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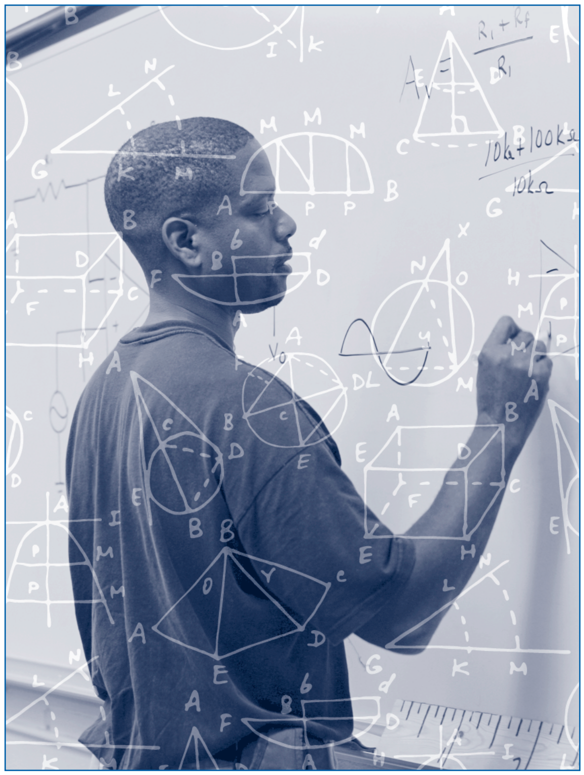
Math and Science Education for the California Workforce:

It Starts with K–12



MOST CALIFORNIANS KNOW THAT the state's current and future economic vitality depends, in part, on a well-educated workforce. But they may not realize that workforce projections show a growing need for people with strong backgrounds in math and science. As the eighth largest economy in the world, California benefits particularly from enterprises in the so-called "STEM" fields—science, technology, engineering, and mathematics.

Californians in math- and science-related jobs work in industries such as energy and the environment, health care services and biomedical science, information and computer technology services and support, and the state's transportation and communications systems. They include people who operate, maintain, and support California's technical infrastructure. They also encompass researchers and developers working on the tools and practices industry and business will need and use in the future.

Tomorrow's workforce is in California's public schools now. How well these students are educated in math and science will help determine the quality of not only their lives, but also the state's future. This report provides a quick snapshot of current projections for California's workforce needs in several important STEM fields. It then explores the extent to which California's K–12 standards-based reforms in the last decade have affected student achievement in math and science, with a particular focus on the higher-level courses students take beginning in 8th grade. Further, the report examines whether traditionally low-achieving student subgroups are taking more rigorous courses and succeeding at them. It also reviews data on the performance of the state's highest-achieving students.

Finally, acknowledging that K–12 education takes students only a portion of the way to their eventual careers, this report also provides a brief snapshot of recent degrees and certificates granted by the state's postsecondary systems in a number of important math- and science-related fields.

Jobs that require math and science are important for students' and California's future

Projections from the California Employment Development Department (EDD) indicate the possible job market that awaits California students and the levels of education that different occupations will likely require. These education requirements are classified according to "the manner in which most workers become proficient in [an] occupation and the preferences of most employers," according to the EDD.

EdSource® is a not-for-profit 501(c)(3) organization established in California in 1977.

Independent and impartial, EdSource strives to advance the common good by developing and widely distributing trustworthy, useful information that clarifies complex K-12 education issues and promotes thoughtful decisions about California's public school system.

Technology is central to California's economy

- California exported $41.8 billion in computer and electronics products in 2005, according to the California Legislative Analyst's Office (LAO). This represented about 36% of all exports in California that year.
- California ranks among the top quarter of U.S. states in the share of its business establishments that are "high technology," according to *Science and Engineering Indicators 2006,* published by the National Science Board (NSB) and using data from the U.S. Census Bureau. These are businesses in which "the proportion of employees both in research and development and in all technology occupations is at least twice the average proportion for all industries."
- California in 2002 had more "high technology" business establishments than any other U.S. state by a wide margin, according to the same NSB publication. The state had about 14% of the national total.

This report adopts a broad definition of the "STEM" workforce

"STEM" jobs, broadly defined, include those in science, technology, engineering, and mathematics. Various reports put different jobs into their definition. Consider the National Science Board's 2003 report, *The Science and Engineering Workforce: Realizing America's Potential.* In addition to engineering and the natural, agricultural, mathematical, and computer science fields, NSB includes pre-college teachers who hold a degree in one of these fields. NSB also considers technical workers who hold a related associate's degree or certificate from a community college. This report adopts a similarly broad definition of the STEM workforce, which includes engineers and the various sciences described above, secondary school math and science teachers, and the biomedical and health care fields. In addition, like NSB, this report considers occupations that require a range of education credentials, including associate's degrees from community colleges.

The EDD measures job demand in two ways. The first method sorts California occupations by their projected rates of job growth. The second measures occupations by their projected number of job openings. This second method includes both job creation and "net replacements." ("Net replacements" is a calculation of the number of jobs opened when workers permanently leave an occupation and other experienced workers do not fill their jobs.)

These projections provide policymakers, employers, and educators with some basis for making judgments about the state's future workforce needs. Because they are based on assumptions about how the economy will work in the future, they could be affected by unforeseen events or other changes. Nevertheless, these projections highlight opportunities in the adult world of work to which California students can reasonably aspire.

Many of California's fastest-growing jobs are in math- and science-related fields

One way to think about California's workforce needs is to consider which occupations are projected to grow most rapidly. Figure 1 shows the fastest-growing occupations in California, based on the EDD's projections for 2004 to 2014. (The wage figures are based on data for California provided by the U.S. Bureau of Labor Statistics.)

Technology jobs are prominent among California's fastest-growing occupations. These include computer software engineers, database administrators, systems managers, and network systems and data communications analysts. These jobs tend to require at least a bachelor's degree and, in some cases, additional work experience.

The rapid job growth projected for medical scientists is also notable. These scientists, which include clinical researchers and lab directors, conduct research into human disease and health and hold doctoral degrees. Several other occupations in the life and physical sciences that require some level of graduate education are also expected to grow by at least 25% between 2004 and 2014. But they do not appear in Figure 1 because they are each expected to employ fewer than 5,000 people. These include

Inside This Report

This report was written and researched by:
Matthew Rosin, Ph.D.
Heather Barondess

With research support from:
Kathy Wilson

Edited by:
Mary Perry

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figure 1 | **Some of the fastest-growing occupations in California, from 2004 to 2014, require math and science backgrounds**

Top 10 Fastest-growing Occupations, (based on % change in annual average employment over 10 years)	Annual Average Employment		Percent Change	Mean Annual Wage, California, May 2006 (BLS)[1]	Education & Training Levels[2]
	2004	2014			
Network Systems and Data Communications Analysts	24,200	38,500	59.1	$71,870	BA/BS Degree
Home Health Aides	41,200	60,900	47.8	$20,950	30-day OJT *
Computer Software Engineers, Applications	84,400	123,600	46.4	$91,590	BA/BS Degree
Computer Software Engineers, Systems Software	51,100	74,500	45.8	$96,070	BA/BS Degree
Network and Computer Systems Administrators	29,600	42,000	41.9	$72,680	BA/BS Degree
Dental Hygienists	19,900	28,200	41.7	$73,950	AA Degree
Database Administrators	11,300	16,000	41.6	$74,150	BA/BS Degree
Dental Assistants	41,300	58,200	40.9	$32,170	1–12 Month OJT *
Gaming Dealers	9,100	12,600	38.5	$21,140	Postsec. Voc. Ed.
Physician Assistants	5,900	8,100	37.3	$80,960	BA/BS Degree
Other Math- and Science-related Occupations with High Rates of Projected Growth					
Medical Assistants	51,000	69,200	35.7	$30,960	1–12 Month OJT *
Medical Scientists, Except Epidemiologists	15,500	21,000	35.5	$78,790	PhD Degree
Computer Systems Analysts	55,400	72,800	31.4	$76,970	BA/BS Degree
Computer and Information Systems Managers	34,900	44,700	28.1	$120,600	BA/BS plus Experience
Registered Nurses	230,300	291,200	26.4	$75,130	AA Degree
Pharmacy Technicians	23,900	30,200	26.4	$34,320	1–12 Month OJT *
Medical Records and Health Information Technicians	13,900	17,500	25.9	$34,200	AA Degree
Computer Support Specialists	58,300	73,200	25.6	$50,100	AA Degree

Most of the state's 10 fastest-growing occupations are in fields in which a math or science background is an important asset, if not a prerequisite. And although many of the fastest-growing STEM occupations require a bachelor's degree, some need only associate's degrees or vocational training.

[1] The U.S. Bureau of Labor Statistics (BLS) calculates mean (or average) annual wages by multiplying the hourly mean wage by a "year-round, full-time" hours figure of 2,080 hours; for those occupations in which there is not an hourly mean wage published, the annual wage has been directly calculated from the reported survey data.

[2] The BLS classifies training levels by the manner in which most workers become proficient in an occupation and the preferences of most employers.

* OJT means on-the-job training.

Note: Occupations with employment less than 5,000 are excluded.

Data: California Employment Development Department (EDD); U.S. Bureau of Labor Statistics (BLS) — EdSource 1/08

biochemists and biophysicians, zoologists and wildlife biologists, and hydrologists.

Not all of California's fast-growing jobs in these areas require a bachelor's degree or higher, however. For example, jobs among computer support specialists, health information technicians, and registered nurses are expected to grow rapidly. These jobs require an associate's degree from a community college. As California's technology and health care sectors expand, the demand for people who can use and maintain the new tools, processes, and information systems developed by the state's high-tech workers and researchers also expands.

Numerous job openings include many lower-skilled jobs, as well as several math- and science-related occupations

A high rate of job growth does not necessarily correspond with a high number of *job openings,* however. The EDD projections also show that although math- and science-related jobs requiring some form of postsecondary education are prominent among California's fastest-growing jobs, the state will also have large numbers of job openings in occupations that tend to pay lower wages and require less education.

For instance, the occupation projected to offer the most job openings between

The Basics of California's Standards and Accountability Systems

Academic Content Standards: In 1997 the State Board of Education (SBE) adopted a set of academic content standards in mathematics, followed by the adoption of science standards in 1999. These standards are voluntary, as are the state's curriculum frameworks, which outline proposed courses of study.

California Standards Tests (CSTs): Mandatory state assessments were designed to test the material in the academic content standards and the curriculum frameworks. CSTs are based on "blueprints"—developed by the California Department of Education—which map test items to the academic content standards for the subject. California students receive scores on the CSTs that range from "far below basic" to "advanced."

