

AP[®] and American Competitiveness in Science, Technology, Engineering, and Mathematics (STEM)

AP can prepare the next generation of U.S. scientists, mathematicians, and engineers

In 2005, the National Academies released a report focused on “energizing and employing America for a brighter economic future.” This landmark volume, *Rising above the Gathering Storm*, warned that “the dominant position of the United States depended substantially on our own strong commitment to science and technology and on the comparative weakness of much of the rest of the world. But the age of relatively unchallenged U.S. leadership is ending.”¹ “In Germany, 36% of undergraduates receive their degrees in science and engineering. In China, the figure is 59%, and in Japan 66%. In the United States, the corresponding figure is 32%. In 2004, China graduated over 600,000 engineers, India 350,000, and America about 70,000.”²

To maintain American competitiveness, the report included among its top recommendations a call for national investment in the training of many more AP[®] math and science teachers. This recommendation is supported by a wealth of recent research highlighting the strong benefits of expanding the reach of AP math, science and technology courses.

What Recent Research Tells Us

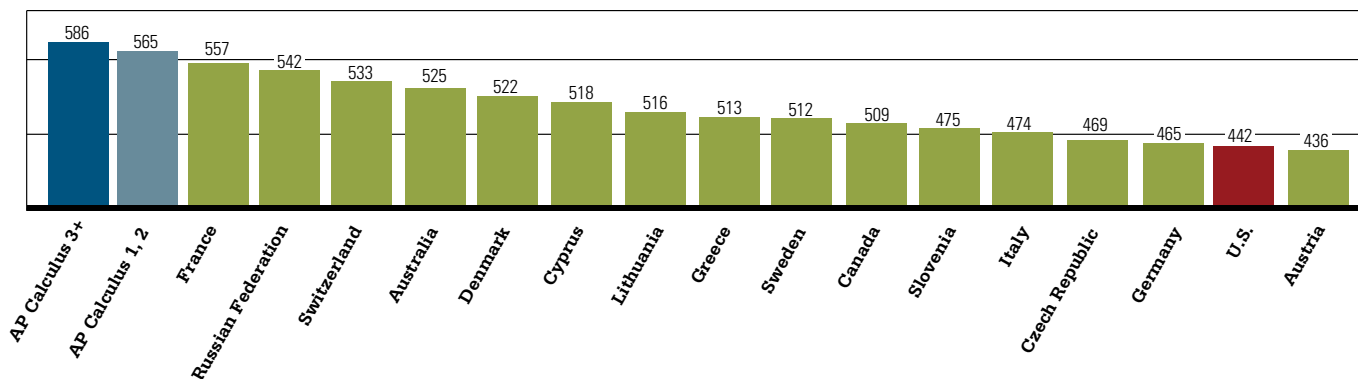
- AP math and science students, particularly those scoring 3 or better on the AP Exam, outperform students in these subject areas from nearly all other nations.³
- Students who take AP math and science courses choose to major in science, technology, engineering and mathematics at dramatically higher rates than other students.
- Women and minorities participating in AP math and science courses choose to major in science, technology, engineering, and mathematics at dramatically higher rates than other students.
- After taking AP math and science courses, students perform at much higher levels in intermediate college math and science courses than matched students with the same SAT[®] scores who did not take AP math or science courses.

Comparing AP Students to Other Countries' Math and Science Students

Boston College's TIMSS Center conducts regular research to compare students around the globe in math and science achievement. Their comparison of math and science achievement in 16 countries found that AP math courses prepare American students to achieve a level of proficiency that exceeds that of students from all other nations in the study. AP Calculus students in the United States who scored a 3 or better

on the AP Calculus Exam ranked first in the world. Even AP Calculus students who scored a 1 or 2 on the AP Calculus Exam were ranked second in the world. By way of contrast, the rest of the United States' advanced math students ranked #15 (out of 16 countries that were included in the international comparison).

