999 and 2002). Across SAT rank categories, AP course and exam students typically achieved significantly better first-year GPAs and completed significantly more first-year credits than AP course only and other courses students. Thus, in terms of first-year GPA and credits, the AP course and exam experience generally prevailed over the AP course only and other courses experiences, despite GPA and SAT rank relationships. However, mean first-year GPAs and credit hours earned by the top SAT rank (score of 1090 or above) students in the other courses group always exceeded those for students with the lowest SAT rank (score of 850 or below) in all AP and dual enrollment groups.

For Research Question 3 (which addressed the 2001 cohort only), the group/AP grade by SAT rank interaction was significant on all GPA and credit hours outcomes. This similar interaction was significant for first-year GPA in the 2001 cohort Research Question 2 analyses, which did not subdivide the AP course and exam group by mean AP grade categories. Regardless of the group/AP grade category, all first- and fourth-year GPAs and credit hours rose, in general, with SAT rank. Regardless of rank, AP course and exam grade 2 students always earned significantly better first- and fourth-year GPAs and significantly more first- and fourth-year credits than the other courses group and, except within the lowest SAT rank (score of 850 or below), achieved significantly higher GPAs than the AP course and exam grade 1 group. Moreover, across SAT ranks, AP course and exam grade 2 students generally compiled significantly more first- and fourth-year credits than the AP course only group.

Group by FRPL status interactions

For Research Question 2, the group by FRPL status ANOVA interaction was significant for two cohorts on each of the first- and fourth-year credit hours outcomes (1999 and 2002 and 1999–2000, respectively). Both FRPL and non-FRPL AP course and exam students garnered significantly more first- and fourth-year credits than their peers in the AP course only and other courses groups, as did both FRPL and non-FRPL AP course only students compared to peers in the other courses group.

Main effects within the AP course and exam group

For Research Question 4, all MANOVA and logistic regression main effects—mean AP grade category, number of AP Exams taken, and number of AP courses—were significant for all 1998–2002 cohorts, except for number of courses in the 1998 cohort. Mean AP grade and the number of AP Exams main effects were significant in ANOVAs for all first-year (1998–2002) and fourth-year (1998–2001) GPA outcomes and for almost all first-year credits (1998–2002),

except for number of exams in 2002. ANOVA number of exams and mean AP Exam grade main effects were significant less often for fourth-year credits (1999–2000 and 1998, 2000–01, respectively). Also in the ANOVAs, the number of courses main effect was significant on all outcomes in at least two cohort years (first-year GPA: 1999–2000; fourth-year GPA: 1999–2001; first-year credits: 1999–2002; fourth-year credits: 1999 and 2001).

Similar to the SAT rank and GPA relationships observed in the other Phase 2 analyses, mean first- and fourth-year GPAs went up with mean AP Exam grade categories, and all higher AP Exam grade categories were significantly higher on GPAs than lower categories. Mean GPAs were also higher for students who took at least three AP Exams compared to those with only one or two exams and, in 1999, for those who completed four or five AP courses compared to one, two, or three AP courses.

AP mean grade 1 students earned significantly fewer credits than those with higher exam grade averages, with the exception of the 1999 cohort. Students, in general, who took at least four AP Exams earned significantly more first-year credits compared to those who took one or two exams (1998–2001), as did those who took at least five AP courses compared to those who took one or two courses (1999–2002).

In logistic regression analyses across all 1998–2001 cohorts, graduation rates went up with mean AP Exam grades and the number of AP Exams taken. Reference group students who took at least four AP Exams graduated at rates significantly higher (e.g., 1998: 51.27 percent) than those with a lower number of exams (e.g., 1998: 3 exams, 39.41 percent; 2 exams, 37.01 percent; 1 exam, 29.68 percent). Also, students who averaged 4–5 AP grades had significantly higher graduation rates (e.g., 2001: 50.42 percent) than those averaging 1–3 (e.g., 2001: 3, 44.13 percent; 2, 32.46 percent; 1, 20.61 percent). Graduation rates also increased with the number of AP courses completed (e.g., 2000: 1–2, 29.18 percent; 3, 35.91 percent; 4, 39.00 percent; 5+, 45.99 percent).

Interaction effects within the AP course and exam group

For Research Question 4, the AP mean exam grade by number of exams interaction was significant in all MANOVAs (1998–2002), all ANOVAs on GPA (first-year: 1998–2002; fourth-year 1998–2001), and 2000-01 ANOVAs on first-year credit hours. Students with mean 1 and 2 AP Exam grades gained the least in GPAs as the number of AP Exams taken rose, compared to students with mean 3 and 4–5 grades, while mean 4–5 grade students gained the most in GPAs as the number of exams taken went up. Mean AP grade 1 students who took only one AP Exam earned significantly fewer first-year credits than mean grade 2 students who took one exam. Mean AP grade 1 students also compiled fewer first-year credits, in general, than those with higher mean grades. Moreover, 4–5 mean grade students who took at least three AP Exams had the highest number of first-year credits.

