

AP Classes and Their Impact on Engineering Education

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Abstract

Many US schools offer students the opportunity to take college level classes in mathematics and science. Studies have shown that students who take these classes are more likely to succeed in college. Other studies have shown that failure in engineering education is strongly correlated to deficiencies in mathematics and science. This paper surveys the history of Advanced Placement (AP) classes and their impact on college education in general and engineering and science education in particular. We also survey AP class offerings in a large Western county school district where a major state university is located. We estimate the number of AP classes offered in mathematics and science, and the percentage of students opting to take these classes. Our results confirm that students who take AP classes are likely to select a major in engineering, science or mathematics. Fifty per cent of students who took AP Physics said they would seek a college major in engineering. Based on the results of the school district surveyed in this study, size, location and socio economic class all affect the number of AP classes offered in high schools.

I. Introduction

A problem with many high schools is that challenging courses are not offered, especially in mathematics and the sciences. In its final report of 2001, The National Commission on the High School Senior Year urged states to offer challenging alternatives to the traditional high school senior year. The report said that not enough high schools are preparing students for college and careers and that while 70 percent of today's high school graduates go on to some form of postsecondary education, only one-half of those who enroll at four-year institutions leave with a degree. The main reason cited was that they were not prepared for the rigors of college academics in high school. It proposed that the college-preparatory track be the learning track for all, not just the privilege of a few ¹.

This proposal is certainly not new. The Committee of Ten ² as far back as 1893 tried to promote uniform college entrance requirements by aligning high school subjects and content with what would be taught in college. After Sputnik I in 1957, *U.S. News and*

¹ Partial support for this work was provided by the National Science Foundation's Division of Undergraduate Education through grant DUE #1970638.

World Report carried an article about “What Went Wrong with American Schools” which advocated that the U.S. emulate the Soviet Union schools in stressing mathematics and science ³. In 1982, Mortimer Adler wrote a book about the need for a standardized, rigorous k-12 curricula that would be the same for all students ⁴. Many reports came out in the 1980s stressing the need for more rigorous high school academic requirements to prepare our country to compete with our economic rivals. The most famous of these was *A Nation at Risk* ⁵.

Experience has shown that educational reforms can improve education. In the last 20 years, there have been increases in achievement in mathematics and science attributed to the reforms that went on, mainly between 1982 and 1994. Challenging academic courses increased from 14 to 52 per cent between 1982 and 1994 and the number of students taking AP courses nearly tripled. Also, in general, scores in mathematics and science on the National Association of Education Progress (NAEP), the so-called nations report card, increased from 1978 to 1992. Still, in the 1996 NAEP, only three percent of grade 12 students performed at the advanced level, 18 percent at the proficient level, 36 percent at basic and 43 percent below basic. Males outperformed females in basic, proficient and advanced. Average proficiency of minority groups, black and Hispanic students were also at least four years behind that of their white peers ⁶. Unfortunately, in the most recent NAEP, 2000, there was no significant change from the 1996 NAEP. In fact, there was a slight decline of three points (four percent) in students’ average score in grade 12 ⁷. Furthermore, in international comparisons, the Third International Mathematics and Science Survey (TIMSS) in 1996, U.S. twelfth graders performance was among the lowest of the participating countries in mathematics, science general knowledge, physics and advanced mathematics ⁸.

Many US schools offer students the opportunity to take college level classes in mathematics and science ⁹. Studies have shown that students who take these classes are more likely to have higher SAT scores and to succeed in college ¹⁰. Other studies have shown that failure in engineering education is strongly correlated to deficiencies in mathematics and science ¹¹. This paper gives a brief background of the Advanced Placement (AP) programs in U.S. high schools and surveys one large Western school district for Advanced Placement (AP) class offerings.