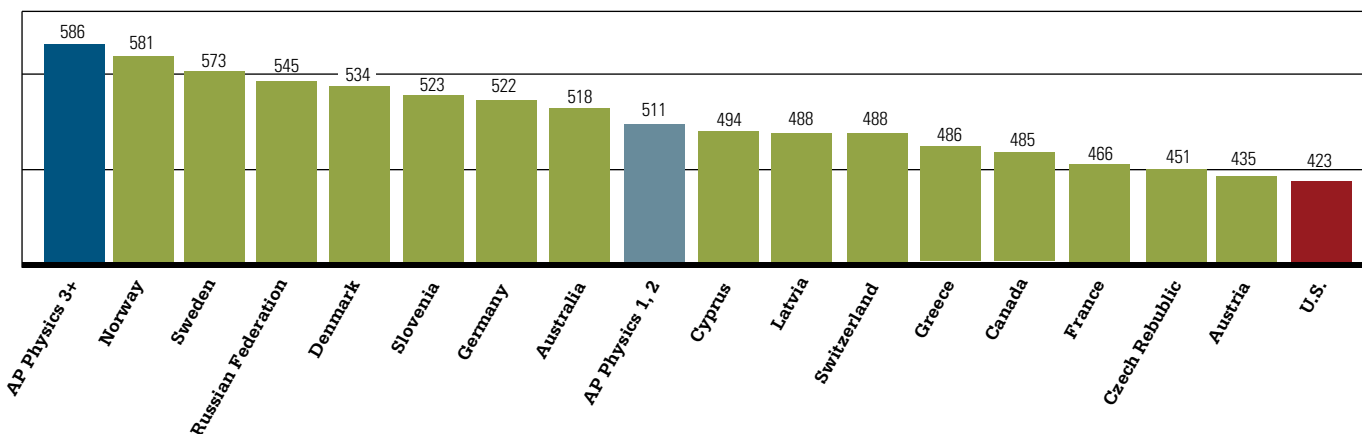
AP Student Performance in Math
TIMSS Report: International Student Achievement in Mathematics



Source: Gonzalez, E. O'Connor, K., & Miles, J. (2000). How well do Advanced Placement students perform on the TIMSS Advanced Mathematics and Physics Tests? Chestnut Hill, MA: The International Study Center, Lynch School of Education, Boston College.

AP® Physics students also demonstrated strong results.

AP Student Performance in Advanced Science Achievement
TIMSS Report: International Student Achievement in Physics



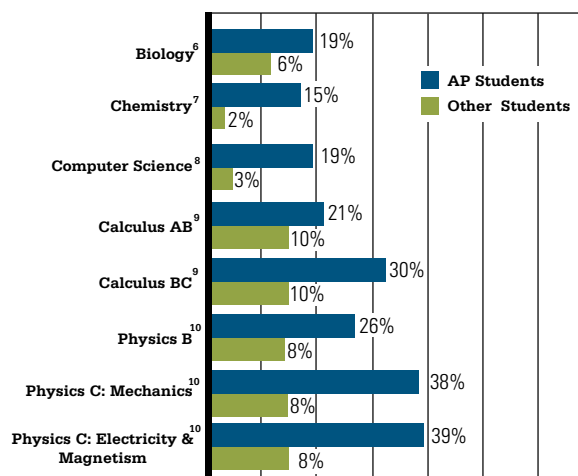
AP® Math, Science and Technology: A Bridge to STEM Majors and Degrees

AP courses in science, math and technology serve as strong preparation for students who choose to major in engineering, biochemistry and other STEM majors. 27 prestigious colleges and universities⁴ participated in a study comparing the degree to which AP science, math and technology students chose to pursue STEM majors, in comparison to students who did not receive exposure to these disciplines via AP. Unsurprisingly, the study found that the sort of student who participates in AP science, math and technology coursework in high school is far more likely than other students to proceed to major in a related STEM discipline.⁵

I have been very impressed by AP Environmental Science's coverage of both traditional and emerging environmental issues.