See the box on No Child Left Behind (NCLB) on page 13 for more information on the federal accountability system.

Enrollments in the first year of integrated math have declined

California high schools may offer courses in mathematics through an integrated approach, in which topics from several subject areas are included in the course each year. Integrated math in high school has three levels, each including aspects of Algebra I, geometry, and Algebra II. Only a small fraction of California's students take integrated math courses, however. In 2002–03, 14,359 students enrolled in Integrated Math I. By 2006–07, only 7,056 students took the course statewide.

2004 and 2014 is retail salesperson. Although the job market for retail salespersons is projected to expand at a slower rate (24.4%) than for applications computer software engineers (46.4%), for example, far more new jobs for retail salespersons will actually be created (115,700 versus 39,200). After replacements in these fields are considered, the difference is even larger. The California economy is projected to need 288,300 retail salespersons between 2004 and 2014, compared with 47,500 openings for applications computer software engineers.

Other occupations that feature prominently among those projected to be the most plentiful include cashiers, waiters, and office clerks. Like retail salespersons, these occupations require on-the-job training and offer much lower wages than the math- and science-related positions described earlier.

Some of the math- and science-related jobs already discussed are also expected to offer large numbers of job openings. Registered nursing, for example, figures prominently as the seventh most in-demand occupation in California. About 109,000 job openings are projected for registered nurses between 2004 and 2014. Job openings for computer software engineers are also projected to be numerous: between 28,500 and 47,500 during this time period, depending on area of specialization.

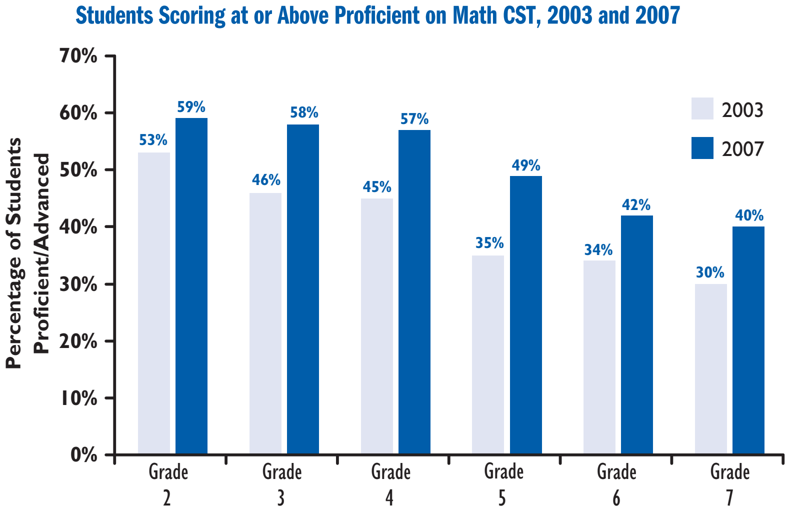
Secondary school teachers, who must hold both a bachelor's degree and a credential, are also among the most in-demand occupations in the state. The EDD projects 55,500 job openings for secondary school teachers between 2004 and 2014. The EDD data do not distinguish these teaching positions by subject area. Estimates published by the California Council on Science and Technology (CCST) and the Center for the Future of Teaching and Learning (CFTL) in March 2007, however, project that California middle schools and high schools will need about 33,000 new math and science teachers over the next 10 years, considering attrition and retirement.

In principle, all secondary school math and science teachers should hold a degree in the math or science subjects that they teach. In practice, however, there are large percentages of underprepared and out-of-field teachers in these subjects due to shortages at both the middle and high school levels, especially in low-performing schools. CCST and CFTL—in their 2007 report on California's capacity to prepare math and science teachers—estimated that as many as 12% of math teachers and 9% of science teachers at the high school level were "underprepared" in 2005–06, meaning that they did not hold a clear or preliminary credential in the subjects that they teach. (For further discussion of the recruitment, support, and retention of California math and science teachers, see the 2008 EdSource policy brief, *Math and Science Teachers: Recruiting and Retaining California's Workforce.*)

K–12 math and science education are important foundations for participation in growing areas of adult life

Opportunities exist for California students willing to pursue math- and science-related occupations, both for those who complete technical training and those who pursue a traditional four-year college degree. The EDD projections make clear that education plays an important role in determining students' future opportunities and earnings, including strong math and science education.

That reality created some of the impetus for California's adoption in the late 1990s of rigorous academic content standards regarding what all students should know and be able to do in both math and science. At that time, the conventional wisdom was that only college-bound students need take Algebra I, more advanced academic math, or rigorous *figure 2* **Proficiency on math CSTs before high school tends to decline across grades but has improved at each grade level**



Although the percentage of students who score proficient or above in math each year tends to decline from 2nd to 7th grade, all grades show steady improvement between 2002–03 and 2006–07.

Data: California Department of Education (CDE) EdSource 1/08

science courses. The standards were an attempt to use state policy to affect the quality of math and science instruction for all students. The evidence to date seems to indicate some success, particularly in regard to the math and science courses California high school students are taking.

More K–12 students take higher math courses following changes to state math standards

In 2000 California took a dramatic step to increase the math abilities of all its high school graduates by making the completion of Algebra I a mandatory requirement for a diploma. The move came on top of a new set of K–12 academic content standards in math that recommended students take the course in 8th grade, a path previously reserved for only the highest-achieving students.

These two state education policies are having an impact. Based on data from the state testing system, more California students are now being exposed to higher math courses, such as Algebra I and beyond. Greater numbers are also demonstrating proficiency in these courses, though the overall proportion of students who did so in 2006–07 was not dramatically different than in 2002–03. The relationship between course-taking and performance in high school math is a complex topic that is explored in more detail below. But the data do show that students in the state do not all take the high school math curriculum according to the same schedule. Those students who succeed at first-year algebra in 8th grade and have completed three years of college-prep math by the end of 10th grade still represent a high-achieving minority within the system. At the other extreme, a sizable portion of students continues to struggle to complete Algebra I.

More students are prepared for high school math, though challenges remain

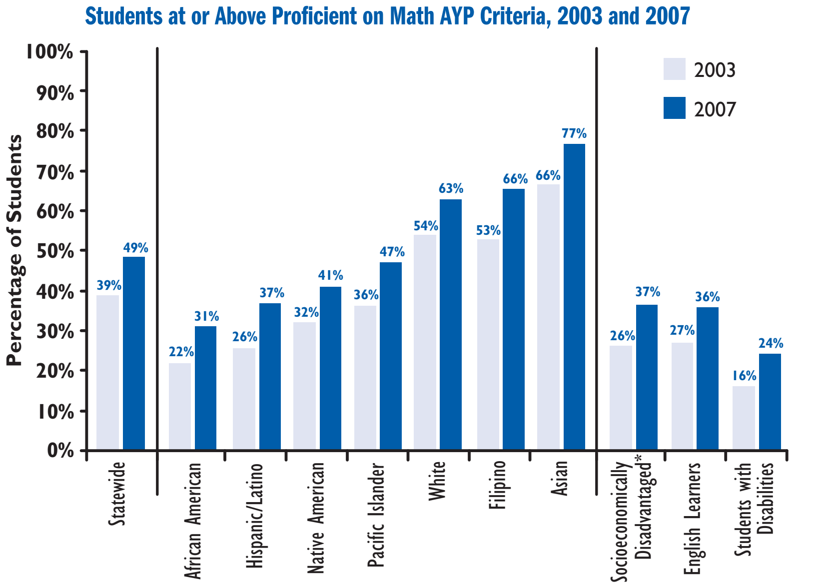
Achievement data from earlier grades provide important context for considering student preparedness for later courses such as Algebra I and beyond. Proficiency data from the California Standards Tests (CSTs) in elementary and middle school math show that more students are prepared for high school math than in the past, though challenges remain.

California assesses students in math beginning in the 2nd grade. Statewide proficiency data from CSTs for grades 2 through 7 show that students are progressively less likely to score proficient or above as they get older. This has been a consistent pattern since the current tests were first given in 2003. However, as Figure 2 makes clear, the percentage of students scoring proficient or advanced on the math CSTs has also increased across all grade levels during the same timeframe.

Every year, California submits an adequate yearly progress (AYP) report to the federal government on student achievement in math and English language arts, as required under No Child Left Behind (NCLB). These data are disaggregated by ethnicity and other measures to track progress among all student subgroups. In math, AYP takes into account all math CSTs taken by students in grades 2 through 8, plus 10th graders' proficiency on the California High School Exit Exam (CAHSEE). Although the inclusion of the CAHSEE in this summary measure confounds the picture somewhat, the data provide an additional window into overall student proficiency in math in the years before high school.

As Figure 3 on page 6 shows, the number of California students who demonstrated proficiency in math increased across all subgroups between 2003 and 2007. These AYP data also reveal large differences in proficiency among student subgroups. At the extremes, almost 77% of Asian students demonstrated proficiency in math compared with about 31% of African American students. The data suggest that many California students are already behind by the time they reach high school, especially among African American, Hispanic/Latino, and socioeconomically disadvantaged students, English learners, and students with disabilities.

figure 3 **Although all subgroups demonstrate increased proficiency in math (as measured by AYP), gaps persist**

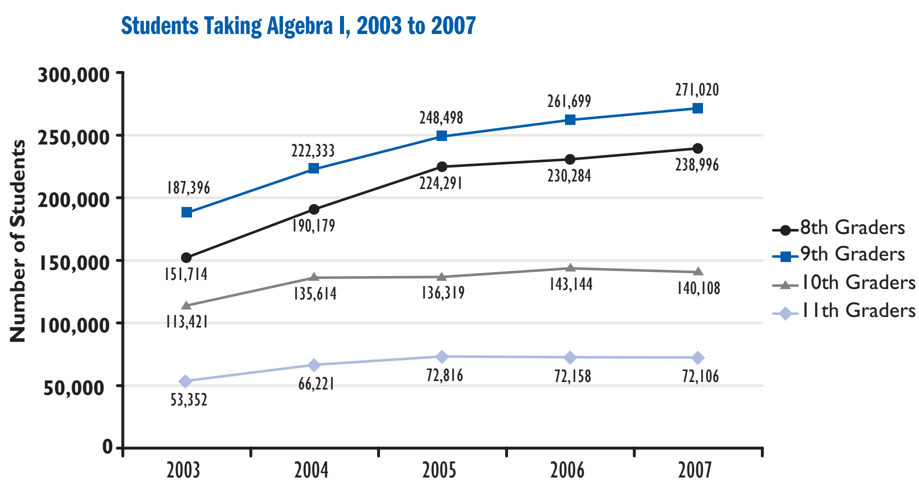


Average proficiency in math in grades 2 through 8 (and including the California High School Exit Exam taken in grade 10) has increased for all significant student subgroups since 2002–03. Significant gaps in proficiency persist among these subgroups, however.

