



Accounting for Advanced High School Coursework in College Admission Decisions

Evidence from college science courses supports the incorporation of letter-grade bonuses into the calculation of high school GPA: one-half for honors courses, one for AP courses, and two for students who earn a three or higher on an AP exam.

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Each January, the flood rages anew: A torrent of applications, transcripts, test scores, and recommendations flows in to be read, considered, compared, grouped, presented, and rated. Each item plays a vital role in admission to colleges and universities. Although weighting differs by institution, all seek to gauge whether a student can navigate the shoals of academia and emerge—a graduate—on the far shore. Generally, grades earned in high school are viewed as the best predictors of college performance (Noble and Sawyer 2004). The aggregate high school grade point average (HSGPA) sums up pre-college preparation and performance.

The majority of colleges and universities recompute HSGPA, eliminating courses viewed as superfluous and accentuating those deemed to be advanced (Hawkins and Clinedinst 2006). The remaining colleges rely upon the HSGPA forwarded by an applicant's high school, accepting that the majority add "bonus points" for advanced coursework (Cognard 1996; Dillon 1986; Jones 1975; National Research Council 2002). Yet research concerning the validity of the variety of systems advocated for calculating HSGPA is quite meager (Sadler and Tai 2007). Nearly all of the variation in calculation of HSGPA relates to the treatment of advanced coursework. Taking honors, International Baccalaureate™ (IB)¹, or Advanced Placement™ (AP) courses demonstrates a student's ability to do advanced work while still in high school, implying greater readiness for college. Typically, such courses are taken by the most apt high school students. It is believed to be more difficult to earn a high grade in the midst of such (presumed) competition; as a result, HSGPA is adjusted.

Often, honors courses are products of a high school's lengthy tradition (or of a particular teacher) and are characterized by curricular freedom to choose texts, topics, and

teaching methods (Herr 1993). Honors courses usually allow for extensive time to be spent in the laboratory and are viewed by their teachers as helping to sharpen students' analytical thinking skills. They often require project work and student reports. In some schools, an honors course is a prerequisite for enrollment in an Advanced Placement course; in others it is the highest-level course offered (Herr 1991a; Herr 1991b).

The AP program has expanded over the last 50 years to involve 1.2 million students taking 2.1 million AP exams in more than 32 subjects (Camara, Dorans, Morgan and Myford 2000; College Entrance Examination Board [College Board] 2005a; Hershey 1990; Rothschild 1999). Increasingly, students apply to college with AP courses on their high school transcripts. In 2006, 61.6 percent of college freshmen reported that they had taken at least one AP course, and 14.9 percent took five or more AP courses (Hurtado and Pryor 2007). In addition, the percentage of students taking AP examinations prior to their senior year in high school has surged by 5.4 percent in the last five years, to 47.7 percent in 2006 (College Board 2006). The average pass rate (three or greater on a five-point scale) on AP exams in the sciences exceeds 60 percent. We estimate that 73,000 college applicants in 2007 will submit a passing AP exam score in science.

While college admissions officers consider AP enrollment a plus, the College Board recognizes only students who earn an exam score of three or higher as having mastered the course content. "AP passers" represent fewer than half of students enrolled in AP courses; the remainder either do not pass (*i.e.*, they score a two or less) or they opt out of taking the exam. An estimated 30 to 40 percent of students enrolled in AP courses choose not to take the AP exam (National Research Council 2002, p.18). The letter grade awarded by an AP teacher (listed accordingly on a student's high school transcript) does not appear to be a proxy for an AP exam

¹ The International Baccalaureate (IB) program is offered in only 564 North American schools, too small a fraction for our study to examine.

score.² Many students earning high course grades do not perform well on the AP exam (Hershey 1990); some suggest this is evidence of a decrease in quality as the program has grown (Lichten 2000). Others argue that the quality of AP courses varies considerably (Honowar 2005).³ We see an opportunity to reconcile high school course rigor, grade earned, and AP exam scores, particularly as “it is anticipated that [AP and International Baccalaureate] examination scores may play a greater role in the admission process in the future.” (NRC 2002, p.57)

