Research Report
No. 2007-4

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John Klaric is currently completing his doctoral studies in Educational Research Methodology at the University of North Carolina at Greensboro. He is also an educational consultant for the North Carolina Department of Public Instruction.

Rick Morgan is a principal psychometrician at Educational Testing Service. In addition, he teaches graduate classes for the Educational Research Methodology department at the University of North Carolina at Greensboro.

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Contents

Introduction

The Advanced Placement Program® (AP®) of the College Board is a cooperative endeavor between secondary schools and institutions of higher education. It is based on the premise that college-level material can be successfully taught to high school students. Currently, there are 37 AP Exams in 22 subject areas. In 2006, more than 1.3 million students from 16,000 schools took more than 2.3 million AP Exams. Nearly 60 percent of high schools in the United States participate in the AP Program (College Board, *AP Fact Sheet*).

The courses and exams are developed by a committee of college and high school faculty. Courses and exams are revised on a periodic basis to ensure that the breadth and depth of content corresponds to that being taught in college courses. Except for the AP Studio Art Exams, which consist of portfolio assessments, the exams follow a common format of a multiple-choice section and a free-response section. The percentage that the multiple-choice section contributes to the composite score ranges from 40 percent to 66.7 percent. AP Exam grades range from 1 to 5. The American Council on Education recommends that colleges and universities grant credit and/or placement into higher-level courses to entrants with AP Exam grades of 3, 4, and 5. However, colleges and universities set their own AP policies concerning both placement and credit.

One of the fundamental underpinnings of the AP Program is that students who perform well on AP Examinations will be successful in college. If the scores from the examinations are not sufficiently reliable or inadequately measure the specific skills and knowledge that the corresponding college courses require, then the validity of the AP grades and the AP Program can be questioned. Furthermore, if the standards used to set the AP grades are not sufficiently high, then the College Board needs to reassess how AP grades are determined. The procedure used to align AP grade standards with college grading standards is outlined in Morgan and Ramist (1998).

Studies following students into college found that students who took one or more AP Exams were more likely than students who did not take any AP Exams to maintain a B average, graduate with honors, and have more course work in the subject area of their AP Exam (Morgan and Maneckshana, 2000; Willingham and Morris, 1986). AP students were also found to perform as well or better than their non-AP counterparts when placed directly into intermediate college courses (Morgan and Ramist, 1998). More recently, Dodd, Fitzpatrick, De Ayala, and Jennings (2002) found results corroborating this earlier research. Their results showed that, compared to non-AP students of similar academic ability, AP students who were exempted from the introductory course in calculus, biology, and English earned the same or higher grades in the subsequent course, took as many or more class hours in the subject area, and had the same or higher grades in additional courses in the subject area. Dougherty, Mellor, and Jian (2006) explored relationships of AP course participation and AP Exam performance with college graduation rates at Texas public colleges and universities. They found that students who earned a 3 or better on one or more AP Exams were more likely to graduate from college in five years or less compared to students who did not take an AP course (64 percent versus 17 percent). After controlling for prior academic achievement and other student-level (e.g., free or reduced-price lunch status) and school-level demographic characteristics (e.g., percentage of low-income students, district dropout rate), the percentage difference was still significant, but the magnitude of the graduation difference was reduced from 47 percent to 20 percent. Smaller differences were shown for AP students who earned a 1 or 2 on AP Exams and for students who took an AP course but not the exam. The difference favoring students who took AP courses was present across minority and low-income students.

However, not all research studies have reported positive results for AP student success in college. Klopfenstein and Thomas (2006), using a sample of 28,000 Texas high school graduates, examined the graduates' college persistence and first semester grade point average. They utilized regression techniques with more than 30 predictor variables, including SAT® scores, high school grade point average (GPA), years of high school study in several areas, student/teacher ratio of the graduates' high schools, and family income. They concluded that the only AP variables significantly related to higher first semester grades were subject areas of AP courses in science and whether students had taken AP courses in economics. The authors, however, used weighted high school GPAs that increase the GPA for each AP course taken. This weighting procedure would result in linear GPA increases, and it assumes that all AP courses have equivalent beneficial effects. Such confounding does not clarify the relationships between AP instruction and first semester college grades and may have resulted in not finding a significant relationship between such instruction and first semester college grades.

The purpose of the current investigation is to explore the academic careers of students who took AP Exams and to compare their careers with those who did not take AP Exams. This study follows college students for five years at a sample of diverse academic institutions and examines their performance and amount of course work in subject areas closely related to their taken AP Exam, their graduation rates, and their eventual college major. This paper uses the term "AP students" to indicate those who took AP Exams. For some analyses, the focus is on a smaller sample of AP students who took and received a grade of at least 3 on an AP Exam. The following set of questions is examined:

(1) Is the performance of AP students in intermediate-level courses into which they are placed based on AP Exam scores, comparable to that of non-AP students? Is the performance comparable after accounting for group differences based on SAT scores?

(2) Does participation in AP courses serve to encourage or discourage future course work in the discipline? In other words, compared to non-AP students, do AP students take more or less course work in the areas in which they took AP Exams?

(3) Is the graduation rate at the university where the students first enrolled higher for AP students compared to that of non-AP students? Are the graduation rates similar after accounting for group differences based on SAT scores? Are the graduation rates for AP racial/ethnic minority students higher than those for non-AP racial/ethnic minority students?

(4) Do AP students graduate with majors in the discipline in which they took AP Exams more often than other college students?

(5) Do females and underrepresented minorities who take AP Exams in mathematics and science continue their study of mathematics and science in college?

Method

Student Sample

A total of 72,457 students from the incoming class of 1994, attending 27 collegiate institutions, were the focus of the current investigation. Institutions contacted for participation were from the 200 colleges receiving the largest number of AP grades. Institutions from the top 200 receiving colleges were first categorized based on geographic location, selectivity, and whether they were public or private institutions. Colleges within the populated cross-classifications of the aforementioned three categories were contacted until at least one institution from each cell of the three-way classification matrix agreed to supply five years of college course–level data. The 27 colleges and universities in Table 1 provided academic data.

The institutions were asked to supply the names, social security numbers, courses taken, course grades, genders, races/ethnicities, majors, graduation dates, and college entrance scores for each of their students who entered in the fall of 1994. The college data files were then matched to each AP candidate using social security numbers and student names. When data were analyzed, unique identifiers were assigned to each student; names and social security numbers were dropped from the data sets. Most institutions complied with the request for additional scholastic data, but there was some variance. Race/ethnicity was not reported by the University of California–Los Angeles (UCLA). College majors at graduation were not provided by Northwestern, UCLA, the University of Illinois, Wesleyan, and Stanford. SAT scores were not reported by Dartmouth and UCLA. Some circumstances unique to institutions included (1) graduation data from Brigham Young University, where most students were in a six-year graduation cycle, (2) performance data from the University of Southern California, which offered only elective credit for AP courses, and (3) a small percentage of students with SAT data at the University of Iowa. Statistical analyses of relevant research questions were performed without these institutions in the sample.