*Socioeconomically disadvantaged students are those who qualify for free/reduced-priced meals.

Data: Adequate Yearly Progress Reports, 2003 and 2007, California Department of Education (CDE) EdSource 1/08

figure 4 **Over time, more students are taking Algebra I in 8th or 9th grade**



The number of students taking Algebra I in 8th or 9th grade increased continuously between 2002–03 and 2006–07. Each year, more 9th graders than 8th graders take the course. The number of 10th and 11th graders who do so is smaller and has leveled out.

Data: California Department of Education (CDE) EdSource 1/08

More students are taking Algebra I—increasingly in 8th grade, but more often in 9th grade

Algebra I is often considered a "gatekeeper" course that determines whether students will go on to postsecondary education. Algebra requires students to move between abstract concepts and concrete facts. According to California's Mathematics Content Standards, higher-level math beginning with Algebra I "allows for applications to a broad range of situations in which answers to practical problems can be found with accuracy."

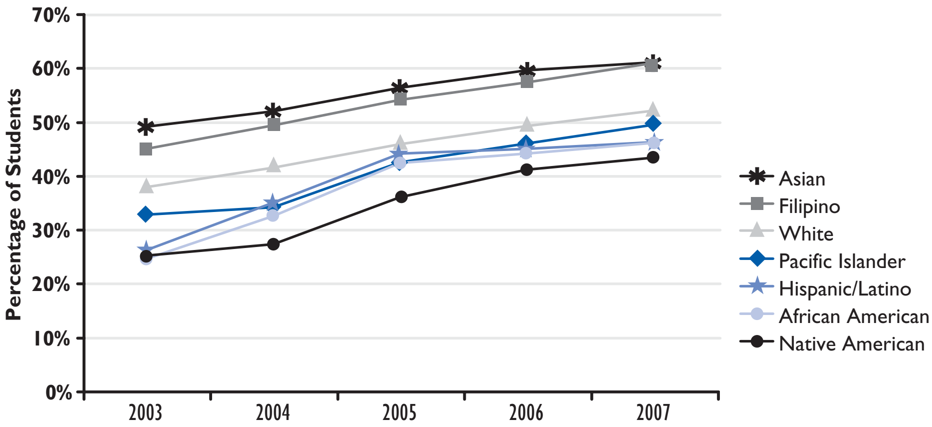
The content standards recommend a course-taking sequence in which students are expected to begin their study of Algebra I in the 8th grade and then continue with geometry and Algebra II. These standards are intended to align with the minimum academic expectations of California's four-year universities. Students who follow this path will complete their graduation requirements and meet the mathematics course-taking requirements for eligibility for admission to a University of California (UC) or California State University (CSU) campus by the end of 10th grade, leaving two years to take advanced math classes before graduation.

In the years since the state explicitly recommended that Algebra I be completed in 8th grade, the number of California 8th graders taking the course has increased greatly. In 1999, the first year California administered course-specific math tests to 8th graders, just 16% of them took the test for Algebra I. As Figure 4 shows, about 152,000 took the course in 2002–03, representing 32% of that year's 8th graders. By 2006–07, nearly half of 8th graders took the test.

Still greater numbers of students take Algebra I in 9th grade each year. More than half of 9th graders took the Algebra I end-of-course CST in 2006–07. Smaller numbers of students take the course in the 10th or 11th grade.

Students' participation in 8th grade Algebra I increased continuously between *figure 5* **Asian and Filipino students are the most likely to take Algebra I in 8th grade**

Students Taking Algebra I in 8th Grade, 2003 to 2007

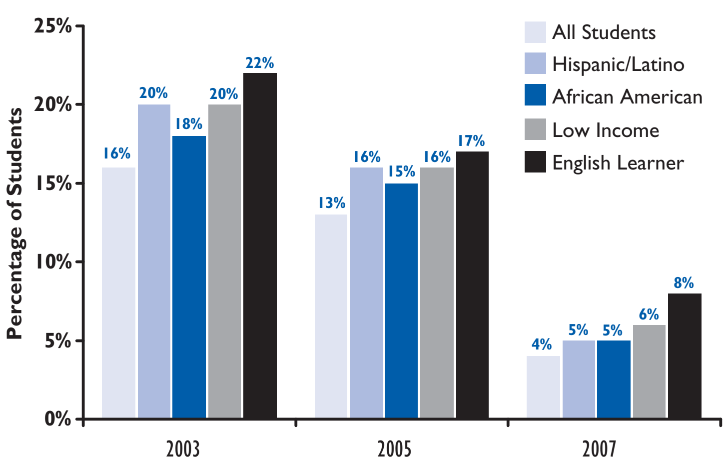


Students in all ethnic subgroups took Algebra I in 8th grade at greater rates in 2006-07 than in 2002-03, though differences in participation persist among them.

Data: Adequate Yearly Progress Reports, 2003 and 2007, California Department of Education (CDE) EdSource 1/08

figure 6 **By 2007 only 4% of all 10th graders had not yet taken Algebra I, though that percentage varies by subgroup**

10th Graders Not Yet Taking Algebra I



The proportion of students not yet taking Algebra I by 10th grade has declined overall since 2003. The proportion of Special Education students not yet taking Algebra I by the end of 10th grade (not shown) has also declined, from 37% in 2003 to 16% in 2007. The HumRRO report does not discuss the percentage of white or Asian students who had not yet taken Algebra I by 10th grade.

Data: Independent Evaluation of the CAHSEE: 2007 Evaluation Report by Human Resources Research Organization (HumRRO) EdSource 1/08

2002–03 and 2006–07 for all significant ethnic subgroups. Students of different subgroups participate in 8th grade Algebra I at different rates, however. Figure 5 shows that Asian and Filipino students remain the most likely to take Algebra I in the 8th grade: 61% of students in each group did so in 2006–07. Slightly more than half of white students (52%) did the same. African American and Hispanic/Latino students were less likely to take Algebra I in 8th grade in 2006–07 (both 46%), though their rates of participation increased especially quickly between 2002–03 and 2004–05 (both by 18 percentage points). Native American students remain the least likely to take Algebra I in 8th grade: 43% did so in 2006–07.

Prior to 2004, California students did not have to take algebra to graduate from high school. The change in policy at the state level in 2000—making Algebra I a state graduation requirement beginning in 2004—appears to be having a continued and dramatic impact on local patterns of math course-taking beyond 8th grade. Although CST data make it clear that enrollments in math courses have changed dramatically since the policy was put into place, its full effect cannot be documented. For example, no data exist regarding what proportion of high school graduates completed Algebra I prior to 2000. It is clear, however, that the vast majority of California school districts did not include the course as a graduation requirement until compelled to do so by the state. Today, presumably every California student who receives a diploma from a public high school has passed Algebra I.

An annual evaluation of the state's graduating high school students conducted by the Human Resources Research Organization (HumRRO) showed that by 2006–07, the proportion of students who had not taken Algebra I by 10th grade had declined considerably overall and across all subgroups of students. As Figure 6 shows, the percentage of all 10th grade students who had not yet taken Algebra I dropped from 16% in 2003 to 4% in 2007.

More students are completing the minimum college-prep math sequence

The end-of-course California Standards Tests provide a rough estimate of how many students enroll in Algebra I, *figure 7* **Overall, high school math course-taking has increased and accelerated, but the most common schedule includes Algebra I in 9th grade**

Subject Area	8th Grade	9th Grade	10th Grade	11th Grade
General Math 2007 (2003)	**45%** (60%)	**17%** (32%)		
Algebra I 2007 (2003)	**49%** (32%)	**52%** (37%)	**28%** (25%)	
Geometry 2007 (2003)		**22%** (16%)	**31%** (26%)	**18%** (15%)
Algebra II 2007 (2003)			**21%** (15%)	**24%** (20%)
Summative High School Math* 2007 (2003)				**20%** (15%)

Standards-aligned Path | Typical Path | A Year Behind the Typical Path

The percentage of students in each grade taking high school math courses according to the state's recommended timetable (beginning in 8th grade) has increased since 2002–03, but larger percentages of students still take math courses a year behind that schedule (beginning in 9th grade). The proportion of 8th and 9th graders taking a course in General Math has decreased.

* Taken by high school students (excluding 12th graders) who had completed Algebra II the previous year.

Data: California Department of Education (CDE) EdSource 1/08

geometry, and Algebra II, and in what grades the students took these classes. As Figure 7 shows, although more 8th grade students are taking Algebra I than before, California students more often take Algebra I and subsequent math courses a year behind the state guidelines. These students—if successful in keeping to this "typical" timetable—complete Algebra II in 11th grade.

Consider the students who took their high school math courses in keeping with the state's recommended "standards-aligned" course-taking schedule:

- 49% of the state's 8th graders took Algebra I in the timeframe intended by the state during the 2006–07 school year. Since 2005–06 a greater proportion of 8th graders took the Algebra I CST than took a General Math CST.
- 22% of 9th graders took geometry, and almost 21% of 10th graders enrolled in Algebra II during the same year.
- 20% of 11th graders completed the Summative High School Math Test, which is taken by students (excluding 12th graders) who have previously completed Algebra II.

Although almost half of the state's 8th graders in 2006–07 took Algebra I, only about 20% of their older peers had completed Algebra II by the end of 10th grade during that same year. This is an improvement from 2002–03, however, when 15% of 10th graders took the Algebra II CST.

Now consider the students who took their high school math courses a year behind the state's recommended schedule. Comparatively more students follow this typical path of high school math course-taking, with 9th graders taking Algebra I. In 2006–07:

- Almost 52% of 9th graders took Algebra I.
- 31% of 10th graders took geometry, and
- 24% of 11th graders took Algebra II.

The proportion of students in each grade who took math according to the typical timetable has increased since 2002–03. These enrollments are consistently higher than the proportion of students who take these courses a year earlier on the standards-aligned path.

Smaller numbers of students take their high school math courses two years (or sometimes more) behind the state's recommendations, or a year behind the typical path. The data show that a larger proportion of 10th graders took Algebra I (28%) than took Algebra II (21%) in 2006–07. Overall, in 2006–07, the proportion of 10th graders taking Algebra I is somewhat greater than it was in 2002–03 but slightly less than in 2005–06.