Prior Research

The calculation and role of HSGPA are of considerable interest to college admission officers. Many arguments have been made in support of honors and AP courses: for example, students more authentically experience the kind of learning characteristically required in college (Venezia and Kirst 2005). Accounting for the rigor of a high school’s academic program helps explain the variance in the GPA of college freshmen, supporting the use of course rigor in making admissions decisions (Bassiri and Schultz 2003; Lang 1997). Accounting for high school performance also can balance out the gender bias evidenced in standardized tests (Bridgeman and Lewis 1996; Bridgeman and Wendler 1991; Gallagher and Kaufman 2005; Wainer and Steinberg 1992). College admissions officers rank AP course enrollment above SAT II scores in importance (Breeland, *et al.* 2002); college admissions officers prefer weighted HSGPA, even when their admissions policies do not state a preference (Seyfert 1981; Talley and Mohr 1993). Applicants from high schools that do not weight advanced courses can be at a significant comparative disadvantage if the colleges to which they apply do not recalculate HSGPA (Lockhart 1990; Rutledge 1991) or emphasize high school rank-in-class in their admissions decisions (Downs 2000).

Researchers have found that weighted HSGPA predicts first-year college GPA better than non-weighted HSGPA (Bridgeman, McCamley-Jenkins and Ervin 2000; Dillon 1986). Several studies have found that students who have taken AP coursework have higher college GPAs (Burton and Ramist 2001; Chamberlain, Pugh, and Shellhammer 1978; Morgan and Ramist 1998), but this result is highly dependent upon the research methodology employed—and particularly on the inclusion of control variables such as standardized test scores, ethnicity, and community affluence (Geiser and Santelices 2004; Klopfenstein and Thomas 2005; Ruch 1968). AP exam score has been found to be a better predictor of college grades than mere enrollment in an AP course (Dodd, Fitzpatrick and Jennings 2002; Geiser and Santelices 2004).

² The correlation between the two is a relatively low 0.336 for the 964 students in our study reporting both.

³ The College Board has responded by implementing an “audit” of high school AP offerings aimed to “...help colleges and universities better interpret secondary school courses marked AP on students’ transcripts (College Board, 2007, p. 3).”

Grade inflation in U.S. high schools is well documented and is problematic in terms of college admissions decisions (Woodruff and Ziomek, 2004). In 1968, only 18 percent of high school seniors had an “A” average; in 2004, nearly half—47 percent (Cooperative Institutional Research Program [CIRP] 2005; Kirst and Bracco 2004)—had an “A” average. Grade inflation is particularly evident at the higher end of the academic scale, where the resulting “ceiling effect” makes it difficult to distinguish among high-performing candidates (Ziomek and Svec 1997). Weighting of AP courses extends the statistical tail of the GPA distribution at the high end, making differences among candidates more readily apparent.⁴

Although colleges and universities utilize a variety of methods to differentiate among applicants of diverse academic backgrounds, the research literature includes no analytical approach to the calculation of a weighted HSGPA which includes advanced coursework and AP examination scores. The purpose of the current study is to investigate the feasibility of accounting for student performance in advanced high school coursework through the adjustment of HSGPA while separating out variables that are independently considered in the admission process, *e.g.*, SAT/ACT scores, community affluence, type of high school, and race/ethnicity.

Methods

This study relates three variables: high school science grade, high school course level (*i.e.*, regular, honors, Advanced Placement), and AP examination score. These three are compared, using as a common metric how well students perform in their introductory college biology, chemistry, or physics coursework. It is assumed that the college grade earned should reflect high school achievement, coursework, and AP exam performance. This analysis is possible because at many colleges, students repeat, rather than “place out” of, their introductory science course, even if they scored well on an AP exam (Ferrini-Mundy and Gaudard 1992; Willingham and Morris 1986). As a group, these “retakers” cannot be dismissed as students who had performed poorly in their AP courses. Forty-five percent of these AP students reported that they took the AP exam; their mean score was 3.05, compared to 2.99 for students who took the exam nationally in these subject areas (College Entrance Examination Board 2005b); and 70 percent of students had earned a grade of “A” in their AP course. The reasons students gave for “retaking” this introductory course were varied:

- Student concern about solidifying their grasp of basic concepts
- Advice from academic advisors and upperclassmen
- Not attaining the departmental requirement of an AP score of 4 or 5
- Not earning a high enough score on the departmental placement exam

⁴ For students in our study, weighting of their science coursework pushed 9% of student GPAs beyond the 4.0 level.