Data Analysis

Question 1

Statistical analyses compared course grades of AP students receiving placement into intermediate courses to the course grades of those who did not take the AP Exam, but took the usual sequence of introductory and intermediate courses. Only students receiving AP grades of 3 or better composed the AP group. Course descriptions, patterns of student course taking, Web-posted AP policies, and course catalogs were used to determine the introductory-level courses for which AP grades could earn credit and for the intermediate courses into which those with sufficient AP grades could earn placement.

Two limitations of the Morgan and Ramist (1998) study were (1) collateral information such as SAT scores was not used, and (2) small sample sizes were employed in the analyses for some AP Examinations. Consequently, in this study a series of regressions accounting for total scores on the SAT test was performed. In addition, these regressions were conducted for those AP Examinations with a sample size of at least 100. The sample was composed of two groups from the respective universities: students receiving an AP grade of 3 or greater who received advanced placement into an intermediate course and non-AP students. For a course to be included in the estimate, two conditions had to be met: At least five students had to follow the usual course sequence by taking the lower-level course in the subject area before taking the higher-level course. In addition, at least one student with an AP grade of 3 or higher on the relevant AP Exam must have taken the intermediate course without previously taking the introductory course. For the analyses of each AP Examination, no single university could account for more than a third of the AP students. An adjustment of one-third of a grade point was made for plus and minus grades.

Table 1

Demographic Profile of Participating Institutions

Institution	Students	Students Taking at Least One AP Exam	Percent of AP Students	Gender		Race/Ethnicity						
				Male	Female	Native Amer.	African Amer.	Asian Amer.	White	Other	Hispanic	Missing
Barnard College	555	442	80	0	555	2	20	135	346	24	28	0
Binghamton University	1,728	1,215	70	793	935	2	88	234	987	12	109	296
Brigham Young University	4,128	2,550	62	1,723	2,405	41	14	137	3,746	12	114	64
Carnegie Mellon University	1,112	775	70	765	347	5	69	221	540	218	58	1
College of William and Mary	1,247	1,040	83	514	733	5	83	107	1,027	0	25	0
Cornell University	2,909	2,412	83	1,526	1,333	13	125	464	1,576	31	195	505
Dartmouth College	1,052	886	84	546	506	22	77	112	621	174	46	0
George Washington University	1,580	921	58	679	869	7	109	195	998	70	65	136
Georgia Institute of Technology	2,181	1,469	67	1,580	600	5	189	234	1,672	5	75	1
Miami University (Ohio)	1,685	648	38	737	948	3	87	34	1,521	0	18	22
North Carolina State University	3,513	1,709	49	2,091	1,422	23	409	158	2,884	0	39	0
Northwestern University	1,838	1,502	82	894	944	5	116	413	1,194	0	57	53
Stanford University	1,587	1,390	88	785	802	17	113	426	775	80	169	7
Texas A&M University	6,044	2199	36	3,111	2,933	0	290	249	4,633	17	854	1
University of California–Davis	2,988	1,891	63	1,407	1,581	41	133	1,084	1,268	50	399	13
University of California–LA	3,973	3,222	81	1,871	2,102	0	0	0	0	0	0	3,973
University of Florida	4,969	3,091	62	2,395	2,574	12	372	325	3,640	20	595	5
University of Illinois–Urbana	5,671	2,899	51	2,938	2,733	11	418	805	4,095	0	318	24
University of Iowa	2,851	445	16	1,298	1,552	13	85	101	2,446	16	67	123
University of Maryland	3,807	1,513	40	1,987	1,820	6	557	583	2,386	0	186	89
University of Miami	1,553	796	51	755	798	4	174	98	835	0	378	64
University of Southern California	2,382	1,447	61	1,211	1,171	11	133	596	1,147	135	343	17
University of Texas–Austin	5,805	2,891	50	2,938	2,867	19	306	860	3,742	43	835	0
University of Virginia	2,743	2,272	83	1,253	1,490	11	302	272	1,994	33	47	84
University of Washington	3,336	1,129	34	1,599	1,737	61	100	791	2,051	54	122	157
Wesleyan College	726	484	67	331	395	0	73	66	512	20	55	0
Williams College	494	392	79	252	242	2	33	50	360	17	32	0

The dependent variable was grade in the second course of the sequences outlined in Appendix A. Parameters were estimated for two models analyzing grades in the second course of the sequence. In the first, dummy-coded AP grades served as the independent variables. In the second model, a covariate term (total score on the SAT test) was added so that prediction of performance in the second course of the sequence was statistically adjusted (Howell, 2002). The regression equation for the second model was: $Y_i = \beta_0 + \beta_1 X_i + \beta_2 X_i + \beta_3 X_i + \beta_4 X_i + r_i$, where Y_i is the grade in the second course, β_0 represents the intercept, the slope coefficients for the three AP grades tested are β_1, β_2, and β_3; X_i for these terms is a member of {0, 1}, β_4 is the coefficient of the covariate's slope, and r_i, is the error term. For the covariate term, X_i is a random variable whose value is total score on the SAT.

Question 3

A logistic regression procedure (Agresti, 1996) was used to predict the probability of college graduation among non-AP students and those participating in any AP Examination. A discrete 0/1 outcome variable was first created for each student (1 = graduation from college in five years or less). This predictive model used AP participation as an independent variable; total score on the SAT (SAT-M + SAT-V) was a covariate. This model adjusted the probabilities of graduation student ability level. The role of gender and race/ethnicity (African American, Asian American, Hispanic, and white) for the prediction of the probability of graduation were also examined in separate SAT-adjusted logistic regressions. The same outcome variable was used (college graduation in five years or less from the institutions in which they first enrolled); gender and race/ethnicity were included separately, along with AP participation, as independent variables.

Questions 2, 4, and 5

These questions were addressed by comparing frequencies and percentages of students with various characteristics. As opposed to Question 1, which examined performance of a subset of AP students (those scoring 3 or higher), the AP sample for Questions 2 through 5 included students earning any AP grade from 1 to 5.

Results

Question 1

Is the performance in intermediate-level courses into which AP students are placed comparable to that of non-AP students? Is the performance comparable after accounting for group differences based on SAT scores?