**–Hilary Inyang, Duke Energy Distinguished Professor,
Director of the Global Institute for Energy and Environmental
Systems, University of North Carolina-Charlotte**

Percentage of Students Choosing to Major in STEM Disciplines⁴



This relationship between the AP course and the choice of a STEM major holds true across several groups of students most under-represented in STEM majors today: women and minorities¹¹:

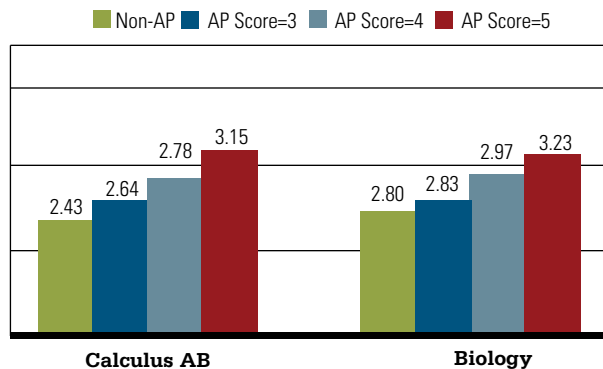
Course	Female Students Who:		African-American Students Who:		Hispanic Students Who:	
	Took AP & Chose Major	Did Not Take AP & Chose Major	Took AP & Chose Major	Did Not Take AP & Chose Major	Took AP & Chose Major	Did Not Take AP & Chose Major
Biology	20%	6%	18%	6%	16%	4%
Chemistry	15%	1%	14%	2%	13%	2%
Computer Science	11%	1%	14%	2%	17%	2%
Calculus AB	11%	4%	21%	9%	23%	8%
Calculus BC	16%	4%	28%	9%	23%	6%
Physics B	16%	3%	31%	7%	25%	8%
Physics C: Mechanics	22%	3%	29%	6%	41%	7%
Physics C: Electricity & Magnetism	25%	2%	48%	6%	47%	7%

While this study does not claim that exposure to AP® causes the higher rate at which AP students choose to major in STEM subjects, it does suggest a complex inter-relationship between academic opportunities, pre-existing student interests, the appetite fostered by AP and the subsequent choice of major. So the key question becomes: does the experience of an AP science, technology or mathematics course prepare a student for success in further STEM studies at college?

The 27-college study goes a step beyond simply describing the majors selected by AP students, and also demonstrates that **“AP students perform well when placed into intermediate college courses after receiving advanced placement for the introductory college course.”**¹² The study compares the academic performance of AP Calculus and AP Biology students in intermediate-level course work at college to the academic performance of non-AP students who took the college’s own introductory course before progressing to the sequent, intermediate-level course. For students scoring 3 or higher on AP Calculus and AP Biology higher grades were earned in the intermediate-level course than the grades of the students who had taken the college’s own introductory course.

The results show that the AP students are performing better in their intermediate-level STEM coursework than students with the same SAT® score who had taken the college’s own introductory course. The statistically significant findings show stronger performance for AP students who skipped the introductory college course than for matched non-AP students who did not skip the introductory college course.

Average Grades of Matched AP and Non-AP Students’ Performance in Intermediate-Level STEM Coursework in College¹³



Future Developments in AP® Science Courses and Exams

Every five to seven years, the College Board reviews the content of AP courses and exams to ensure their continued alignment with the standards and expectations of colleges and universities, which in turn grant credit for qualifying AP scores. To expand the sort of teaching and learning found among experienced AP teachers in high quality AP courses, and to ensure that students will be even better prepared for majors in science and related disciplines, the College Board has partnered with the National Science Foundation to support AP teachers’ efforts to increase depth of study and develop scientific reasoning and inquiry skills among their students.

AP science courses and exams are in the process of shifting their focus from testing facts to testing students’ ability to apply their knowledge and skills to new situations; in other words, the exams are testing less “what” and more “how” and “why.” To apply their knowledge, the students must of course still develop a firm and solid understanding of the course content—but to ensure that depth is emphasized as well as breadth, future AP science courses will facilitate even greater flexibility for teachers to reduce content coverage and emphasize in depth the application of knowledge and skills.