The Survey Instrument

In the first two weeks of their introductory science course, science professors distributed a four-page, machine-readable survey. Revised after two sets of pilot studies so as to refine items relating to high school science experiences (*e.g.*, lab frequency and freedom; classroom activities; homework and other assignments; and time devoted to particular scientific concepts), it also collected information relating to students' personal background and high school. Research papers utilizing these data include the teaching of chemistry (Tai, Sadler and Loehr 2005; Tai, Ward, and Sadler 2006); block scheduling (Dexter, Tai and Sadler 2006); class size (Wyss, Tai, and Sadler, 2007); science activities (Tai and Sadler 2007, in press), high school grade-point-average (Sadler and Tai 2007); student autonomy (Tai, Sadler, and Maltese, in press); performance in college science courses (Sadler and Tai 2007, in press); and preparation for success in college science (Tai, Sadler and Mintzes 2006). An earlier study (Sadler and Tai 2001) found a significant effect on the earned college grade depending on the college year in which students took the course. In particular, graduate students enrolling in an introductory course tended to perform well.

As is common when employing epidemiological methods, subjects self-reported most variables (*e.g.*, high school grades, coursework, and AP experience). College students' self-reports of course taking, grades earned, and standardized test scores have been well studied and tend to be highly accurate (Anaya 1999; Baird 1976). This is especially true of reported enrollment in unambiguous content-specific courses (*e.g.*, chemistry vs. "other history") and for higher-performing students (Sawyer, Laing and Houston 1989). We utilized best practices in survey design, attending to the quality and specificity of survey items, in order to optimize accurate recall (Bradburn, Rips and Shevel 1987; Groves 1989; Niemi and Smith 2003; Pace, Barahona and Kaplan 1985). We conducted our own reliability test by having 113 college chemistry students take the same survey two weeks apart. The similarity of responses was well within the acceptable range for survey research.

The Sample

This study is one component of *Factors Influencing College Science Success* (FICSS), a federally funded national project that includes interviews and surveys of college science students, high school science teachers, and professors of biology, chemistry, and physics (interviews are accessible online at www.ficss.org). In total, we collected data from more than 18,000 students at 63 randomly selected colleges and universities stratified by size to match the proportional enrollment at small (enrollment less than 1,000 students), medium, and large (enrollment greater than 10,000 students) institutions. For the purposes of our analysis, we limited our sample to first-semester, introductory biology, chemistry, and physics courses fulfilling graduation requirements for science or engineering majors. These 133 courses at 56 universities and colleges had a mean enrollment of 69 students and varied in

enrollment from five to 508 students. We chose for our analysis the 113 courses in which enrollment was greater than ten students. Professors were eager to be involved in this project, particularly as other outcomes included identifying pedagogies and activities that best prepare high school students for success in college science courses.

Our sample comprised 40 percent chemistry, 30 percent physics, and 30 percent biology students. Approximately half took a regular course in high school; one-quarter took an honors course; and one-tenth had enrolled in an AP course. The one-sixth of the sample who had not taken a high school-level course in the subject were not included in the analysis, nor were foreign students as nearly all had attended schools that did not follow the year-long course model in place at most U.S. high schools. Neither did we include graduate or special students taking these introductory courses. Thus, the number of students in the resulting sample totaled 6,910. Professors varied in terms of their grading stringency. The average grade awarded in college courses was 81.0 (S.D. of mean course grade = 4.9) out of a maximum of 100 points.⁵ Unable to equate grading standards across institutions, we analyzed differences within institutions by employing a separate dummy variable for each.