Table 2 provides a summary of the regression analysis predicting course grade based on AP grade and SAT total score. The comparisons are based on AP students receiving advanced placement compared to non-AP students who first took the introductory course in the discipline at the college. Shown in the table are the course grade averages of the non-AP students and the difference between that course grade average and the averages for those earning AP grades of 3 through 5. An asterisk indicates a difference that is statistically significant at the .05 level. Additionally, the table provides the estimated differences in course grade averages after accounting for the average SAT score differences between the non-AP group and the three AP groups. Because the AP students had higher average SAT scores, the differences in the average course grades of three AP groups and the non-AP group is less when SAT scores are used in the regression model. For all but six entries in the table, AP students have higher grade averages than the non-AP students. Most of the SAT-adjusted comparisons favor the AP students, and more than half are statistically significant.

The current analyses of college grades in identified course sequences indicate that AP students perform well when placed directly into intermediate college courses after receiving advanced placement for the introductory college course. The results generally parallel findings reported by Morgan and Ramist (1998), which used a different statistical approach to provide comparative grade information aggregated across colleges.

Parameter estimates obtained from 10 separate regressions modeling course grades by AP Exam performance, along with their standard errors, are presented in Appendix B. Also shown are the parameter estimates when total SAT score was used in the regression model.

Question 2

Does participation in AP courses serve to encourage or discourage future course work in the discipline? Do AP students take more or less course work in the areas in which they took AP Exams?

Since a concern voiced by colleges is that those taking AP courses will not continue to take courses in areas closely related to the discipline characterized by that exam, the number of courses taken by students in the areas related to each AP Exam was examined. Table 3 presents the percentages of AP and non-AP students taking at least a single college course in a closely allied discipline. This comparison is included to show the relative extent to which AP and non-AP students were exposed to disciplines closely related to each AP Exam.

Table 2

Differences in Performance in Intermediate Courses, AP Students Compared to Non-AP Students

			Average Differences in Course Performance			*SAT-Adjusted Differences in Course Performance*		
			AP Exam Grade			*AP Exam Grade*		
AP Exam	N	*Non-AP Course Grade*	*3*	*4*	*5*	*3*	*4*	*5*
U.S. History	752	2.87	.18	.46*	.61*	.17	.43*	.57*
Biology	3,743	2.80	.07	.29*	.63*	.03	.17*	.43*
Chemistry	5,085	2.88	.06	.22	.33*	−.08	.03	.11
Macroeconomics	6,080	2.88	.16	−.03	.68*	.05	−.33*	.33
English**	9,057	3.04	.33*	.44*	.79*	.22*	.28*	.59*
U.S. G&P	3,425	2.76	.17*	.41*	.51*	.08	.22*	.26*
Calculus AB	5,932	2.43	.26*	.47*	.91*	.21*	.35*	.72*
Calculus BC	5,411	2.50	.50*	.95*	.96*	.42*	.85*	.77*
Psychology	4,440	2.90	.10	.19	.88*	.11	.09	.63
Spanish Language	1,104	3.11	.16*	.22*	.82*	.12	.17	.76*

* $p < .05$.
** English refers to AP candidates taking either English Literature and Composition or English Language and Composition.

The percentages for non-AP students are based on all the non-AP students in the sample. The percentages for AP students are based on the students who took the indicated AP Exam in high school. Table 3 also shows the number of courses taken by all AP and non-AP students in related academic areas.

For six AP Exams (United States History, English Literature and Composition, United States Government and Politics, Comparative Government and Politics, Calculus AB, and Calculus BC), the percentage of non-AP students taking at least one course in closely related disciplines was marginally higher than the percentage for students who took the corresponding AP Exam. However, for eight AP Exams (all three AP Exams in art, both AP Exams in computer science, both AP Exams in French, and the AP German Language Exam) the percentage of non-AP students taking at least one course in closely related disciplines was less than half than the percentage for students who took the corresponding AP Exam.

With the single exception of the students who took the AP English Literature and Composition Exam, AP students took a greater number of courses in an academic area related to their AP Exam than their non-AP counterparts. Indeed, AP students taking the three AP Exams in art, the two AP Exams in French, the higher-level AP Exam in computer science, the AP German Language Exam, or the AP Music Theory Exam took at least five times as many courses in a related area as did members of the non-AP student group. Given the data, there are few signs of AP Exams serving to discourage continued college course work. There are many more signs that taking an AP Exam in a discipline is followed by substantial course work in an area closely related to the discipline.

Question 3

Are graduation rates at the university where the student first enrolled higher for AP students compared to those of non-AP students? Are the graduation rates similar after accounting for group differences based on SAT scores? Are the graduation rates for racial/ethnic minority students who took AP higher than those for non-AP racial/ethnic minority students?

The time to graduation for both groups of students was first determined, with students assigned to categories describing length of time to college graduation. Table 4 provides unweighted percentages of AP and non-AP students in each category: graduation in four years or less, graduation in five years, and nongraduation due to dropout, transfer, or completing their degree in more than five years. As can be seen in the table, while only 45 percent of the non-AP students completed their studies at the university within four years, 63 percent of those with at least one AP Exam grade earned a degree within

Table 3

Amount of College Course Work in a Closely Related Discipline

AP Exam	*AP Students Taking at Least One Course in a Related Area (%)*	*Non-AP Students Taking at Least One Course in a Related Area (%)*	*All AP Students: Number of Courses in Related Areas*	*All Non-AP Students: Number of Courses in Related Areas*
U.S. History	61	70	1.7	1.6
Art History	45	14	1.5	0.3
Art–Drawing	36	9	4.4	0.3
Art–General	43	9	4.4	0.3
Biology	63	59	4.5	2.6
Chemistry	71	56	5.5	2.7
Computer Science A	58	28	3.7	0.9
Computer Science AB	56	28	4.9	0.9
Microeconomics	74	46	2.6	1.2
Macroeconomics	68	46	2.1	1.2
English Language and Composition	96	92	3.3	3.1
English Literature and Composition	83	96	3.2	3.3
European History	59	59	1.9	1.3
French Language	56	13	2.2	0.4
French Literature	59	13	2.2	0.4
German Language	54	7	2.5	0.2
U.S. Government and Politics	60	70	2.8	2.3
Comparative Government and Politics	51	63	2.7	2.2
Latin*	25	13	0.9	0.2
Calculus AB	84	90	7.7	5.7
Calculus BC	89	90	10.7	5.7
Music Theory	56	30	10.1	1.0
Physics B	72	59	8.2	4.2
Physics Mechanics	70	59	10.0	4.2
Physics E & M	80	59	11.3	4.2
Psychology	68	61	3.2	1.7
Spanish Language	44	27	1.9	0.8
Spanish Literature	50	27	2.2	0.8

* Latin refers to AP candidates taking either Latin Literature or Latin: Vergil.