Summary Implications

Overall, results from this study provide strong support for AP Program benefits over non-AP experiences for students and their subsequent college GPA, credits earned, and graduation performance. The preponderance of academic subject-specific analyses (AP English Language, English Literature, Calculus, Biology, and History) showed that students, matched on SAT ranked score intervals (measuring ability or college readiness) and FRPL status (family income measure), who took both an AP course and exam in the corresponding AP subjects significantly outperformed AP course only, dual enrollment only (excluded for AP Biology), and other courses students on all the college outcomes, even after gender and ethnicity were taken into account. In addition, the subject-aggregated AP course and exam group significantly outperformed the AP course only and other courses groups on all outcomes in all years and, in general, exceeded AP Exam only and dual enrollment group performances on the outcomes. Most notably, aggregated AP course and exam students had significantly higher four-year graduation rates than students in the AP course only, AP Exam only, dual enrollment, and other courses groups. These results agree with previous findings of several studies (e.g., Dodd et al., 2002; Dougherty et al., 2006; Geiser and Santelices, 2004; Morgan and Maneckshana, 2000) demonstrating that students who take AP Exams perform as well as or better in college on a number of different outcome measures than various comparison groups.

Phase 1 results also provided evidence that the benefits of participating in both AP courses and exams extend across gender and ethnic groups, despite several instances of the group by ethnicity interaction. Within the AP English Language and Composition, AP English Literature and Composition, and AP Calculus AB analyses, for example, AP course and exam students tended to outperform students of the same ethnic group in the AP course only, dual enrollment, and other courses groups.

Phase 2 results also provided further support for the benefits of participating in both AP courses and exams with aggregated subjects, taking SAT rank and FRPL status into account. That students with higher SAT ranks performed better on the college outcomes than students at lower SAT ranks is not surprising and is consistent with numerous studies (see Kobrin and Michel, 2006), but benefits of the AP experience remained evident regardless of SAT rank. Similarly, AP course and exam students, regardless of FRPL status, earned a greater number of credit hours than those in the other AP and

non-AP groups in the significant group by FRPL status ANOVA interactions.

The benefits of participating in both AP courses and exams also extended across mean AP grade categories within the AP course and exam group in comparison to other AP and non-AP groups, not only for mean grades of 3 and above, but also for mean grades of 2. Four-year graduation rates also rose with mean AP grades, the number of AP Exams, and number of AP courses taken. Thus, performance on the college measures was also related to the AP experience as a function of mean AP Exam grades and the number of exams and AP courses taken.

Notably, the benefits of participating in both AP courses and exams extended across all outcomes and, in particular, for graduation rate, the critical standard for college success. AP course and exam students graduated at consistently higher rates than any of the other groups, and those students with the highest AP Exam grades also graduated at the highest rates (e.g., 2001: 50.42 percent) within four years. Among the intermediate college success measures, the underestimation of first- and fourth-year credits for students passing dual enrollment courses or earning qualifying AP Exam grades was problematic because these credits were unavailable in the credits earned measures. Regardless of these problems, however, the relative performances of AP and dual enrollment students on all outcomes were remarkably consistent.

In sum, the relationships between the various types of AP and non-AP high school experiences and the outcomes appeared to be very consistent across the 1998–2002 high school graduate cohorts, even for the 2002 cohort with only one year of available outcome data. The 2002 cohort represented the broader group of students in college attendance during the year subsequent to high school graduation. In contrast, 1998–2001 cohorts included students who had graduated from college within four years or had been in college during their fourth year after high school graduation. Despite the difference between 2002 and the prior cohorts, relationships between the college outcomes and AP/non-AP high school experiences held, in general, across cohorts and, if anything, were more evident in the later cohorts. Perhaps this was due in part to policy initiatives that resulted in a rapidly growing pool of college students with AP experience and increases in teacher training.

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Appendix A: Correspondences Between AP Exams/Courses and Dual Enrollment Courses in Phase 1