Students taking introductory science courses appeared to have done well in the relevant high school science subject, with 57 percent having earned a grade of "A" (*see* Figure 1). AP students in particular had performed better than other students, having earned higher grades, having taken more mathematics courses, and having attained higher standardized test scores. Only 1 percent of students who enrolled in college science courses had earned grades lower than a "C" in their high school biology, chemistry, or physics courses in the same subject.

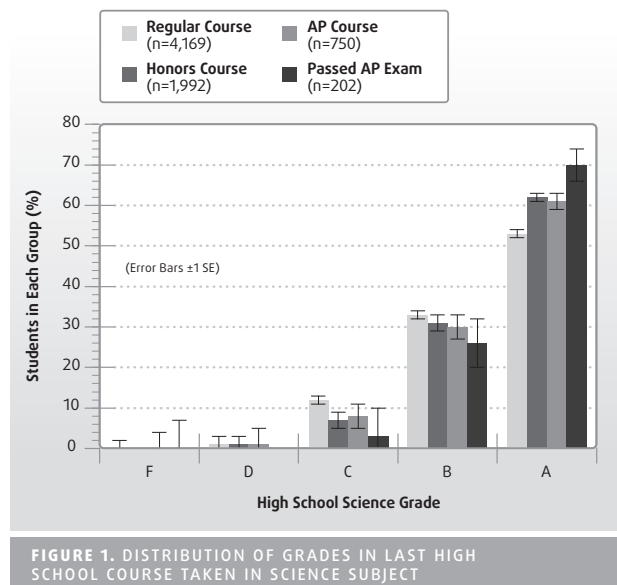


FIGURE 1. DISTRIBUTION OF GRADES IN LAST HIGH SCHOOL COURSE TAKEN IN SCIENCE SUBJECT

⁵ Where letter grades were reported, they were converted using the assignment: A+ = 98, A = 95, A- = 92, B+ = 88, etc.

Table 1: Variables and Their Significance for Four Models Relating High School Course Rigor and Grade

Variable	DoF	Raw Data	+Professor	+SAT/ACT	Full Model
Constant	1	≤0.001	≤0.001	≤0.001	≤0.001
Honors Course	1	≤0.001	≤0.001	≤0.001	≤0.001
Advanced Placement	1	≤0.001	≤0.001	≤0.001	≤0.001
AP Exam score ≥3	1	0.008	≤0.001	≤0.001	≤0.001
HS Grade in Science Subject	1	≤0.001	≤0.001	≤0.001	≤0.001
Professor	112		≤0.001	≤0.001	≤0.001
College Year	3		≤0.001	0.043	0.092
SAT Quantitative	1			≤0.001	≤0.001
SAT Verbal	1			≤0.001	≤0.001
Race/Ethnic Group	4				≤0.001
Mean Ed. Level of Community	1				≤0.001
Type of High School	8				0.001
Highest Math Level in High School	2				≤0.001
# of Subjects		6,910	6,910	6,493	6,368
R ²		12.1%	24.7%	30.4%	32.4%

Graphing the mean college science grade by high school grade in each course type reveals substantial differences (see Figure 2⁶). The patterns are quite clear: Students with higher grades in a high school science subject also had higher average grades when they took the subject in college. Each increase in high school letter grade averages to a 4-point difference (out of 100) in college grade, or a little less than half a letter grade. The increase in course rigor from a regular course to an honors course represents a 2.5 point difference. The difference in rigor between honors and AP courses adds an additional 3.5 points. Students who take and pass the AP exam with a score of 3 or above average a college grade 1.7 points higher than those who do not pass the AP exam. Of course, these observations do not take into account the different numbers of students in each group (they also ignore students who earned a grade lower than a “C”). Instructive as this graph is, it also is misleading as other measures that are considered along with course grade and level are also part of the admissions process. It is only by accounting for these other variables that more valid estimates of the impact of high school course-taking and performance can be made.