Table 4

Time to Graduation for AP and Non-AP College Students

	Percent Within 4 Years	*Percent in 5 Years*	*Percent Dropout/Transfer/> 5 Years*
AP	62.8	14.5	22.7
Non-AP	44.8	17.0	38.2

four years. After five years, 77 percent of AP students had completed their degree at their original institution, while only 62 percent of the non-AP students had earned their degree at their original institution.

A set of logistic regressions was conducted to further examine these results. Table 5 indicates that even after accounting for the higher SAT scores of the AP students, the odds ratio for graduation is 61 percent higher for those in the AP group. These results led to a model predicting graduation from AP participation that controlled for SAT score, a proxy variable for student achievement level.

As with Question 2, all AP students are included in the analyses. The predicted probabilities of graduation when using total score on the SAT as a predictor variable are shown in Figure 1. Two subgroups are shown: students who have taken at least one AP Examination and those who have not taken an AP Exam. For both groups between SAT total scores of 800 and 1200, a 400-point increase in total SAT score is associated with approximately an 8 percent increase in the predicted probability of graduation. As indicated in the figure, the predicted probability for non-AP students with SAT total scores of 800 graduating in five years is 58 percent, while the corresponding probability at the total score of 1200 is 66 percent. Figure 1 shows that 76 percent of AP students with SAT scores of 1200 graduate in five years. Only 66 percent of those with the same SAT total score, but without an AP Exam grade, graduate in five years. The 10 percent difference in the probabilities is generally consistent up and down the SAT score scale.

Preliminary analyses also revealed that gender significantly enhances model fit to the data as detected by likelihood statistics. Gender was therefore added as a variable to the logistic regression model. Figure 2 shows that throughout the SAT score scale, the probabilities of females graduating within five years are about 10 percent higher than those for males. Figure 2 shows for those with SAT scores of 1200, the probability of graduation is approximately 81 percent for females who took an AP Exam,

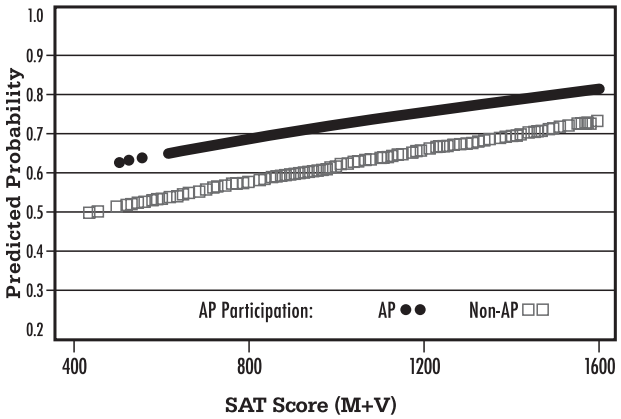

Figure 1. Probability of graduation predicted by AP participation with total SAT score (mathematics and verbal) as a covariate.

72 percent for females who did not take an AP Exam, 71 percent for males with an AP grade, and 60 percent for males who did not take an AP Exam. A deviance test reveals that gender significantly contributes to model fit ($\chi^2 = 21.0$, $df = 1$, $p < 0.01$). Including a gender by AP participation interaction term does not significantly contribute to the predicted probability of graduation. A likelihood ratio χ^2 test indicates that AP males statistically significantly differ in probability of graduation compared to non-AP males, and AP females similarly differ from non-AP females ($p < 0.001$). In addition, AP males and females significantly differ in probability of graduation, as do non-AP females and males ($p < 0.001$). The likelihood ratio χ^2 test indicates that the difference between predicted probabilities of graduation among non-AP females and AP males is not statistically significant ($p > 0.05$).

Time to graduation for African Americans, Asian Americans, Hispanics, and whites are presented in Table 6. The percentages for each racial/ethnic group at a given college are weighted by the total number of students in the sample at that college. The percentage of students not

Table 5

Analyses of Four Logistic Regression Models Predicting College Graduation

Model	*Variable*	*Odds Ratio*	χ^2	p
SAT Alone	SAT Total	1.32	38.90	< .001
AP Alone	AP Status (AP Participation=1)	1.85	69.44	< .001
AP with SAT As Covariate	AP Status (AP Participation=1)	1.61	32.48	< .001
	SAT Total	1.20	12.45	< .001
AP, Gender with SAT As Covariate	AP Status (AP Participation=1)	1.56	27.41	< .001
	Gender	1.67	41.46	< .001
	SAT Total	1.27	20.84	< .001

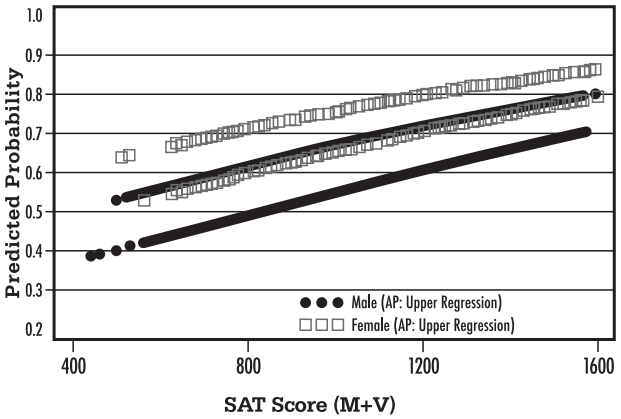

Figure 2. Probability of graduation predicted by AP participation and gender, adjusted for SAT score (mathematics and verbal).

Table 6

Weighted Latency to Graduation by Racial/Ethnic Group

Racial/Ethnic Group	*% Graduating*		*% Not Graduating (Dropout/Transfer/ > 5 Years)*
	4 or Fewer Years	*5 Years*	
African American			
AP	47.9	16.5	35.5
Non-AP	39.7	16.8	43.5
Asian American			
AP	58.8	18.1	23.2
Non-AP	46.1	19.6	34.3
Hispanic			
AP	49.7	17.8	32.5
Non-AP	36.0	17.8	46.1
White			
AP	60.8	15.3	23.9
Non-AP	51.7	15.5	32.8

Note: Percentages may not sum to 100 due to rounding.

graduating within five years is at least 8 percentage points higher for non-AP students in each of the four groups. The percentage difference is the smallest for African American students (36 percent versus 44 percent). The weighting procedure standardized the raw cell frequencies, making them easily comparable.