II. Advanced Placement Programs

As early as the 1950s, there was concern among educators in higher education as well as high schools, that our most talented students were not being challenged in existing high school courses. Course content and rigor, graduation requirements and inconsistent college admission requirements were all cited as weaknesses for successful college work. A study titled *General Education in School College*, sponsored by the Ford Foundation in 1952, recommended the development of achievement exams to enable high school students who passed them to get university credit in single subjects. In 1954, the Educational Testing Service (ETS) developed the exams, called Advanced Placement (AP) and during the 1955-56 school year the AP program became a program of the College Board ¹².

Given the variety of courses in high school; e.g., honors, college preparation, gifted, etc; it is difficult for parents, educators, employers and college admission officers to determine the quality of the courses; e.g., what standard the content meets and what a particular grade in a course means. This is especially true given the grade inflation of many high schools where the average GPA may exceed 3.0 for graduating high school seniors with some students even having GPAs above 4.0. As more and more students try to attend college, GPAs are rising, but at the same time, SAT scores are remaining static or falling. An A average was a worthy achievement of entering college freshman at UCLA in 1969 with only 12.5% of students achieving it. But, in 1999, 34% of entering college freshman at UCLA indicated an A grade point average¹³. Some universities are even dropping the SAT and ACT as part of the entrance requirements. In the past these nationally standardized achievement tests served as a bench-mark for the many students who applied. Now, standardized test scores may be of even more value with grade inflation and the difficulty in assessing the content of many “college preparatory” courses. AP courses can offer some of the same predictability for college success that the SAT and ACT have. The big advantages of AP courses are: They are consistent in their standard for content; the same exam is administered externally to all students and the standard is known and can be accepted by parents, teachers and college admissions officers. Moreover, even if the high school *AP grade* is inflated, the *AP examination score* can still be used by college admissions officers to judge academic potential. The range on AP exams is from 1-5 with most colleges and universities accepting 3 as the minimum score needed for college credit. The College Board stated “AP provides a true national standard of achievement that is consistent over time.” Furthermore, according to the ETS and the College Board, the average SAT scores of AP graduates are often 164 points higher than the combined national average scores¹⁴.

Currently, over 100,000 teachers worldwide, teach AP courses. The Program is strengthened by their participation in professional development workshops and Summer Institutes and in the annual AP Reading where thousands of AP teachers and college faculty gather at college sites across the United States to score the AP exams using rigorous guidelines. The AP program currently offers many courses in many subject areas. Each course is developed by a committee composed of college faculty and AP teachers, and covers the breadth of information, skills, and assignments found in the corresponding college course. High school teachers use the AP Course Descriptions to guide them. The course description for each discipline outlines the course content, describes the curricular goals of the subject, and provides sample examination questions. While the course descriptions are a significant source of information about the course content on which the AP Exams will be based, AP teachers have the flexibility to determine how this content is presented. Published in the spring of the school year before the course will be taught, the course descriptions are available in the AP Central™, accompanied by a course overview written by an experienced AP teacher. The following facts are taken from the College Board Annual Report¹⁵.

AP Program Facts

- The AP Program offers 35 courses in 19 subject areas.

- Nearly 60 percent of U.S. high schools participate in the AP Program. In those schools, 820,880 students took AP Exams in 2001.
- In 2001, 1,414,387 AP Exams were administered worldwide.
- More than 60,000 teachers worldwide attended AP workshops and institutes for professional development last year.
- Over 90 percent of the nation's colleges and universities have an AP policy granting incoming students credit, placement, or both, for qualifying AP Exam grades.
- Some 50 percent of U.S. colleges and universities offer sophomore standing to students who have a sufficient number of qualifying grades.
- A 1998 ETS study concluded that students with qualifying grades of 3 or above on AP Exams earn higher grades in advanced college courses than classmates who have taken the prerequisite college course.
- Recent data show that AP students tend to follow the same course of study at college that they began in AP. This is particularly true of AP students of biology, physics, calculus, studio art, and Spanish literature.