Analysis

Multiple linear regression is the proper tool for the proposed analysis because it establishes the predictive power of variables while holding others constant, isolating the effect of conditions that may co-vary. In this case, we want to separate the highest level of high school rigor (regular, honors, taking AP, or passing the AP exam) from the grade earned (A, B, C, D, or F) in high school biology, chemistry, or physics. By doing this while controlling for other variables considered in admission decisions, a “point bonus” could be calculated. We developed five models to predict college grade, accounting for an increasing number of relevant factors, including:

⁶ Categories with fewer than 50 students are not plotted.

- **Raw Data.** Uses high school course rigor and letter grade only.
- **+Professor.** Adds in college course and college year.
- **+SATs.** Adds in SAT or ACT scores.
- **Full Model.** Adds in race/ethnicity, mean educational level of the community, type of high school, and highest mathematics level in high school.
- **Weighted Model.** Adjusts for differences between national AP exam frequencies and observed enrollment in introductory science courses.

The *Raw Data Model* accounts for 12.1 percent of the variance in college grade in introductory biology, chemistry, or physics. The *+Professor* model accounts for variation in grading severity by professor, in essence normalizing college grades to have identical means for each course. We also included college year, since older students have more experience dealing with college life and other stresses that may affect their grades. (On the other hand, less-well-prepared students often delay taking required science courses). The *+SAT/ACT* model adds in SAT and ACT scores measuring quantitative and verbal achievement. (These measures are independent of high school grades.) ACT scores are converted to the SAT scoring scale using a concordance study (Dorans 1999). In the *Full Model*, four additional variables were added: Three serve as proxies for students’ socioeconomic status: race/ethnicity, mean educational level of the community (attained by matching student-supplied zip codes with U.S. Census data), and type of high school (e.g., private,

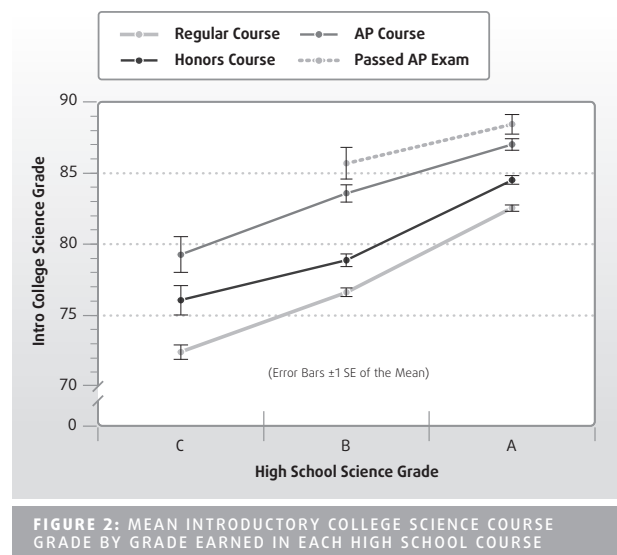


FIGURE 2: MEAN INTRODUCTORY COLLEGE SCIENCE COURSE GRADE BY GRADE EARNED IN EACH HIGH SCHOOL COURSE

Table 2: Increase in College Science Performance Associated with One Letter-Grade Increase in High School Science Grade and with High School Course Rigor

	Raw Data		+Professor		+SAT/ACT Scores		Full Model		Weighted Model	
	Coefficient	Bonus	Coefficient	Bonus	Coefficient	Bonus	Coefficient	Bonus	Coefficient	Bonus
HS Letter Grade	4.70 (0.18)		4.57 (0.18)		3.69 (0.18)		3.44 (0.18)		3.41	
Honors	2.16 (0.29)	0.46	2.66 (0.29)	0.58	1.73 (0.29)	0.47	1.27 (0.29)	0.37	1.28	0.38
AP	4.81 (0.49)	1.02	4.78 (0.47)	1.05	3.71 (0.46)	1.01	3.34 (0.46)	0.97	3.20	0.94
AP Exam ≥3	7.15 (0.77)	1.52	8.57 (0.75)	1.87	6.51 (0.73)	1.76	6.13 (0.72)	1.78	6.47	1.90

public, magnet, home school, etc.). Earlier work has shown that the level of mathematics instruction reached in high school—particularly calculus—has a strong relationship with college science performance (Sadler and Tai, 2001; Tai, Sadler and Loehr 2005). This model accounts for 32.4 percent of the variance in college science grade.