Figure 3, based on logistic regression analyses, displays in four panels the probability of graduation within five years given SAT scores for each of the four racial/ethnic groups tested. The differences between AP students and those who did not take AP are pronounced within each of the four groups, with an approximately 8- to 12-percentage point difference in graduation rate regardless of SAT score level. The panels in Figure 3 also reveal that the probabilities of graduation at all levels of SAT scores are higher for Asian American and white students than those for African American and Hispanic students.

Question 4

Do AP students graduate with majors in the discipline in which students took AP Exams more often than other college students?

The majors of graduating college students were examined. Students who did not graduate were not included in the analyses. If AP courses are viewed by students as just an alternative way to meet college graduation requirements or if the AP courses are not meeting the needs of students, one consequence is that students may decide not to major in a discipline closely related to their AP Exams. For each AP Exam, Table 7 provides the proportion of students who took the AP Exam and who also graduated with a major that was determined to be in a discipline closely related to the AP Exam. The majors corresponding to the AP Exams are listed within the second column of Table 7. These same majors were used to define the course work areas for the analyses displayed in Table 3. In order to make comparisons, Table 7 also includes the percentages of students who did not take any AP Exam and who graduated with a major in the discipline closely related to the AP Exam. As found by Morgan and Maneckshana (2000), the percentages were the highest for the AP courses in physics with nearly 40 percent of those taking the AP Physics C: Electricity and Magnetism Exam majoring in a discipline closely related to physics. In contrast, only 8 percent of the non-AP students graduated with a degree in an area related to physics. The lowest percentages (4 percent) are found for those taking an AP Exam in a foreign language. However, the corresponding percentages for the non-AP population are all less than 1 percent. As can be seen in the table, the percentages for all AP Exams except the English exams and the economics exams are at least twice as high for the AP students as for those who did not take an AP Exam. The students who took the AP Exams in Studio Art, Art History, Computer Science AB, French

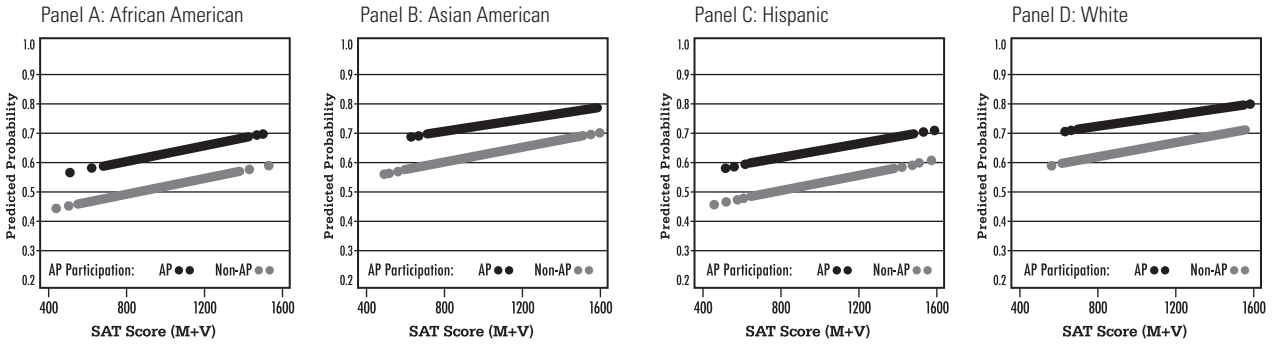

Figure 3. Probability of graduation predicted by AP participation and racial/ethnic group, adjusted for SAT score (mathematics and verbal).

Table 7

Percentage of Students Majoring in a Discipline Closely Related to the AP Exam

AP Exam	*Majors Related to AP Exam*	*AP Graduates with Closely Related Majors (%)*	*Non-AP Graduates with Closely Related Majors (%)*
U.S. History	American Civilization, American Studies, History, History Teaching, International Affairs	5%	2%
Art History	Art, Art History, Fine Art	5%	< 1%
Art–Drawing	Art, Illustration	13%	1%
Art–General	Art, Art Education	18%	1%
Biology	Animal Science, Biology, Applied Biology, Biological Studies, Biology and Society, Psychobiology, Biology Technology, Botany, Zoology	19%	6%
Chemistry	Chemistry, Biochemistry, Chemistry Education, Chemical Engineering, Textile Chemistry	15%	2%
Computer Science A	Computer Science Information Systems, Computer Science, Computer Engineering, Information Systems	19%	3%
Computer Science AB	Computer Science Information Systems, Computer Science, Computer Engineering, Information Systems	32%	3%
Microeconomics	Economics	11%	7%
Macroeconomics	Economics, International Business	10%	7%
English Language and Composition	English, English and Rhetoric, English Teaching, Communication Arts, Comparative Literature, Dramatic Literature, Journalism	8%	6%
English Literature and Composition	English, English and Rhetoric, English Teaching, Communication Arts, Comparative Literature, Dramatic Literature, Journalism	8%	6%
European History	History, International Affairs, Political Science	11%	4%
French Language	French, French Studies, French Teaching	4%	< 1%
French Literature	French	4%	< 1%
German Language	German	6%	< 1%
U.S. Government and Politics	Political Science, American Studies (Civilization), Political Communication, Government	11%	5%
Comparative Government and Politics	Political Science, International Studies, International Affairs (Relations), European History, Government	17%	6%
Latin*	Classics	7%	<1%
Calculus AB	Engineering (Aerospace, Agricultural Ceramic, Chemical, Civil, Computer, Electrical), Applied Mathematics (Mathematics), Civil and Environmental Engineering, Computer Science, Economics and Math, Engineering Science and Technology	21%	10%
Calculus BC	Engineering (Aerospace, Agricultural Ceramic, Chemical, Civil, Computer, Electrical), Applied Mathematics (Mathematics), Civil and Environmental Engineering, Computer Science, Economics and Math, Engineering Science and Technology	30%	10%
Music Theory	Music, Music Education	18%	1%
Physics: B	Engineering (Aerospace, Ceramic, Chemical, Civil, Computer, Electrical, Industrial, Materials, Mechanical, Nuclear, Textile), Physics, Physics Teaching, Applied Physics, Engineering Physics	26%	8%
Physics: Mechanics	Engineering (Aerospace, Ceramic, Chemical, Civil, Computer, Electrical, Industrial, Materials, Mechanical, Nuclear, Textile), Physics, Physics–Astronomy, Applied Physics, Engineering Physics	38%	8%
Physics: Electricity and Magnetism	Engineering (Aerospace, Ceramic, Chemical, Civil, Computer, Electrical, Industrial, Materials, Mechanical, Nuclear, Textile), Honors Physics, Physics, Physics–Astronomy, Applied Physics, Engineering Physics	39%	8%
Psychology	Psychology, Human Resources Management, Human Development and the Family	13%	5%
Spanish Language	Spanish, Spanish Teaching, Spanish American Literature	4%	< 1%
Spanish Literature	Spanish, Spanish American Literature	4%	< 1%

* Latin refers to AP candidates taking either Latin Literature or Latin: Vergil.