AP Exam/Course	*Dual Enrollment Course Title in Subject Area of AP Exam*
English Language and Composition OR English Literature and Composition	English I (1 Unit) (Eng 1)
	English II (1 Unit) (Eng 2)
	English III (1 Unit) (Eng 3)
	English IV (1 Unit) (Eng 4)
	Research/Technical Writing (1/2–1 Unit) (Tech Wr)
	Creative/Imaginative Writing (1/2–1 Unit) (Creat Wr)
	Practical Writing Skills (1/2–1 Unit) (Pract Wr)
	Literary Genres (1/2–1 Unit) (Lit Genr)
	Humanities (1 Unit) (Humanit)
	Independent Study In English (1/2-1 Unit) (Ind Eng)
	Independent Study In English (Second Time Taken) (1/2-1 Unit) (Ind Eng2)
	Independent Study In English (Third Time Taken) (1/2-1 Unit) (Ind Eng3)
Calculus AB	Algebra I (1 Unit)
	Algebra I-4 Mathematics (Alg I4m)
	Algebra II (1/2–1 Unit) (Alg 2)
	Algebra II-3 (1–1/2 Units) (Alg 2–3)
	Geometry (1 Unit)
	Precalculus (1/2–1 Unit) (Precalc)
	Mathematical Models With Applications (1/2–1 Unit) (Mthmod)
	Independent Study In Mathematics (1st Time Taken) (1/2–1 Unit) (Instumth)
	Independent Study In Mathematics (Second Time Taken) (1/2–1 Unit)(Instmth2)
Biology	Biology (1 Unit) (Bio)
Chemistry	Chemistry (1 Unit) (Chem)
U.S. History	United States History Since Reconstruction (1 Unit) (Us Hist)
	World History Studies (1 Unit)
Spanish Language	Langs Other Than Eng Level I (1 Unit)–Spanish (Span 1)
	Langs Other Than Eng Level II (1 Unit)–Spanish (Span 2)
	Langs Other Than Eng Level III (1 Unit)–Spanish (Span 3)
	Langs Other Than Eng Level IV (1 Unit)–Spanish (Span 4)
	Langs Other Than Eng Level V (1 Unit)–Spanish (Span 5)

Note: Minus any official statewide designations, all dual enrollment courses in the same subject area as the corresponding AP Exam were used due to the voluminous number of distinct dual enrollment courses in the database.

Appendix B: Correspondences Between AP Exams/Courses and Dual Enrollment Courses in Phase 2

AP Exam/Course	*Dual Enrollment Course Title*
Biology	Biology (1 Unit) (Bio)
Environmental Science	Environmental Systems (1 Unit) (Envirsys)
Chemistry	Chemistry (1 Unit) (Chem)
Physics B OR Physics C: Elec. & Mag. OR Physics C: Mechanics	Physics (1 Unit) (Physics)
Music Theory	Music I Theory (1 Unit) (Mus1thy)
Eng. Lang. & Comp. OR English Lit. & Comp.	English I (1 Unit) (Eng 1)
	English II (1 Unit) (Eng 2)
	English III (1 Unit) (Eng 3)
	English IV (1 Unit) (Eng 4)
Human Geography	World Geography Studies (1 Unit)
Government and Politics: U.S.	United States Government (1/2 Unit) (Govt)
U.S. History	United States History Since Reconstruction (1 Unit) (Us Hist)
World History	World History Studies (1 Unit) (W Hist)
Psychology	Psychology (1/2 Unit) (Psych)
French Language OR French Literature	Languages Other Than English Level I (1 Unit)–French (Fren 1)
	Languages Other Than English Level II (1 Unit)–French (Fren 2)
	Languages Other Than English Level III (1 Unit)–French (Fren 3)
	Languages Other Than English Level IV (1 Unit)–French (Fren 4)
	Languages Other Than English Level V (1 Unit)–French (Fren 5)
German Language	Langs Other Than English Level I (1 Unit)-German (German 1)
	Langs Other Than English Level III (1 Unit)-German (German 3)
	Langs Other Than English Level VI (1 Unit)-German (German 6)
Spanish Language OR Spanish Literature	Languages Other Than English Level I (1 Unit)-Spanish (Span 1)
	Languages Other Than English Level II (1 Unit)-Spanish (Span 2)
	Languages Other Than English Level III (1 Unit)-Spanish (Span 3)
	Languages Other Than English Level IV (1 Unit)-Spanish (Span 4)
	Languages Other Than English Level V (1 Unit) -Spanish (Span 5)
Studio Art: 2-D Design	Art I (1 Unit)
Studio Art: Drawing	Art II Drawing (1 Unit)
	Art IV Drawing (1 Unit) (Art4draw)
Studio Art: 3-D Design	Art III Drawing (1 Unit) (Art3draw)
Art: History	Art III History (1 Unit) (Art3hist)
Computer Science A	Computer Science I (1 Unit) (Tacs1)
Computer Science B	Computer Science II (1 Unit) (Tacs2)
Latin: Vergil	None
Latin: Literature	None
Statistics	None
Govt. & Politics: Comparative	None
Calculus AB	None
Calculus BC	None
Economics: Micro	None
Economics: Macro	None
European History	None

Note: Minus any official statewide designations, the authors independently reviewed a list of dual enrollment courses to develop a consensus list of dual enrollment courses that appeared to best match all AP subject exams included in Phase 2 aggregate analyses.


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