Coefficients for variables relevant to equating high school course rigor and grade are reported in Table 2. For each advanced group (honors, AP, and AP Exam Score ≥ 3), a regression coefficient is listed, representing the difference in college grade earned (on a 100-point scale) from the college grade of those enrolled only in a regular high school course in the subject. Also calculated was a coefficient representing the increase in college grade accounted for by a one-letter grade increase (e.g., from a B to an A) in the last high school course in the subject. While the slopes of lines in Figure 1 (on page 9) are slightly different, a test of the interaction between high school grade and type of course is not significant, so the same grade coefficient can be used for each group in the model. These coefficients and their standard errors are listed for each of the four regression models. For example, using the *Raw Data* model, the difference in college grade earned between those who were awarded an A and those who were awarded a B in high school is 4.70 points. The difference between those in an honors course in high school and a regular course in high school proved to be equivalent to a 2.16 point difference in college grade. Dividing the latter by the former resulted in an estimate of the value of an advanced course in units of high school letter grade. For the above example:

$$\text{Bonus (honors course)} = \frac{\Delta \text{ College Grade (honors course)}}{\Delta \text{ College Grade (one HS letter grade)}}$$

$$\text{Bonus (honors course)} = \frac{2.16}{4.70} = 0.46$$

This calculation was performed for each group within each model and represents the number of “bonus points” or “fraction of a letter grade” one would add to a student’s science grade for being in each advanced course.

The distribution of AP exam scores among the students in our study suggests that higher-scoring students may bypass the introductory course and lower-performing students may choose not to take the college course. To account for this difference, we weighted the full model to make up for the

shortfall of students in these categories and to more accurately reflect the fact that the population of students applying to college differs somewhat from that of students who choose to take an introductory science course. This weighting produces coefficients not significantly different from the full model (see Table 2).

The results proved remarkably similar for each group over the five models generated: one-half a bonus point for an honors course, one point for an AP course, and two points for passing an AP exam. Alternatively, a “GPA bonus” could be added to the overall HSGPA by assuming that students take five year-long courses for each of the four years (for a total of 20 courses) they are in high school. This would add 0.025 to the HSGPA for an honors course, 0.05 for an AP course, and 0.10 for passing an AP exam.

Plotting the two variables (Δ in college grade related to HS course rigor and Δ in college grade related to Δ of one HS letter grade) presents the data in a particularly useful form (see Figure 3). The relationships show up even more clearly, as do the estimated errors. For this graph, each axis is measured in units of 1 point on a 100-point college grading scale, with an A equal to 95 points and a B equal to 85 points. Each diagonal line represents a “bonus point” value. The example calculated above is plotted as the “*Raw Data* honors course” and is represented by the closed diamond lowest and farthest to the right on the graph. (It is near the diagonal line labeled “½

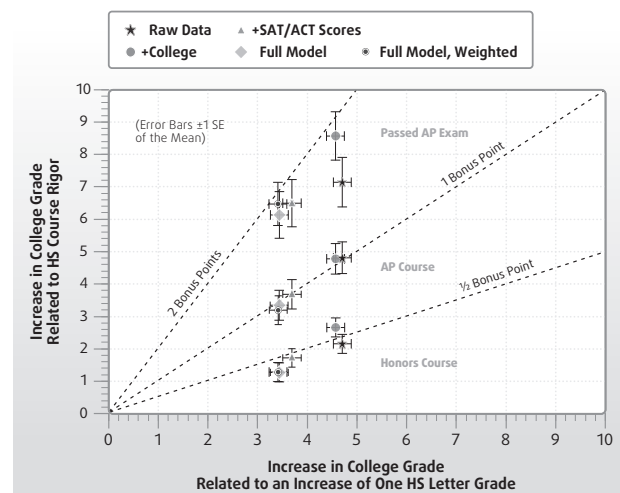


FIGURE 3: COMPARISON OF CALCULATED BONUS POINT VALUES BY HIGH SCHOOL COURSE RIGOR

Bonus Point.”) Each set of four points representing High School Course Rigor is clustered along a diagonal. The inclusion of more variables in each regression model generally forces the data points downward and leftward. Each additional group of variables explains some additional bit of the predictive value of high school course grade and high school course rigor. The *Full Model, Weighted* appears only minimally different from the full model.