Language, French Literature, German Language, Latin[1], and Music Theory were at least 10 times more likely to major in an area related to the specific AP Exam than non-AP students. These data also serve to reinforce the earlier findings in Question 2 that taking an AP Exam may serve to encourage students to take continued course work in areas closely related to the AP Exam.

Question 5

Do females and underrepresented minorities who take AP mathematics and science courses continue their study of mathematics and science in college?

The question of whether taking AP math and science courses encourages females and underrepresented minorities to pursue academic study in these areas can be approached in several ways. The approach used in this paper was to determine whether students who take a particular math and science AP Exam majored in an area related to the exam. Table 8 is similar in format to Table 7. The table provides, for the two gender groups and four racial/ethnic groups, the proportion of students who took the AP Exam and also graduated with a major determined to be closely related to the discipline of the AP Exam. Table 8 also provides, for the two gender groups and four racial/ethnic groups, the percentages of non-AP students majoring in a discipline closely related to the AP Exam. The percentages in the table are a result of weighting the percentages of each group within each university by the number of students attending that university. This weighting preserves the nature of the within-college and within-racial/ethnic group differences between the AP and non-AP groups.

All comparisons of the AP students with the non-AP students show that the AP science and math students are much more likely to major in a field closely related to the AP math and science exam taken than are non-AP students. For most AP courses, the percentages for African American and Hispanic AP students taking related courses are at least four times the corresponding percentages for non-AP students. The ratios of the AP students and non-AP student percentages for females are most striking for students majoring in chemistry, computer science, and physics.

Discussion

This study adds to the research literature concerning AP students in college. The study compared those students who took at least one AP Exam with those college students who did not take an AP Exam. This research was not able to answer questions concerning those students who took AP courses but chose not to take AP Exams. Perhaps in the future, the College Board will be able to track these students.

Based on the results of this study, for most AP Exams, students with AP grades of 3 or better had higher grade averages in intermediate college courses than did the non-AP students who first took an introductory course.

As was true in Morgan and Ramist (1998), the course grade averages for students with AP grades of 5 are much higher than those for both AP students earning lower grades and those for the non-AP group. This was also true, although to a lesser extent, after accounting for SAT score differences. The course grade averages for those with AP grades of 4 and AP grades of 3, however, are often close. While comparisons of course averages of the groups

Table 8

Percentage of Students Majoring in a Discipline Closely Related to the AP Exam by Gender and Racial/Ethnic Group

	Percent of AP Students Majoring in Related Math/Science Content Area						*Percent of Non-AP Students Majoring in Related Math/Science Content Area*					
	Asian American	*African American*	*Hispanic*	*White*	*Female*	*Male*	*Asian American*	*African American*	*Hispanic*	*White*	*Female*	*Male*
Biology	22	18	16	18	20	17	7	6	4	5	6	5
Chemistry	17	14	13	14	15	15	2	2	2	1	1	2
Computer Science A	15	14	17	20	11	20	3	2	2	3	1	4
Computer Science AB	9	26	15	28	12	33	3	2	2	2	1	4
Calculus AB	21	21	23	22	11	28	12	9	8	8	4	13
Calculus BC	32	28	23	35	16	36	11	9	6	8	4	13
Physics B	24	31	25	27	16	28	10	7	8	7	3	11
Physics Mechanics	34	29	41	38	22	40	10	6	7	7	3	11
Physics E and M	39	48	47	40	25	40	10	6	7	7	2	10

[1]The data from the two AP Latin Exams were combined due to the small numbers of students taking the AP Latin Exams.

earning the different AP grades is outside the primary focus of this research, the pattern of somewhat small differences between those with AP grades of 4 and those with AP grades of 3 suggests that colleges with AP policies of awarding advanced placement only to those with AP grades of 4 or higher might want to consider awarding advanced placement to those with AP grades of 3.

AP students to a large extent graduate earlier than non-AP students. These findings apply within all the racial/ethnic and gender groups studied. Although students without SAT scores were excluded in analyses when such scores were used, differences in graduation outcomes are also quite evident when these scores were statistically controlled. The percentages of AP students who graduate with a degree in an area closely related to their AP Exam are noticeably higher than the corresponding graduation percentages for students who did not take an AP Exam. Furthermore, while no statistical control was implemented in analyzing data concerning number of courses and major, AP participation does not appear to discourage students from taking college courses in disciplines closely related to their AP Exams. The data show, that for most AP Exams, AP students take on considerably more course work in the area of their AP Exam than do non-AP students.

No research, without a controlled experimental design, can definitively determine the causal effects of advanced course work in high school on the futures of secondary school students. In the future, nonexperimental research that accounts for variables such as socioeconomic status and student motivation may lead to increased understanding of the relationship of AP participation and future outcomes. Nevertheless, it appears that after controlling for SAT scores, those who elect to take AP Exams have a higher probability of graduation than their non-AP counterparts, graduate earlier, and earn higher grades in intermediate courses.

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Appendix A: Course Sequences

	Introductory Course		*Intermediate Course*	
Biology				
Barnard	BIOLOGY	1001	BIOLOGY	1002
Binghamton	BIOL	113	BIOL	114
BYU	BIOLOGY	100	BIOLOGY	101
Carnegie Mellon	BSC	03121	BSC	03122
Cornell	BIO	110	BIO	207
George Washington	BISC	004	BISC	011
Georgia Tech	BIOL	1110	BIOL	1111
Miami (OH)	ZOO	116	ZOO	121
North Carolina State	BIO	105	BIO	125
UC Davis	BIS	010	BIS	101
Illinois	BIOL	120	BIOL	122
Iowa	002	21	002	22
Maryland	BIOL	106	BIOL	222
Miami (FL)	BIL	161	BIL	235
Virginia	BIOLOGY	201	BIOLOGY	203
Washington	BIOL	101	BIOL	201
Florida	BSC	2010	BSC	2011
Texas	BIO	302	BIO	303
Wesleyan	BIOL	104	BIOL	205
Dartmouth	BIOL	002	BIOL	014
Texas A&M	BIOL	124	BIOL	357
William & Mary	BIO	102	BIO	103
Chemistry				
Barnard	CHEMISTRY	BC1601	CHEMISTRY	BC3230
Binghamton	CHEM	111	CHEM	231
BYU	CHEMISTRY	106	CHEMISTRY	107
Carnegie Mellon	CMY	9106	CMY	9117
George Washington	CHEM	012	CHEM	151
Georgia Tech	CHEM	1100	CHEM	1101
North Carolina State	CH	202	CH	221
UC Davis	CHE	002	CHE	118
Illinois	CHEM	231	CHEM	234
Iowa	004	7	004	13
Maryland	CHEM	113	CHEM	233
Miami (FL)	CHM	202	CHM	203
Virginia	CHEMISTRY	142	CHEMISTRY	151
Washington	CHEM	162	CHEM	237
Florida	CHM	2041	CHM	2046
Texas	CH	302	CH	304K
Wesleyan	CHEM	252	CHEM	257
Dartmouth	CHEM	005	CHEM	006
Texas A&M	CHEM	102	CHEM	111
William & Mary	CHEM	354	CHEM	391