These data leave certain details ambiguous, especially when it comes to students who may repeat math courses. For instance, data from end-of-course CSTs do not distinguish between 9th graders in Algebra I who took a course in General Math the previous year and those who repeated Algebra I from the prior year. Students who repeat math courses constitute an important and continuous area of uncertainty for interpreting the data presented here.

Students who take math according to the standards-aligned schedule demonstrate higher rates of proficiency

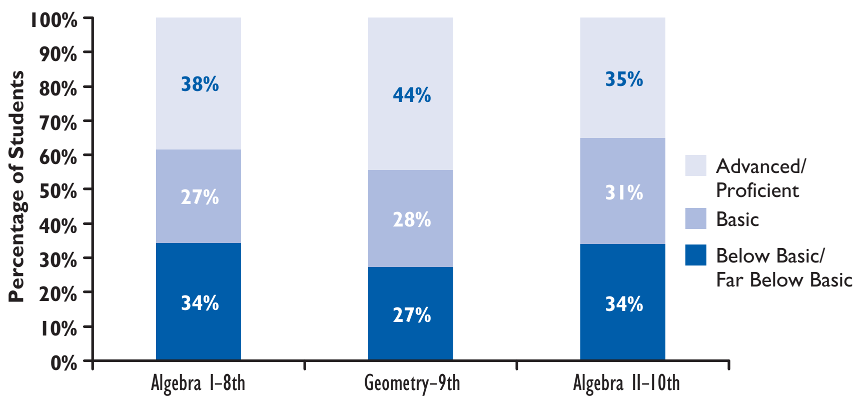
The data also reveal a consistent relationship between when students take higher math and their demonstrated proficiency on end-of-course CSTs. On average, students who take high school math courses on the standards-aligned path tend to score proficient or advanced on end-of-course CSTs at higher rates than their peers on the typical path—who, in turn, tend to score at higher rates than their peers a year behind the typical path. (See Figure 8.)

On the standards-aligned path, 38% of students scored advanced or proficient on the Algebra I CST in the 8th grade in 2006–07. Of the students who took geometry in the 9th grade, 44% scored advanced or proficient; 35% of the 10th graders in Algebra II did the same.

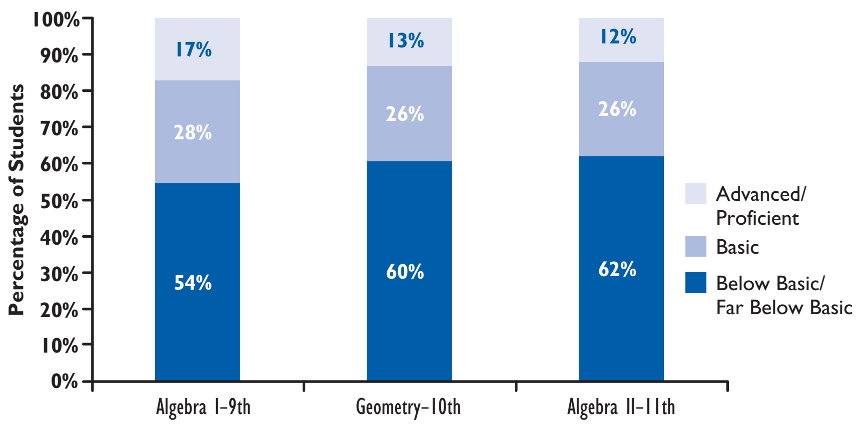
figure 8 **Students on the standards-aligned math course-taking path are more likely to score proficient or above on CSTs**

Rates of Proficiency Among High School Math Course-takers, by Course-taking Timetable, 2006–07

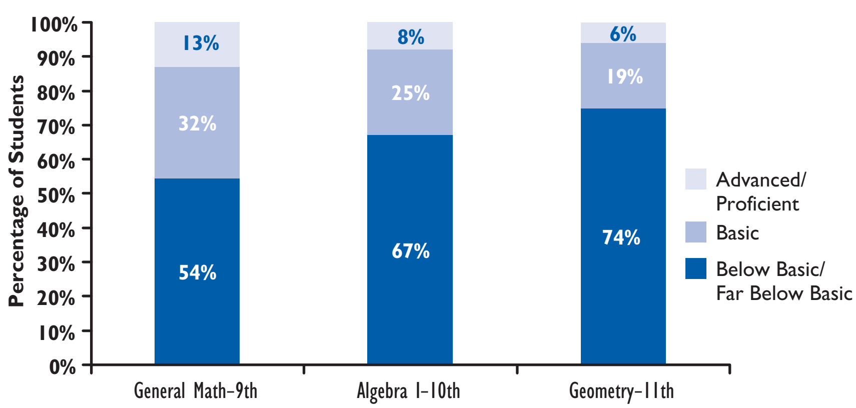
Math Achievement of Students on the Standards-aligned Path, 2006–07



Math Achievement of Students on the Typical Path, 2006–07



Math Achievement of Students One Year Behind the Typical Path, 2006–07



Students who take the Algebra I, geometry, and Algebra II sequence earlier (beginning in 8th grade) tend, in the aggregate, to demonstrate higher proficiency than their peers who take these courses a year or two later. These rates of proficiency were largely the same in 2002–03 as they were in 2006–07.

Data: California Department of Education (CDE) EdSource 1/08

The percentage of students scoring advanced or proficient on end-of-course CSTs decreases greatly among students on the typical course-taking path, a year behind the state's recommended schedule. Among these students, between 12% and 17% achieved at the proficient level or higher in 2006–07, as Figure 8 shows. The majority of students in each grade actually score below basic or far below basic.

The proportion who score proficient or advanced declines even further among students who take math courses a year behind the typical path—or two years behind the state's recommendations. Among the 10th graders who took Algebra I in that year, just 8% scored proficient or advanced; among 11th graders who took geometry, only 6% reached that level of achievement. The percentages of those students who scored below basic and far below basic were 67% and 74%, respectively.

This relationship between when students take higher math and their demonstrated proficiency on end-of-course CSTs has persisted over time. Overall, the rates of proficiency on the three course-taking timetables (shown in Figure 8) are much the same as they were in 2002–03, with some variation.

However, somewhat larger proportions of students on each path scored below or far below basic in 2006–07. For example, 60% of 10th graders who took geometry scored below basic or far below basic in 2006–07, compared to 50% in 2002–03.

Although the rates at which California students on these various paths score advanced or proficient have not changed very much, the percentages of students in each grade who take these courses have changed. For example, the percentage of 8th graders who scored proficient or advanced on the Algebra I CST in 2006–07 (38%) is much the same as in 2002–03 (39%), but more 8th graders took the test. Roughly 31,500 more

Enrollments in the first year of integrated science have increased

Some California high schools offer science courses through an integrated approach, in which topics from several subject areas are included in the course each year. Integrated courses in science have four levels, each covering components of the high school content standards in biology, chemistry, earth science, physics, and investigation and experimentation. Enrollment in Integrated Science I is increasing. Almost 97,000 students took Integrated Science I in 2006–07, compared with 62,000 four years earlier. Only 960 students completed the four-course sequence in 2007, however.

Roughly 31,500 more students scored advanced or proficient on the Algebra I CST in 8th grade in 2006–07 than did so in 2002–03—a 53% increase.

students scored advanced or proficient on the Algebra I CST in 8th grade in 2006–07 than did so in 2002–03—a 53% increase. By contrast, overall 8th grade enrollments were only 3% higher in 2006–07 than in 2002–03.

Similarly, although the percentage of 10th graders who scored proficient or advanced on the Algebra II CST in 2006–07 (35%) is lower than in 2002–03 (41%), more 10th graders took the test. Almost 7,600 more students scored advanced or proficient on the Algebra II CST in 10th grade in 2006–07 than did so in 2002–03—a nearly 27% increase, compared to a 9.5% increase in the overall 10th grade population between these two years.

These findings on course-taking and proficiency contain both good and bad news. They make clear that schools have responded to state policies by ensuring that more students have the opportunity to take advanced math courses, beginning with Algebra I in 8th grade. The total number of students scoring proficient and advanced in these more difficult courses has also increased substantially.

However, it is also clear that proficiency rates are lower among those students who take the math sequence later. The data cannot clarify why this relationship has persisted over time. But they do indicate that significant numbers of California's students are struggling with math. Would these students benefit from the opportunity to take Algebra I sooner, or would this simply compound the problem? It is legitimate to ask what can be done to increase these students' exposure to algebra sooner and to better support their mastery of the course content.

Science course-taking and achievement have improved, but the data are more difficult to analyze

Science course-taking among California high school students is more challenging to evaluate than in mathematics. Unlike in math, the state does not recommend a particular course sequence for California high school students. Students must complete two years of science, including biological and physical science, in order to graduate from high school. Students pursue these and other science courses in various orders, however, based on their own and their schools' preferences.

Data from the state testing system show that more California students are enrolling in biology, chemistry, earth science, and Integrated Science I, and that student achievement in these courses has tended to improve since 2002–03. Overall enrollment in high school science remains lower than in mathematics, however.

The data from end-of-course CSTs do not provide much perspective on students' actual course-taking paths in high school science. However, a recent analysis of student records by the California Department of Education (CDE) provides an intriguing look at the courses taken by high school students who enrolled in both a math and a science course in 2005–06. The analysis sheds some light on how their science course-taking is related to the pace at which these students moved through the state's recommended math sequence.

More students are taking high school science courses, and performance is somewhat better

End-of-course CST data in science among 9th, 10th, and 11th graders during the 2006–07 school year show several things. (See Figure 9.) For instance, enrollments in certain courses varied by students' grade level. Most students took chemistry in the 10th and 11th grades, but few students took earth science after 9th grade. In addition, student performance in Integrated Science I and earth science—which are not typically college-prep courses—was generally lower than in biology, chemistry, and physics. Because 12th graders do not take CSTs, it is not known how these patterns carry forward in students' last year of high school.

The test data indicate that student enrollment in high school science courses has been increasing since 2002–03. In most cases, student performance on end-of-course CSTs in these science classes has also improved. Consider the following trends in each subject area.

- **Biology:** Enrollments in biology courses have increased considerably from the 334,000 students who took the class in 2002–03. By 2006–07, 507,000 students took biology—and almost half were in 10th grade. Achievement in biology has not made such notable gains, however. The proportion of students scoring at or above proficient on the biology CST rose slightly for students in the 9th and 11th grades and fell slightly for students taking the test in 10th grade.