In summary, two variables were found to correspond to substantially better performance in college science courses: increasing rigor of high school science experience and higher grades in high school science courses. These two variables can be related to each other using relative improvement in college grade as a common metric. The results are stable even with the inclusion of control variables—variables typically treated separately in the admissions process. In units of high school letter grade, an honors course in the subject corresponds to an increase of one-half of a letter grade and an AP course corresponds to an increase of one letter grade; for students who pass the requisite AP exam, the grade level equivalent is two additional letter grades.

Discussion

Many educators proclaim the benefits of taking advanced courses in high school over less rigorous alternatives, despite the possibility that a student may earn lower grades (Adelman 1999; Rose and Betts 2001; Venezia *et al.* 2003). The award of bonus points added to earned grades in advanced science courses ties together grading scales in different kinds of courses, purposefully combining two related variables into a single measure. We explored four different models for doing this based on the inclusion of other factors often considered separately in admissions decisions. The fact that the calculated bonus values remain relatively unchanged is evidence that the taking of advanced coursework (or passing an AP exam) can be dissociated from other measures commonly used in admissions. Our models account for information typically available to college admissions officers and exclude other measures that typically are unavailable (*e.g.*, parental education, family income).

This study cannot be interpreted as evidence that advanced coursework contributes to student performance in college science courses *per se*, only that they are a significant predictor of performance. Apart from including other variables in regression models, one cannot know if better performance is the result of greater student motivation, better preparation prior to taking advanced coursework, parental education, teacher quality, or a multitude of other variables (Dougherty, Mellor and Jian 2006). Moreover, “...like all educational interventions, AP is not a panacea” (Bleske-Rechek, Lubinski and Benbow 2004, p.220). If students are ill-prepared, advanced coursework may be unproductive and even may have deleterious effects (Bleske-Rechek *et al.* 2004; National Research Council 2002) It is beyond the scope of this paper to examine this issue (see Sadler and Tai 2007, in press, for a

discussion) given that our primary concern was to utilize high school grades and course rigor to predict performance in college courses.

Some may view to our recommendations as contributing to a “two-tiered educational system” (Dupuis 1999, p.1) whereby students of higher socioeconomic status (SES) have more access to advanced courses and thus might garner more bonus points and higher HSGPA’s as a result (Burdinan 2000). High schools in wealthier communities and elite private schools do offer advanced coursework with greater frequency. Students who do not have the opportunity to take advanced high school coursework would be penalized by the kinds of admissions policies recommended in this paper *unless* an adjustment were made for the lack of advanced course offerings (Dupuis 1999). It is the authors’ view that admission to our nation’s colleges and universities should not be based on academic indicators alone. Institutions of higher education benefit from having a diverse student body. However, those determining access to higher education should not shy away from using the most valid measures available for estimating students’ academic success. Just as SAT scores are correlated with SES, they are still utilized in admissions decisions (Belz and Geary 1984). We present in this paper a defensible method to ascertain the relative strength of applicants’ academic preparation. Should an institution decide to accept students who are less well-prepared academically, it behooves them both to offer support programs and to adopt retention strategies designed to help compensate for these differences (Marable 1999).

The method presented here for combining two admissions variables into one utilizes performance in introductory college science courses as a common metric. The same technique could be used with other metrics, *e.g.*, SAT II scores in particular disciplines or exams used by colleges for placement into different levels of academic courses. If similar bonus point values result, this would add to the evidence supporting this approach to the recasting of HSGPA. The current study explored only science coursework and grades. While it may be attractive to generalize to advanced coursework in all fields, there is no reason to believe that similar findings would result. Moreover, the use of larger datasets than ours would serve to determine whether advanced biology, chemistry, and physics high school courses should be treated differently.

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