	Introductory Course		*Intermediate Course*	
English				
BYU	ENGLISH	115	ENGLISH	201
Carnegie Mellon	ENG	76100	ENG	76101
Cornell	ENGL	270	ENGL	281
George Washington	ENGL	010	ENGL	011
George Washington	ENGL	052	ENGL	071
Georgia Tech	ENGL	1001	ENGL	1002
North Carolina State	ENG	111	ENG	112
North Carolina State	ENG	208	ENG	209
UC Davis	ENL	003	ENL	101
Illinois	RHET	105	ENG	103
Illinois	ENGL	103	ENGL	104
Iowa	08G	1	08G	9
Maryland	ENGL	101	ENGL	205
Maryland	ENGL	240	ENGL	241
Miami (FL)	ENG	106	ENG	201
Virginia	ENGLISH	101	ENGLISH	201
Virginia	ENGLISH	214	ENGLISH	230
Washington	ENGL	111	ENGL	121
Florida	ENC	1102	ENC	2210
Florida	ENL	2022	ENL	2330
Texas	E	306	E	316K
Texas	E	316K	E	321
Williams	ENGL	101	ENGL	201
Wesleyan	ENGL	181	ENGL	201
Wesleyan	ENGL	182	ENGL	203
Texas A&M	ENGL	203	ENGL	210
Texas A&M	ENGL	241	ENGL	203
William & Mary	WRIT	101	ENG	201
William & Mary	ENG	201	ENG	203
U.S. History				
BYU	HISTORY	202	HISTORY	300
Carnegie Mellon	HIS	79110	HIS	79202
Cornell	HIST	152	HIST	190
George Washington	HIST	072	HIST	101
Georgia Tech	HIST	1001	HIST	1002
Miami (OH)	HST	112	HST	121
North Carolina State	HI	252	HI	263
UC Davis	HIS	017	HIS	111
Illinois	HIST	111	HIST	112
Iowa	16A	62	16A	122
Maryland	HIST	157	HIST	211
Miami (FL)	HIS	131	HIS	132
Virginia	HISTORY	202	HISTORY	203
Washington	HSTAA	201	HSTAA	202
Florida	AMH	2020	AMH	3421
Texas	HIS	315L	HIS	320L
Williams	HIST	101	HIST	227

	Introductory Course		*Intermediate Course*	
Wesleyan	HIST	110	HIST	201
Dartmouth	HIST	001	HIST	002
Texas A&M	HIST	106	HIST	213
William & Mary	HIST	202	HIST	211
Economics				
Barnard	ECONOMICS	BC1001	ECONOMICS	BC3033
Binghamton	ECON	160	ECON	162
BYU	ECONOMICS	110	ECONOMICS	230
Carnegie Mellon	ECO	73100	ECO	73250
Cornell	ECON	102	ECON	103
George Washington	ECON	012	ECON	121
Georgia Tech	ECON	2000	ECON	2001
Miami (OH)	ECO	202	ECO	201
North Carolina State	EC	202	EC	301
UC Davis	ECN	001	ECN	101
Illinois	ECON	103	ECON	102
Iowa	06E	2	06E	100
Maryland	ECON	201	ECON	203
Miami	ECO	212	ECO	302
Virginia	ECONOMICS	202	ECONOMICS	301
Washington	ECON	201	ECON	300
Florida	ECO	2013	ECO	202
Texas	ECO	302	ECO	320L
Williams	ECON	101	ECON	252
Wesleyan	ECON	111	ECON	272
Texas A&M	ECON	203	ECON	322
William & Mary	ECON	102	ECON	303
Calculus AB				
Barnard	MATH	V1101	MATH	V1102
Binghamton	MATH	221	MATH	222
BYU	MATHEMATIC	112	MATHEMATIC	113
Carnegie Mellon	MSC	21121	MSC	21122
Cornell	MATH	121	MATH	122
George Washington	MATH	031	MATH	032
Georgia Tech	MATH	1507	MATH	1508
Miami (OH)	MTH	151	MTH	251
North Carolina State	MA	141	MA	241
UC Davis	MAT	012	MAT	016
Illinois	MATH	120	MATH	130
Iowa	22M	25	22M	26
Maryland	MATH	140	MATH	141
Miami (FL)	MTH	131	MTH	132
Virginia	MATH	131	MATH	132
Washington	MATH	125	MATH	126
Florida	MAC	2311	MAC	2312
Texas	M	408C	M	408D
Williams	MATH	104	MATH	105
Wesleyan	MATH	121	MATH	221