II.1 Access and Equity in AP Programs

In 2001, the federal government provided more than 20 million dollars to more than 40 US states and territories to subsidize AP exam fees for low-income students and to provide support for AP teacher professional development and instructional resources for AP classes. In 2002, the US Department of Education will give 18 states and the district of Columbia, \$6.5 million to encourage low-income students to take AP courses. According to the U.S. Secretary of Education, Rod Paige, "These grants can help close the achievement gap between students from disadvantaged backgrounds and their peers." The money will pay for low-income students in urban areas to prepare for and take AP tests and pay for on-line courses in rural areas where courses may not be available ¹⁶.

III. Research Question

This paper surveyed the AP course data in a large western school district to determine the number of AP classes offered in mathematics and science, and the percentage of students opting to take these classes. The data is used to assess the impact of these classes on college education in general and on engineering education in particular. The following research question addressed in this paper has relevance to attracting and retaining students in college level engineering programs: Are students who take AP courses in high school more likely to pursue college majors in engineering than students who do not take AP courses?

IV. Method

IV.1 Subjects

The data is from eight high schools in a diverse school district of approximately 57,000 students. The total high school enrollment, grades 9-12, was 15,635. The senior class enrollment of the eight high schools surveyed for AP courses was 2,732 students. Some

alternative high schools including a charter high school, an occupational training high school and a rural high school were also included in data for career selections after high school graduation. Approximately 70 percent of the graduating seniors said they would be attending institutions of higher learning after graduation. The institutions range from universities to community colleges to trade schools. The state in which the data was collected also offers a millennium scholarship, \$10,000 per student over four years of college, and of 65% of graduating seniors who were eligible for it in SY 2000-2001, 75 percent took it. Their average GPA was 3.36.

IV.2 AP Course Data

The data was collected through the school district science coordinator. Although data was available for a number of years, only the most current data from SY 2000-2001 was used. Moreover, only science and mathematics courses were surveyed. The eight high schools offered AP courses in one or more of the following science and mathematics classes: Biology, Chemistry, Physics, Environmental Science, Calculus and Statistics. The other most common AP courses offered included English, American History and Government, as well as others that also were not surveyed. In the sciences and mathematics, of 2,732 seniors, 529 AP course units were taken. The 2,732 seniors included students who took as many as five AP courses and many students who did not take any. The 529 AP course units also included some courses taken by juniors. The student enrollment by AP course was 66 for biology, 144 for chemistry, 77 for physics, 11 for environmental science, 214 for calculus and 17 for statistics (See Table 1).

Table 1. AP Enrollment by Science and Mathematics Courses in SY 2000-2001

Biology	Chemistry	Physics	Env. Science	Calculus	Statistics	Total
66	144	77	11	214	17	529

V. Results

In answer to the Research Question - Are students who take AP courses in high school more likely to pursue college majors in engineering than students who do not take AP courses? – The following data was collected for projected college majors. In the six AP science and mathematics courses, only career data for seniors in AP physics was available and it was not complete. Seventy-seven students took AP Physics in five of the eight high schools. Only two of the five schools that taught AP physics reported career choices after graduation, but these two schools had 64 of the 77 students who took AP Physics. These two schools also had 294 students in AP courses and 801 seniors. One of these high schools served an upper middle class area, and the other served a middle class area. Thirty-two of those 64 students who took AP Physics said they were going into engineering in college. Another 17 said they were going into science or mathematics. Five students indicated pre-med as their college choice, six indicated social studies and one each indicated business and fine arts (see Table 2).

Table 2. Total AP Enrollment and College Career Choices for AP Physics Students

Total AP Enrollment	AP Physics Enrollment	Engineering Choice	Science or Mathematics Choice	Pre-Med Choice	Social Studies Choice	Business Choice	Fine Arts Choice
294	64	32 (50%)	17 (27%)	5 (8%)	6 (9%)	1 (2%)	1(2%)

The career choice for the high school seniors in seven high schools who answered an outside survey ¹⁷ (N=692) that included technology (there was no breakdown specifically for engineering) was 12 per cent for SY 2000-2001(see Table 3). Of 73 high school seniors in the highest socio-economic area high school, 15 per cent selected technology. In the two lowest socio-economic area high schools, five per cent of 80 seniors in one school and 11 per cent of 184 seniors in the other high school selected technology. In two middle class areas, 12 percent of 155 seniors in one school selected technology, and 15 per cent of 187 seniors in the other school selected technology. This data also included an occupational training school, a charter school of seven seniors and a rural school of six seniors that did not have any AP courses due to their specialized nature (the charter school was for culinary arts) or small size. No data from the outside survey was available for four of the eight main high schools in the school district and those four schools included one very affluent high school, two high schools in predominantly middle class areas and one in a lower middle class area.