- **Chemistry:** Chemistry enrollments increased from 153,000 students in 2002–03 to 228,000 four years later. In both years, the majority of these students took the course in 11th grade. Chemistry students scoring at or above proficient on the CST increased by 1 percentage point for 11th graders since 2003, was the same for 10th graders, and dropped by 2 points for the few 9th graders who took the test.
- **Physics:** The proportion of students who study physics has not changed much over the past four years, and most of those students take the course in 11th grade. Physics students tend to perform best, in the aggregate, in the 11th grade. This pattern was more pronounced in 2003, when 10% of 9th graders scored proficient or advanced compared to 39% of 11th graders.
- **Earth Science:** Overall enrollments in earth science have more than doubled since 2003, jumping from 90,000 to 207,000 in 2007, with most students taking the course in 9th grade. Achievement in this course has risen slightly by between 3 and 6 percentage points, depending on grade level.
- **Integrated Science I:** Ninth grade enrollments in Integrated Science I have increased considerably since 2003, but enrollments in other grades have remained fairly stable. Student achievement in Integrated Science I is markedly lower than in other science courses, however. This has been consistently the case since 2003, though the percent of students at or above proficient has increased by 3 to 5 percentage points (depending on the grade level) since then.

figure 9 **High School Science CST Data, 2006–07**

	9th Grade	10th Grade	11th Grade
CST Biology/Life Sciences			
% Proficient or Advanced	47%	30%	36%
(% of Enrollment)	(31%)	(50%)	(21%)
CST Chemistry			
% Proficient or Advanced	40%	39%	26%
(% of Enrollment)	(1%)	(20%)	(27%)
CST Physics			
% Proficient or Advanced	20%	29%	42%
(% of Enrollment)	(3%)	(2%)	(9%)
CST Earth Science			
% Proficient or Advanced	27%	20%	24%
(% of Enrollment)	(26%)	(6%)	(8%)
CST Integrated/Coordinated Science 1			
% Proficient or Advanced	11%	7%	8%
(% of Enrollment)	(14%)	(2%)	(2%)

Data: California Department of Education (CDE) EdSource 1/08

General science and life science tests provide snapshots of performance before and during high school

The general science CSTs that are given to all students in the 5th and 8th grades and the life science CST given to all 10th graders offer one broad view of students' achievement in science. These tests assess cumulative science knowledge.

Fifth grade students have taken a general science CST since 2004, and the proportion of students who score proficient or advanced has steadily increased from 24% in 2004 to 37% in 2007.

As of 2006, 8th graders are also required to take a general science CST and 10th graders a life science CST. The percentage of 8th graders who scored at the proficient or advanced levels increased from 38% in 2006 to 42% in 2007, but the proportion of 10th graders achieving at this level remained stable at 35%.

Overall, enrollment in high school science courses is lower than in math courses. Math and science CST data for 2006–07 show that 100,000 more 9th graders took a course in math than took one in science. This difference is less pronounced among 10th graders: only 14,000 more students enrolled in math than science during 10th grade. Among 11th graders, however, the enrollment difference was 48,000.

Certain limitations to the conclusions that can be drawn from data on high school science CSTs should be acknowledged. For instance, data on end-of-course CSTs in science do not provide a basis for differentiating between students who take two science courses in high school and those who take four, or the order in which students take them. In addition, CST data do not illuminate enrollments and achievement

figure 10 | **High school math course-taking provides a window into science course-taking**

Figure 10A. Science Course-taking of Students on the Standards-aligned Math Path, 2005–06

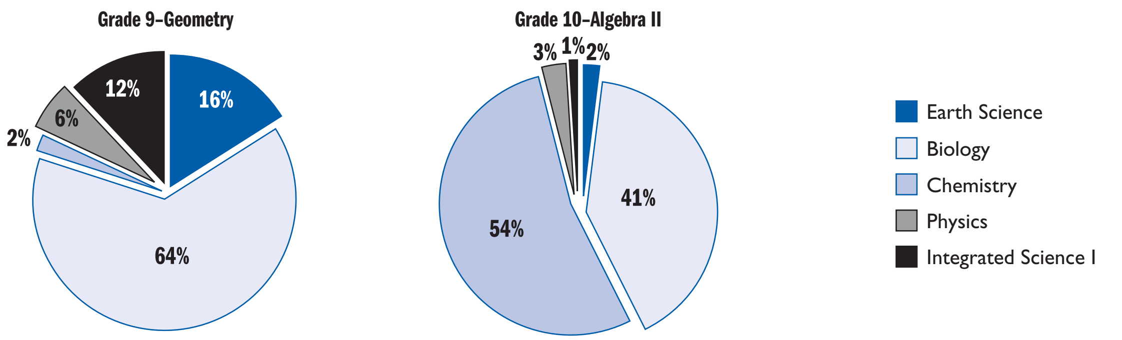


Figure 10B. Science Course-taking of Students on the Typical Math Path, 2005–06

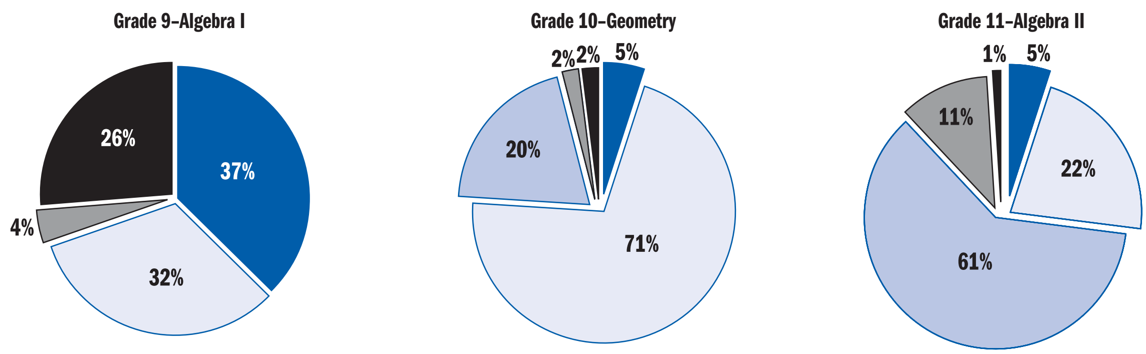
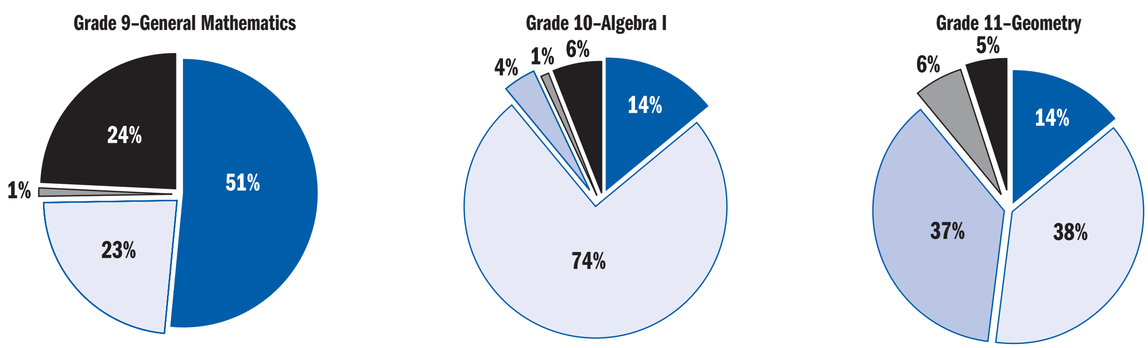


Figure 10C. Science Course-taking of Students One Year Behind the Typical Math Path, 2005–06



Among students who took both math and science in 2005–06, students who took geometry in 9th or 10th grade (on either the standards-aligned or typical schedule) tended heavily to take biology. The majority of students who took Algebra II in 10th or 11th grade took chemistry. Students who took math a year behind the typical schedule tended to take biology in 10th grade (along with Algebra I) and either chemistry or biology in 11th grade (along with geometry)—but were also more likely to take Integrated Science I or earth science later in their high school careers.

Data: California Department of Education (CDE) EdSource 1/08

among 12th graders in courses such as physics, chemistry, and biology because, as is the case in math, these students do not take end-of-course CSTs.

Student-level data show relationships between science and math course-taking

Interestingly, the math course-taking paths previously described can provide a window into science course-taking. The key to this type of analysis is student-level data. The following analysis was done by the Standards and Assessment Division of the CDE using test results from student records. These data reveal common science course-taking patterns among students in each of the math course-taking paths. The analysis pertains only to the subset of students who took both a math and a science course during the 2005–06 school year. Students who enrolled in a math course but not in a science course are not included.

Consider the students who took their high school math courses according to the standards-aligned schedule in 2005–06. The CDE found that, among the 9th graders who took geometry concurrently with a science course, the majority took biology. Meanwhile, among 10th graders who took Algebra II and a science course concurrently, the majority took chemistry; most of the remainder took biology. (See Figure 10A.)

Students who took their high school math courses according to the more typical schedule in 2005–06 generally followed a similar pattern, according to CDE data. Tenth graders who took geometry concurrently with a science course tended heavily to take biology. Eleventh graders who took Algebra II along with a science course tended to take chemistry. Meanwhile, 9th graders who took Algebra I and a science course tended to take a roughly equal mix of earth science, Integrated Science I, and biology. (See Figure 10B.)

Students who took their high school math courses a year behind the typical schedule during the 2005–06 school year tended, if they took a science course concurrently, to take biology in 10th grade and either biology or chemistry in 11th grade. (See Figure 10C.) In addition, notable proportions of these 10th and 11th graders took either Integrated Science I or earth science, doing so much later in their high school careers than their peers in either the standards-aligned or typical paths. These courses are not usually considered college-prep courses.

Available data offer a partial picture of the state's highest-achieving students in math and science

Many high-achieving students complete their required coursework and pursue upper-level math and science courses in high school. In math, for instance, more than 269,647 high school students in California (14% of all 9th–12th graders) enrolled in a "third- or fourth-year advanced math" course, such as trigonometry, statistics, or calculus, in 2006–07, according to CDE. These data provide a summary measure of advanced course-taking in math.

Some additional sources—such as data on student participation in the Summative High School Math CST and advanced placement (AP) courses—offer further information about California's highest-achieving students in math and science. Data on the students who finish high school with enough courses to be eligible for admission to the state's four-year university systems provide another view of the state's most successful high school students.