	Introductory Course		*Intermediate Course*	
Dartmouth	MATH	003	MATH	008
Texas A&M	MATH	151	MATH	152
William & Mary	MATH	111	MATH	112
Calculus BC				
Barnard	MATH	V1102	MATH	V2010
Binghamton	MATH	221	MATH	222
Carnegie Mellon	MSC	21122	MSC	21127
Cornell	MATH	122	MATH	221
George Washington	MATH	032	MATH	033
Georgia Tech	MATH	1507	MATH	1508
Miami (OH)	MTH	251	MTH	252
North Carolina State	MA	141	MA	242
UC Davis	MAT	021	MAT	022
Illinois	MATH	134	MATH	225
Iowa	22M	26	22M	35
Maryland	MATH	141	MATH	240
Miami (FL)	MTH	132	MTH	210
Virginia	MATH	132	MATH	221
Washington	MATH	125	MATH	126
Florida	MAC	2312	MAC	2313
Texas	M	408C	M	408D
Williams	MATH	105	MATH	143
Wesleyan	MATH	122	MATH	221
Dartmouth	MATH	003	MATH	011
Texas A&M	MATH	152	MATH	161
William & Mary	MATH	112	MATH	211
U.S. Government and Politics				
Binghamton	PLSC	111	PLSC	112
BYU	POLITICAL	110	POLITICAL	150
Carnegie Mellon	SDS	88104	SDS	88105
Cornell	GOVT	111	GOVT	161
George Washington	PSC	001	PSC	002
Miami (OH)	POL	141	POL	271
North Carolina State	PS	201	PS	202
UC Davis	POL	001	POL	003
Illinois	POL S	100	POL S	150
Iowa	030	1	030	50
Maryland	GVPT	170	GVPT	200
Miami (FL)	POL	211	POL	212
Virginia	GOVERNMENT	101	GOVERNMENT	311
Washington	POL S	202	POL S	203
Florida	POS	2041	POS	2112
Texas	GOV	310L	GOV	312L
Williams	PSCI	102	PSCI	209
Wesleyan	GOVT	151	GOVT	201
William & Mary	GOVT	201	GOVT	202

	Introductory Course		*Intermediate Course*	
Psychology				
Barnard	PSYCHOLOGY	1001	PSYCHOLOGY	1101
Binghamton	PSYC	111	PSYC	220
BYU	PSYCHOLOGY	111	PSYCHOLOGY	220
Carnegie Mellon	PSY	85102	PSY	85211
Cornell	PSYCH	101	PSYCH	205
George Washington	PSYC	001	PSYC	011
Georgia Tech	PSY	1010	PSY	3303
Miami (OH)	PSY	111	PSY	221
North Carolina State	PSY	200	PSY	240
UC Davis	PSC	001	PSC	100
Illinois	PSYCH	100	PSYCH	201
Iowa	031	1	031	13
Maryland	PSYC	100	PSYC	221
Miami (FL)	PSY	110	PSY	203
Virginia	PSYCHOLOGY	101	PSYCHOLOGY	220
Washington	PSYCH	101	PSYCH	102
Florida	PSY	2013	EAB	3002
Texas	PSY	301	PSY	304
Williams	PSYC	101	PSYC	242
Wesleyan	PSYC	105	PSYC	201
Dartmouth	PSYC	001	PSYC	010
Texas A&M	PSYC	107	PSYC	306
William & Mary	PSY	201	PSY	202
Spanish Language				
Binghamton	SPAN	215	SPAN	251
BYU	SPANISH	310	SPANISH	321
Carnegie Mellon	ML	82242	ML	82342
Cornell	SPAND	121	SPAND	122
George Washington	SPAN	010	SPAN	054
Georgia Tech	SPAN	2022	SPAN	2023
Miami (OH)	SPN	311	SPN	312
North Carolina State	FLS	202	FLS	310
UC Davis	SPA	003	SPA	021
Illinois	SPAN	210	SPAN	214
Maryland	SPAN	207	SPAN	301
Miami (FL)	SPA	212	SPA	221
Virginia	SPANISH	202	SPANISH	311
Washington	SPAN	203	SPAN	301
Florida	SPN	2201	SPN	3300
Texas	SPN	312L	SPN	319
Wesleyan	SPAN	111	SPAN	221
Dartmouth	SPAN	009	SPAN	032
Texas A&M	SPAN	201	SPAN	202
William & Mary	SPAN	207	SPAN	208

Appendix B: Question 1 Regressions: Parameter Estimates and Their Standard Errors

		Beta Weights (Standard Errors)				
AP Exam	***Regression***	***Intercept***	***AP Grade 3***	***AP Grade 4***	***AP Grade 5***	***SAT Total***
U.S. History	Model1	2.874 (0.033)***	0.182 (0.120)	0.460 (0.140)*	0.609 (0.285)*	
	Model2	2.601 (0.221)***	0.166 (0.121)	0.430 (0.142)*	0.567 (0.287)*	0.0002 (0.0002)
Biology	Model1	2.796 (0.017)***	0.072 (0.060)	0.291 (0.077)**	0.629 (0.087)***	
	Model2	1.363 (0.122)***	0.029 (0.059)	0.170 (0.076)*	0.435 (0.087)***	0.0012 (0.0001)***
Chemistry	Model1	2.877 (0.013)***	0.061 (0.076)	0.216 (0.118)	0.325 (0.160)*	
	Model2	1.513 (0.092)***	-0.075 (0.075)	0.035 (0.116)	0.112 (0.157)	0.0012 (0.0001)***
Macroeconomics	Model1	2.883 (0.012)***	0.158 (0.143)	-0.029 (0.156)	0.678 (0.209)*	
	Model2	1.059 (0.081)***	0.045 (0.137)	-0.330 (0.151)*	0.331 (0.201)	0.0016 (0.0001)***
English	Model1	3.043 (0.010)***	0.326 (0.060)***	0.438 (0.081)***	0.791 (0.125)***	
	Model2	2.156 (0.069)***	0.222 (0.060)**	0.276 (0.081)**	0.594 (0.125)***	0.0008 (0.0001)***
U.S. Government and Politics	Model1	2.762 (0.016)***	0.169 (0.072)*	0.409 (0.102)***	0.514 (0.119)***	
	Model2	1.289 (0.118)***	0.082 (0.071)	0.221 (0.101)*	0.258 (0.118)*	0.0013 (0.0001)***
Calculus AB	Model1	2.436 (0.016)***	0.265 (0.047)***	0.475 (0.066)***	0.907 (0.077)***	
	Model2	1.113 (0.117)***	0.211 (0.046)***	0.350 (0.066)***	0.719 (0.078)***	0.0011 (0.0001)***
Calculus BC	Model1	2.501 (0.016)***	0.503 (0.125)***	0.946 (0.176)***	0.955 (0.154)***	
	Model2	1.336 (0.117)***	0.416 (0.124)**	0.851 (0.175)***	0.767 (0.154)***	0.0010 (0.0001)***
Psychology	Model1	2.900 (0.014)***	0.100 (0.175)	0.191 (0.278)	0.876 (0.377)*	
	Model2	1.358 (0.098)***	0.106 (0.170)	0.087 0.271)	0.631 (0.367)	0.0013 (0.0001)***
Spanish Language	Model1	3.106 (0.027)***	0.159 (0.078)*	0.216 (0.106)*	0.818 (0.098)***	
	Model2	2.265 (0.169)***	0.115 (0.077)	0.173 (0.105)	0.764 (0.098)***	0.0007 (0.0001)***

* $p < 0.05$.
** $p < 0.001$.
*** $p < 0.0001$.


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