Table 3. Technology Enrollments in Reporting High Schools

Socio-Economic Level	Seniors Answering Survey	Percent Selecting Technology	AP Enrollment in Math and Science
Lower Middle	184	11	20
Rural	6	17	0
Occupational	80	5	0
Charter	7	14	0
High	73	15	32
Middle	155	12	68
Middle	187	15	46
Totals	692	12	166

VI. Discussion and Conclusions

Much has been written concerning the need to offer a more challenging curriculum to high school students if they are to be motivated to finish high school and to be prepared for university and career choices that may as a prerequisite require rigorous high school work. It is also apparent that to make reliable decisions about what curriculum is needed in high school to prepare students for higher education and career choices, school districts should be collecting more data. For this paper, most of the data was only available because of the interests of business. A schools-to-career program ¹⁷ collected and provided most of the school district data, however incomplete, through a federal grant, and more data will be available in the future as it continues to dribble in.

Administrators in colleges of engineering have long suspected that students who take upper division mathematics; e.g., AP Calculus; and upper division science courses; e.g., AP Physics; are more likely to pursue study in engineering in college¹⁸. Based on the available data, the following conclusions can be drawn regarding the correlation of student enrollment in AP science and mathematics courses to majoring in engineering. At least, regarding AP Physics, it is clear from this data that the highest percentage of the students who take AP Physics, 50 per cent in this case, expect to enroll in a college level engineering program. Furthermore, the second highest percentage of students, 27 per cent, expect to enroll in a college level program in mathematics or science. Unfortunately, the data for AP Calculus was not available and it is not known whether that data would have further reinforced the predictive value of AP Physics as a gateway to the study of engineering in college. Based on our limited data, we recommend that more high schools make AP Physics available to students as well as encourage them to take more AP courses in high school for other reasons as well. These other reasons include the standard of the course work, reduction in college costs, and the motivation to achieve at a higher level as a result of the challenge inherent in AP courses.

The data from the other seven high schools regarding career choices, showed two trends that have some significance to increasing enrollment in college level engineering. First, it appears that enrollments in AP Courses are related to the socio economic level of students. The higher socio economic level schools offer more AP courses and have more students enrolled in them. The common wisdom for this is that the higher socio economic level schools have “better” students and they are more able to take challenging AP courses. The authors experience in education indicates that the parents of these students are more likely to understand the lifelong advantages a good education provides and advocate for a more challenging curriculum as well as have the political power to see that they get it. The recent federal aid mentioned earlier in the paper¹⁶, that aims to provide equity by providing access to AP courses for lower income and disadvantaged students, is encouraging. It is hoped that more teachers and school officials will work with these students’ parents to encourage more students to get the pre requisite courses in the lower grades to handle AP courses in high school.

A second trend indicated by the data is the lack of AP courses in small and rural schools. This is being addressed by overseas American schools; e.g., Department of Defense Schools; and some U.S. states, through the implementation of distance learning and on-line programs for AP courses. Making AP courses available to both of these pools of students will certainly increase the prospect for more students to gain the needed mathematics and science skills for success in engineering in college.

Further research will address the impact of AP mathematics and science courses on attrition rates of students majoring in engineering. Do students in college engineering programs who took AP courses in high school have a lower attrition rate in engineering than students who did not have AP courses in high school? We currently have the data to answer this question but the data was too extensive to be properly analyzed for this paper.

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Bibliographical Information

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