Summative High School Math CST data show that more California students are finishing Algebra II by the end of 10th grade

The Summative High School Math CST provides one snapshot of the achievement of some of California's most advanced

No Child Left Behind (NCLB) affects instructional time in elementary math and science differently

Although this report focuses primarily on California's K–12 academic content standards and assessments, the federal No Child Left Behind Act (NCLB) is also an important piece of the story. Math and science education are commonly cited together in discussions of future workforce competitiveness. But federal accountability requirements affect these two subjects very differently.

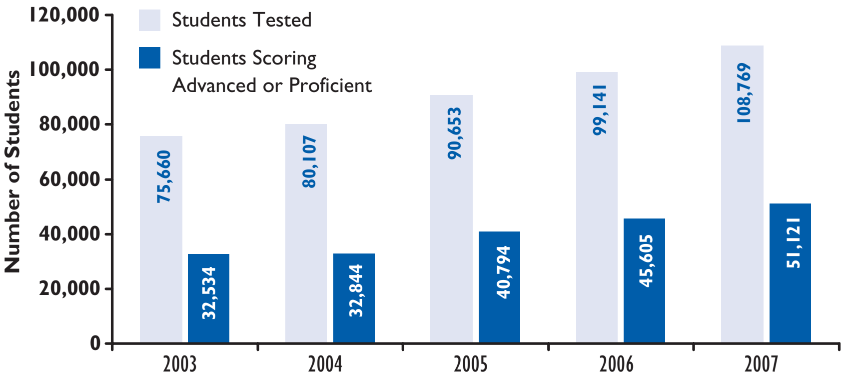
NCLB's accountability measures focus on how well students across multiple subgroups perform on standardized tests in math and English language arts. The results of a national survey of school districts published in 2007 by the Center on Education Policy found that 62% of districts surveyed reported increasing elementary instructional time in math and/or English language arts, with 41% reporting that changes to their math curricula were "to a great extent" undertaken in response to NCLB testing considerations. In addition, 43% of districts that had at least one school in the intervention called Program Improvement (PI) under NCLB reported decreased instructional time in science; this percentage was 23% in districts that had no schools in PI.

A 2007 brief that looked at elementary science education in the San Francisco Bay Area came to similar conclusions. Published by the Lawrence Hall of Science at Berkeley and WestEd, the brief was based in part on surveys of Bay Area districts and elementary teachers and interviews at districts and county offices of education. The authors found that as many as 80% of elementary teachers with multiple-subject credentials reported spending no more than 60 minutes per week on science instruction, and as many as 16% reported spending no time. Again, these results were most pronounced in districts with schools in PI.

Whether and how science education might become more fully integrated into NCLB's measurement of schools' adequate yearly progress (AYP) remains unclear. The law requires that districts begin testing in science annually in 2007 within three grade spans: 3–5, 6–9, and 10–12. As this report discusses elsewhere, California already administers general science CSTs in 5th and 8th grades and a life science CST in 10th grade.

figure 11 **The number of students who complete Algebra II by 10th grade has steadily increased**

Summative High School Math Test, 2003 to 2007



The number of California students completing Algebra II by the end of 10th grade increased steadily between 2002–03 and 2006–07. The proportion of these students who score proficient or above on the Summative High School Math CST has also increased slightly during that time.

Data: California Department of Education (CDE) EdSource 1/08

Overall, enrollment in high school science courses is lower than in math courses. Math and science CST data for 2006–07 show that 100,000 more 9th graders took a course in math than took one in science.

students in mathematics. Students (excluding 12th graders) take this CST the year after they complete Algebra II, even if they are not enrolled in a higher-level math course. The test incorporates key components of Algebra I and II, geometry, and probability and statistics that students should have mastered during their high school math education. Although no new math content is tested, the administration of the Summative High School Math test permits the scores of these high-achieving math students to be included in their schools' API.

The results from the Summative High School Math test confirm that the number of students who complete Algebra II by 10th grade, if not earlier, has increased since 2003. (See Figure 11.) Nearly 109,000 students took the test in 2006–07, compared to almost 77,000 in 2002–03. Of the students who took it in 2006–07, 84.7% were in 11th grade, 14.6% were in 10th grade, and a few (0.6%) were precocious 9th graders. Students who take this test may have taken it twice already, gone on to study calculus, statistics, or trigonometry, or not been enrolled in another math course after Algebra II.

The proportion of students who score advanced or proficient on the Summative High School Math test has increased only slightly from 43% to 47% during the past five years (including a dip to 41% in 2004). This represents a substantial increase in the number of students who score well, however. More than 51,000 students achieved advanced or proficient on the test in 2006–07, compared to about 33,000 in 2002–03.

UC and CSU eligibility requirements set additional standards in math and science

Students interested in postsecondary education at one of California's public universities must complete a set of courses required by the University of California (UC) and California State University (CSU) systems, known as the "a-g" course sequence. These course-taking requirements incorporate what the state's public universities have specified as a minimum course of study in preparation for college. The "a-g" requirements in math and science are more extensive than the state's course-taking requirements for high school graduation, which call for two years of math, including Algebra I, and two years of science, including biological and physical science. (School districts can—and often do—set higher requirements.)

Students must complete 15 qualifying "a-g" courses with a minimum grade of C to be considered for admission to the CSU or UC systems. In math and science subjects, "a-g" requirements include:

- **Mathematics:** Three years of college preparatory mathematics that include the topics covered in Algebra I and II and two- and three-dimensional geometry. Four years are strongly recommended.
- **Laboratory Science:** Two years of laboratory science providing fundamental knowledge in at least two of the following disciplines: biology, chemistry, and physics. Three years are strongly recommended. Courses are allowed that incorporate applications in some other scientific or career-technical subject area, or that constitute the final two years of a three-year

sequence in integrated science with rigorous coverage of at least two of the "foundational subjects."

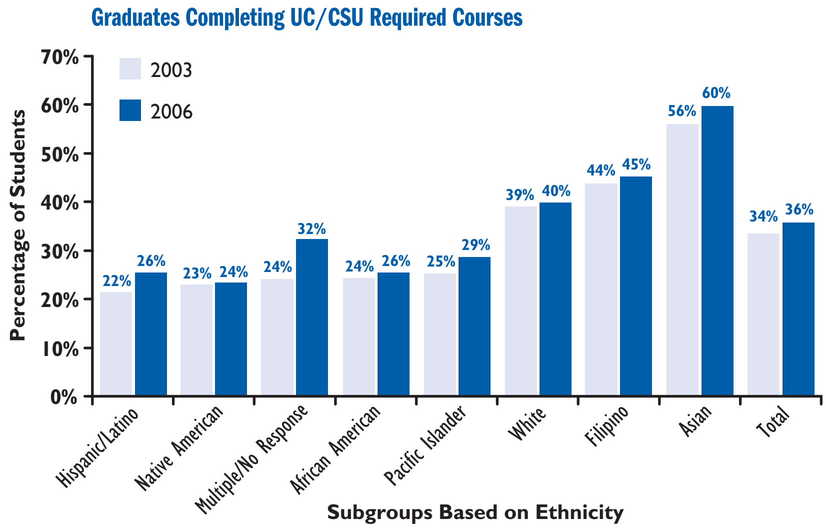
In 2005–06, California high schools graduated 124,782 12th graders who completed the "a-g" requirements with a grade C or better, including summer graduates. (This does not include students with high school equivalencies.) This represented 35.9% of all graduates that year. (See Figure 12.)

Statewide, 40% of female and 31.5% of male students completed the required coursework to be eligible for entry to a UC or CSU campus. The gap in achievement based on ethnicity is more dramatic, however. Altogether, 60% of Asian high school graduates met CSU/UC course requirements, but only 25.5% of Hispanic/Latino and African American graduates were eligible. (See Figure 12.)

Overall, the "a-g" course completion rate has improved, but not dramatically. Some subgroups have experienced more growth than others. The percentage of Native American and white students who completed these requirements has increased by 2% compared with an almost 19% increase for Hispanic/Latino students. Asian students increased their rate of "a-g" course completion by about 7%, Pacific Islanders by 13%, Filipinos by 3%, and African Americans by 5%.

All high schools must provide their students with access to the courses required for UC and CSU admission. The quality of teaching and instructional materials varies across classrooms and schools, however, as does the number of classes offered. The University of California has a course-approval process for quality control purposes, but its methods have been criticized as inadequate. Not all students who complete the "a-g" requirements can necessarily perform at the college level. In 2006, for example, 37.5% of all regularly admitted first-time freshman in the CSU system required mathematics remediation.

figure 12 **The percentage of graduates completing UC/CSU required courses has increased over time, but achievement gaps based on ethnicity persist**



Since 2003 every significant subgroup has experienced an increase in the percentage of students who complete the course requirements for UC/CSU eligibility. The overall percentage of students who complete these requirements has increased only slightly, however.

Data: California Department of Education (CDE), CBEDS, 11/21/07 EdSource 1/08

The Early Assessment Program gauges some students' readiness for college-level math

The Early Assessment Program (EAP) is a college-readiness testing program, jointly administered by the CDE and California State University (CSU). The EAP is voluntary and offered to 11th grade students. It involves 15 additional questions on the CSTs in English language arts, Algebra II, and Summative High School Math. (In math, this means that the EAP is available to students who take Algebra II by 11th grade.) A written essay is also required.

CSU uses EAP results to exempt students from college placement tests or inform them that they need additional preparation before enrolling in college. The program acts as an early intervention to help future CSU students improve their math and English skills during their senior year in high school, and to reduce the number of students requiring math and English remediation once enrolled at CSU. The EAP also serves as a tool to help CSU align its own placement standards with the K–12 math and English language arts content standards.

Overall, more than 346,000 11th graders volunteered to take the EAP in 2006–07, but only about 141,600 took the math section. Of these math test-takers, 55% demonstrated college readiness—the same percentage as in 2005–06.

The appropriate statewide goals for how many students should attain UC/CSU eligibility are far from clear. On the one hand, increasing the numbers of under-represented students who are eligible to go to four-year colleges is figure 13 **Number of Advanced Placement Exams Taken in Math and Science Subjects in California, 2007**

Course	Tests Taken
Biology	25,808
Calculus AB/BC	45,609
Chemistry	14,167
Computer Science A/AB	2,927
Environmental Science	9,566
Physics B/C (Elec. & Magnet, Mechanics)	15,033
Statistics	16,551

Data: College Board, 2007 EdSource 1/08

Many argue that the skills and knowledge required for student success in technical training programs—or in today's work world more generally— are quite similar to what is required for college academics.

widely seen as desirable. On the other hand, the state's public universities have clear limits on the number of students they can and will enroll. That said, completion of the "a-g" course sequence is an important achievement if students want to pursue math- and science-related occupations that require at least a bachelor's degree.