The AP Program is working closely with experts across the nation to explore the potential for new AP offerings in Engineering, Energy and the Environment (with a focus on the engineering solutions based on alternative energy sources), and Anatomy and Physiology. Because the “AP” designation has been proven to be so attractive to students, parents, and school administrators, by offering such new science and engineering courses within the AP Program, we could foster a significant expansion of such studies and interest in further college studies, among an increasingly diverse group of AP schools nationwide.

*The AP Exam in Chemistry reflects current practices in college courses as determined by surveys of the first-year college chemistry course. The exam covers a sufficient breadth of subject areas to ensure that students who do well on the exam are well grounded in chemistry. However, as new pedagogical methods in chemistry increasingly focus on conceptual understanding, AP is committed to the redesign of the curriculum and exam to remain consistent with these new approaches to instruction in accordance with the National Science Education Standards. In this respect **the AP Program is ahead of many college curricula in complying with an emphasis on conceptual understanding as urged by the National Research Council.** In particular, the AP Chemistry Exam is moving toward more emphasis on laboratory and inquiry-based learning.*

—Professor James N. Spencer, Franklin & Marshall College

AP Science, Technology and Mathematics Offerings

SCIENCE	Teachers	Students
Biology	9,090	154,504
Chemistry	7,171	100,586
Environmental Science	2,771	61,380
Physics B (Algebra-based)	4,184	57,758
Physics C: Mechanics (Calculus-based)	2,054	28,190
Physics C: Electricity & Magnetism (Calculus-based)	1,117	12,328
MATHEMATICS	Teachers	Students
Calculus AB	13,323	222,835
Calculus BC	4,359	69,103
Statistics	5,401	108,284
TECHNOLOGY	Teachers	Students
Computer Science	1,870	15,537

I am confident that the AP[®] Statistics course taken by high school students is at least equivalent to, and in many cases better than, the comparable course that is offered at colleges and universities.

–Professor Brad Hartlaub, Kenyon College

FOOTNOTES

- 1 - Rising above the Gathering Storm. Washington, D.C.: National Academies, 2005. p. 9.2.
- 2 - Rising above the Gathering Storm, p. ES.11.
- 3 - Eugenio J. Gonzalez, Kathleen M. O'Connor, and Julie A. Miles, "How Well Do Advanced Placement Students Perform on the TIMSS Advanced Mathematics and Physics Tests?" (2001), The International Study Center, Lynch School of Education, Boston College.
- 4 - Rick Morgan and John Klaric, "AP Students in College: An Analysis of Five-Year Academic Careers." New York: The College Board, 2007. Colleges participating in this study represented the span of American higher education, and include Cornell, Dartmouth, Georgia Tech, Northwestern, Stanford, Texas A&M, UCLA, University of Florida, University of Texas-Austin, University of Virginia, University of Washington, Wesleyan, and Williams.
- 5 - Morgan and Klaric, 8.
- 6 - Majors selected: Animal Science, Biology, Applied Biology, Biological Studies, Biology and Society, Psychobiology, Biology Technology, Botany, Zoology.
- 7 - Majors selected: Chemistry, Biochemistry, Chemistry Education, Chemical Engineering, Textile Chemistry.
- 8 - Majors selected: Computer Science Information Systems, Computer Science, Computer Engineering, Information Systems.
- 9 - Majors selected: Engineering (Aerospace, Agricultural Ceramic, Chemical, Civil, Computer, Electrical), Applied Mathematics (Mathematics), Civil and Environmental Engineering, Computer Science, Economics and Math, Engineering Science and Technology.
- 10 - Majors selected: Engineering (Aerospace, Ceramic, Chemical, Civil, Computer, Electrical, Industrial, Materials, Mechanical, Nuclear, Textile), Physics, Physics Teaching, Applied Physics, Engineering Physics, Physics-Astronomy.
- 11 - Morgan and Klaric, 9.
- 12 - Morgan and Klaric, 4.
- 13 - Morgan and Klaric, 4.