Advanced placement tests provide additional perspective on high-achieving students in math and science

Advanced placement (AP) test-taking data for advanced math and science courses offer another perspective on high-achieving students. The College Board, which oversees AP tests, provides data on California AP performance disaggregated by subject area and ethnicity. The College Board reports that 184,268 11th and 12th grade students took an AP test (in all subjects) in May 2007. (Some 9th and 10th grade students also take AP tests.)

During the past 10 years, the number of students taking advanced placement courses has steadily increased, as have the number of exams those students have taken. At the same time, California's total student population has increased. According to the College Board's 2007 Summary Reports, the percentage of California students who took an AP exam in high school has increased from 22% in 2000 to 31% in 2006.

The College Board also reports that California students took 129,661 AP exams in math and science subjects in 2007. (See Figure 13.) And 78,331 (60%) of these exams received a passing score of 3, 4, or 5. The achievement of California's students on AP tests varies by subject. In math and technology subjects (calculus, computer science, statistics), 62% of the exams receive a passing score. In science fields (biology, chemistry, physics, and environmental science), 59% of these tests scored a 3 or higher in 2007.

The College Board's 2007 *Advanced Placement Report to the Nation* notes that, in 2006, California ranked fifth in the nation among "states with the greatest percentage of graduating seniors having scored 3+ on an AP exam in high school," behind New York, Maryland, Utah, and Virginia. About 20% of California's graduating seniors had received a passing score, up from 15% in 2000. (This measured participation in all AP subject areas, not just math and science.) However, when the College Board evaluated California's progress in eliminating an "equity gap"—that is, the degree to which the percentage of a minority group in the population matches the percentage of that minority group's AP examinees—California was found to have made little progress compared to other states between 2000 and 2006.

Higher education provides students with a crucial connection to jobs that put math and science to work

For most students, it is a fair distance between high school graduation and their ultimate career objectives, particularly for those targeting occupations that require a college degree. When it comes to careers in the STEM areas of science, technology, engineering, and math, students have a wealth of options in terms of postsecondary education. In addition to a robust public system of colleges and universities, the state has a vast assortment of private vocational training providers and private colleges. Less clear is the extent to which all of these institutions are preparing enough graduates for the opportunities available in math- and science-related fields.

Some data indicate a gap between higher education graduates and California's workforce needs in math and science fields

Some California experts have expressed concern that too few students are graduating from the state's colleges with the degrees and certifications necessary for jobs in the STEM fields. A September 2007 report by the California Postsecondary Education Commission (CPEC) cites gaps between the number of degrees granted by California's postsecondary institutions in 2005 and job openings in several important STEM fields. These data include both public and private or independent institutions. These shortfalls were especially great in computer science. Computer science degrees granted by California postsecondary institutions in 2005 lagged behind job openings by approximately 6,600. CPEC also noted shortfalls among California's nurses, pharmacists, and physician assistants; ambiguities in the data left open the possibility of shortfalls among engineers as well.

According to a 2007 analysis by the Public Policy Institute of California (PPIC), these needs are likely to grow. The authors predict that jobs in the health and education services and professional services industries—which include engineering and computer occupations—will continue to increase their shares of the overall economy. By 2025 the "share of workers with a college degree" in each of these industries will be greater than 50%; overall, the authors project, jobs requiring a bachelor's degree may increase by as much as 78%, and those that require a graduate degree by as much as 68%.

Existing shortages and future projections such as these put pressure on the state's K–12 and postsecondary education systems. Preparing California students for the opportunities and demands that lay ahead of them is an important indicator of the success of both systems. The same PPIC analysis suggests that such preparation is also important for the state's future economic growth. The authors note that such factors as high California home prices and increasing international competition for educated workers make it unlikely that California can import enough people—either from other states or other nations—to fill its future workforce needs. Nor is such a solution one that meets the future employment needs of the state's young people who are in school now.

California is not alone in coming to terms with such issues. Many researchers, business leaders, and policymakers at the national level focus on math and science education as key to sustaining individual opportunity and economic growth and competitiveness for the nation. One highly publicized report—*Rising Above the Gathering Storm,* published in 2007 by The National Academies Committee on Science, Engineering, and Public Policy—argued that the United States must strengthen its capacity to prepare and retain people with expertise in scientific and technological fields in order to thrive economically. The report identified K–12 math and science education as the first leverage point for ensuring that American students will be prepared to participate in such fields. It also highlighted the important role of higher education, which provides students with opportunities to develop competence and earn credentials in math- and science-related fields, as well as providing institutions for research.

As workforce projections make clear, many of the fastest-growing and most in-demand jobs in the math- and science-related fields require some form of postsecondary certification.

California's public higher education systems contribute to workforce preparation in different ways

As workforce projections make clear, many of the fastest-growing and most in-demand jobs in the math- and science-related fields require some form of postsecondary certification, such as vocational certificates, associate's or bachelor's degrees, or graduate degrees. Community colleges and the UC and CSU systems play different roles in preparing and certifying California students for entry into these careers.

The most recent data available from CPEC regarding degrees granted in math- and science-related fields are for 2006. These data, which pertain only to public colleges and universities—California community colleges, CSU, and UC—provide some perspective regarding how these crucial institutions currently connect California's young people to career opportunities in these fields through certification and degrees.

Community colleges offer direct access to some math- and science-related careers and a path to further education

California's community colleges, with their open door policy, educate a vast number of students. CPEC reports that 1.35 million credit-seeking students enrolled in a community college in 2006, and another 287,000 students took noncredit courses.

Due, in part, to the many roles that community colleges play—academic preparation, vocational training, remediation, adult enrichment—enrollment data are not collected by subject area. Some data are available regarding program completions, however, and they indicate that thousands of California students receive degrees in math, science, and technology fields from community colleges. These terminal degrees include both pre-baccalaureate certificates and two-year associate's degrees that allow students to enter a STEM-related occupation and associate's degrees valid for transfer to a four-year university.

Some occupations in the technology and health care sectors require credentials less extensive than a baccalaureate degree—a niche that the community college system fills effectively. For example, a student can begin a career as a registered nurse—an area of particular workforce demand in California and nationwide—with an associate's degree awarded by a community college. The community college system responded to California's need for nurses and other health services professionals by graduating more than 15,000 individuals with associate's degrees or other certifications in 2006. Some campuses have launched programs to increase enrollment and completion in nursing and health services certification programs. During the same year, California community colleges also granted about 2,200 degrees and certificates in computer and information sciences and support services, as well as about 1,700 in engineering technology.

California community colleges also enable students to transfer to a UC or CSU to continue their studies. The California Community Colleges Chancellor's Office (CCCCO) reported in March 2007 that about 45% of UC and CSU graduates in all fields in 2005–06 had transferred from community colleges. Although data on what transfer students studied at their community college are not available, about 20% of students who transferred and enrolled in a particular program chose a STEM discipline when they matriculated in the UC or CSU systems in the fall of 2006. (This percentage includes the following programs of study: Agriculture, General; Biological and Biomedical Sciences; Computer and Information Sciences and Support Services; Engineering; Engineering Technology, General; Health Services/Allied Health/Health Sciences, General; Mathematics and Statistics; Natural Resources and Conservation; and Physical Sciences.)

The community college system responded to California's needs for nurses and other health services professionals by graduating more than 15,000 individuals with associate's degrees or other certifications in 2006.

Degrees granted by UC and CSU in computer science, engineering, and the biological and biomedical sciences have increased at various rates

The UC and CSU systems are also important institutions for students who aspire to work in math- and science-related fields. These universities provide access to the preparation, knowledge, and degrees required to enter such occupations as computer software engineering, teaching, and others. The CSU system does this by drawing from the top third of California's public high school graduates and offering both bachelor's and master's level programs. The UC system draws from the top eighth of public school graduates and offers bachelor's, master's, and doctoral programs. A September 2007 report by CPEC—which discusses how California's postsecondary institutions contribute to workforce development in the state—notes that UC is the public education institution responsible for preparing professionals in fields such as medicine.

Figure 14 provides a summary of the bachelor's and graduate degrees granted in 2006 by UC and CSU in three programs of study: computer science, engineering, and the biological and biomedical sciences. More people earned bachelor's and graduate degrees in these fields in 2006 than in 1997. The proportion of degrees earned in these areas, as a percentage of all degrees granted by UC and CSU each year, has varied by program of study during this time period.

- **Computer Science:** The number of bachelor's degrees granted in computer science by UC and CSU declined between 2004 (about 3,400) and 2006 (about 2,300), but this number remained higher than in 1997 (about 1,500). The number of graduate degrees earned in computer science has increased without interruption since 1998.
- **Engineering:** The number of bachelor's degrees earned in engineering fields at UC and CSU increased between 2000 and 2006. The share of bachelor's degrees earned in engineering was essentially the same in 2006 as it was in

1997, though higher than in the intervening years. Graduate degrees earned in engineering increased between 2001 and 2006.

- **Biological and Biomedical Sciences:** The numbers of bachelor's and graduate degrees earned at UC and CSU in the biological and biomedical sciences both increased steadily between 2002 and 2006. However, the degrees earned in 2006 constituted a smaller share of all bachelor's and graduate degrees granted than was the case in 1997.

figure 14 **Degrees Granted by UC and CSU in Computer Science, Engineering, and Biological and Biomedical Science, 2006***

STEM Program of Study	Bachelor's Degrees	Graduate Degrees
Computer Science (% of all degrees)	**2,318** (2.1%)	**1,243** (3.8%)
Engineering (% of all degrees)	**6,846** (6.2%)	**3,283** (10.0%)
Biological and Biomedical Science (% of all degrees)	**7,393** (6.7%)	**1,201** (3.7%)

* The number of degrees earned in each STEM program of study was counted using the 2-digit, or most general, Classification of Instructional Program (CIP) codes for "Computer and Information Sciences and Support Services," "Engineering," and "Biological and Biomedical Sciences."

Data: California Postsecondary Education Commission (CPEC) EdSource 1/08

Women earned slightly more than 60% of degrees awarded in the biological and biomedical sciences from UC and CSU in 2006. By contrast, men earned almost eight in 10 degrees in computer science and engineering.

Student subgroups earn degrees in computer science, engineering, and the biological and biomedical sciences in varying proportions

Between 1996 and 2006, the student population in K–12 education changed significantly in terms of ethnicity, with white students decreasing from 40% to 30% of students and Hispanic students increasing from 39% to 48%. At UC and CSU, however, the ethnic distribution of students has remained relatively stable over the same time period. Overall, white students have comprised approximately 40% of enrollment at UC and CSU since 1996. Asian/Pacific Islanders make up about 18% of the universities' student body, a proportion that has not changed over the past 10 years. African American students, who represent about 8% of K–12 students, have continued to make up about 5% of all UC/CSU enrollees. Hispanic enrollment at UC and CSU has increased slightly over the past 10 years, but still represents less than 20% of the student population.

Figure 15 on page 20 shows that different student subgroups earned varying proportions of the bachelor's and graduate degrees granted in the STEM fields of computer science, engineering, and the biological and biomedical sciences at UC and CSU in 2006. In addition to ethnic subgroups, these data include students who are categorized as "nonresident aliens." These are students who are not citizens or nationals of the United States, are in the country on a visa or temporary basis, and do not have the right to remain indefinitely without proper sponsorship and documentation.

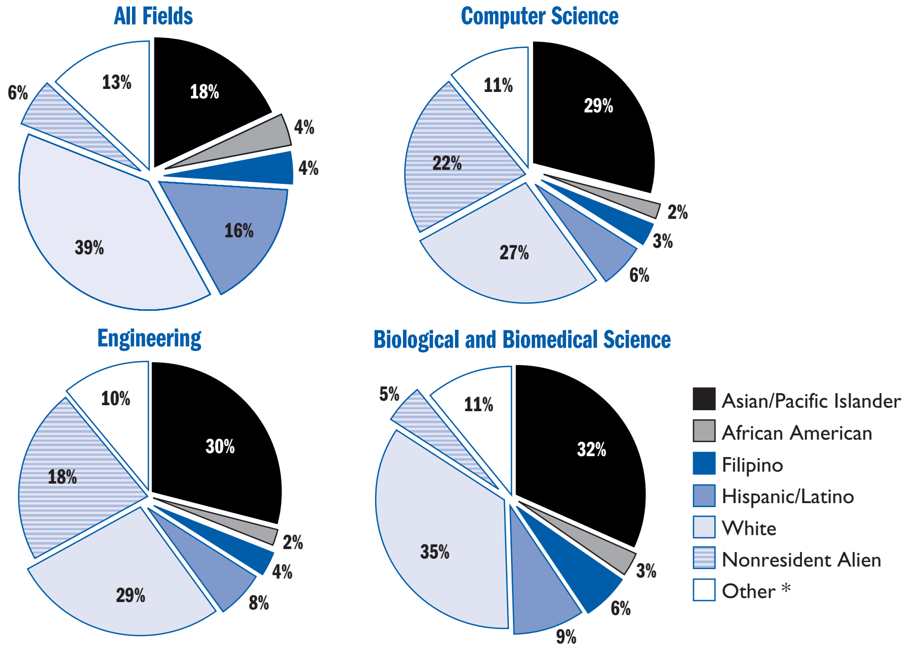
As Figure 15 shows, African American and Hispanic students at UC and CSU in 2006 each earned smaller shares of the bachelor's and graduate degrees awarded in computer science, engineering, and the biological and biomedical sciences than they earned in all fields as a whole. For example, Hispanic students earned 15.8% of the degrees granted in all fields, but only 9.3% in the biological and biomedical sciences. Similarly, African American students earned 4.0% of degrees in all fields, but 2.5% of degrees in the biological and biomedical sciences.

This was also true for white students. For example, Figure 15 shows that these students earned 39.1% of all bachelor's and graduate degrees conferred by UC and CSU in 2006, but only 27.2% in computer science and 28.5% in engineering. However, white students earned a greater proportion of bachelor's and graduate degrees in the biological and biomedical sciences than any other subgroup, as well as in all fields overall.

Asian and Pacific Islander students, on the other hand, earned greater proportions of the degrees granted in these three STEM fields in 2006 than they earned in all disciplines overall. As Figure 15 shows, Asian and Pacific Islander students earned 18.3% of all bachelor's and graduate degrees granted, but received 32.1% of degrees in the biological and biomedical sciences. These students earned a greater proportion of degrees in computer science and engineering than any other subgroup.

Figure 15 also shows that nonresident alien students received 6.2% of all the *figure 15* **Different student subgroups earned varying proportions of degrees granted in computer science, engineering, and the biological and biomedical sciences by UC and CSU in 2006**

Bachelor's and Graduate Degrees Granted by UC and CSU in All Fields and Select STEM Disciplines in 2006, by Subgroup

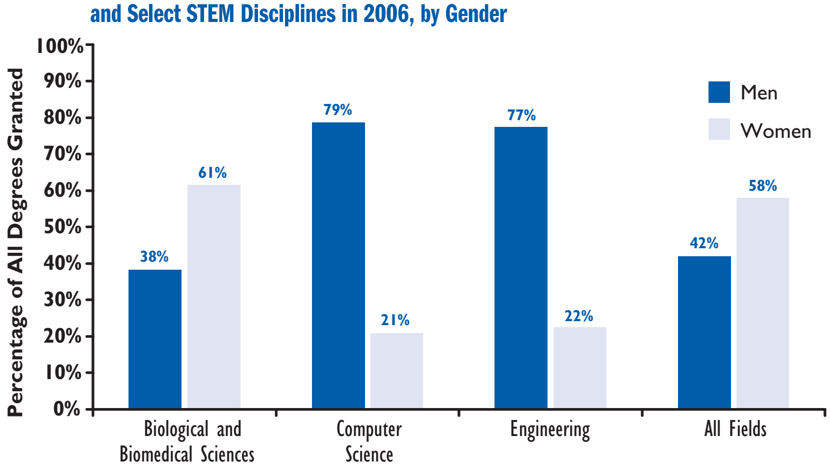


* Includes students who identified themselves as Native American or other, or who did not indicate an ethnicity.

DATA: CALIFORNIA POSTSECONDARY EDUCATION COMMISSION (CPEC) EDSOURCE 1/08

figure 16 **Women earned the majority of degrees in the biological and biomedical sciences and in all fields at UC and CSU in 2006, while men earned the majority of degrees in computer science and engineering**

Bachelor's and Graduate Degrees Granted by UC and CSU in All Fields and Select STEM Disciplines in 2006, by Gender



Since 2003 every significant subgroup has experienced an increase in the percentage of students who complete the course requirements for UC/CSU eligibility. The overall proportion of students who complete these requirements has increased only slightly, however.

DATA: CALIFORNIA POSTSECONDARY EDUCATION COMMISSION (CPEC) EDSOURCE 1/08

bachelor's and graduate degrees granted by UC and CSU in 2006, but were awarded 22.4% and 17.8% of the degrees granted in computer science and engineering, respectively. These students earned especially large proportions of the graduate degrees granted in these two fields. They received 14.6% of all graduate degrees awarded by UC and CSU in 2006, but 46% of graduate degrees in computer science and about 39% in engineering.

California is not alone in this regard. According to *Science and Engineering Indicators 2006,* published by the National Science Board (NSB), foreign students on temporary visas nationally earned 46% of master's degrees awarded in computer science and 41% in engineering in 2002. They also earned "43% to 44% of doctoral degrees awarded in mathematics, computer sciences, and agricultural sciences" in 2003, and 55% in engineering. These doctoral students were most likely to come from Asian nations such as China, Taiwan, India, and South Korea. The NSB notes that 74% of foreign science and engineering doctorate earners "with known plans" between 2000 and 2003 "intended to stay in the United States," with those in the physical sciences, computer sciences, and mathematics among the most likely to have firm plans to do so.

Examining this data by gender also reveals different rates of degree earning by men and women in computer science, engineering, and the biological and biomedical sciences. As Figure 16 shows, about 58% of all bachelor's and graduate degrees awarded in 2006 by UC and CSU were earned by women, compared to about 42% awarded to men. Women also earned a majority—slightly more than 60%—of degrees granted in the biological and biomedical sciences. By contrast, men earned almost eight in 10 degrees in computer science and engineering from UC and CSU that year. Women were awarded about 21% of the degrees granted in computer science. This proportion has been falling since 2002. The proportion of degrees earned by women in engineering has remained at or near 23% since 2004, and is greater than prior years.

Growing workforce needs and higher academic standards in K–12 pose challenges for California schools

The workforce and other projections discussed in this publication make clear that mathematics and science are important for California's economic future. A number of key math- and science-related occupations in California—including computer science, nursing, and teaching—are expected to be areas of high labor demand in coming years. As a result, California's K–12 and postsecondary education systems are under pressure to ramp up the number of people who are prepared to meet these workforce needs.

Math and science are also important for students' future prospects as adults. High quality math and science education can help provide California students with knowledge and skills that are crucial to their abilities to participate in the emerging opportunities that the changing California economy affords.

Math and science education, though closely connected in workforce discussions, are distinct in education policy

Policymakers, researchers, business leaders, and others—including this report—often discuss math and science education in the same breath. But state and federal policy approach these two subject areas differently, particularly before high school. In California's accountability system, competence in math (and English language arts) is considered fundamental to student success, and that priority is reflected in the student testing system. Elementary and middle school students take grade-level CSTs in mathematics every year between the 2nd and 8th grades. By contrast, grade-level CSTs in science are administered only in grades 5, 8, and 10.

Some worry high-stakes accountability in general—and NCLB in particular—has reduced the instructional time schools devote to science. One policy reaction to that concern in California is the current Reading/Language Arts Curriculum Framework, adopted by the State Board of Education in April 2006. It requires educators and publishers of instructional materials to address the state's science content standards simultaneously with the kindergarten through grade three English language arts standards. This K–3 curriculum integrates such science topics as the characteristics of plants and animals, or the properties of solids, liquids, and gases, with instruction in reading and language arts. California will adopt new reading and language arts curricula and instructional materials consistent with this framework in 2008.

Another key difference between science and math is the way the two subjects are taught in high school. Students in California are now all expected to take the same course, Algebra I, as a graduation requirement. The course also serves as the prerequisite for all other higher-level math courses, most notably geometry and Algebra II. This three-course sequence is widely accepted by postsecondary institutions—as well as by high schools—as the minimum math background students need for entry, and presumably success, in four-year universities.

The expectations regarding science course-taking are much less prescriptive in terms of state policy. Although students must take both a biological and physical science course in order to

California policymakers decided that all students must take Algebra I in part to increase the number of students—particularly low-income students— who could have access to a college-preparatory math and science curriculum.

Limitations of This Report

Ideally, a report on math and science education could answer the fundamental question of whether California is preparing enough math and science students to meet its future workforce needs. However, the answers are currently not clear-cut, in part because California has no public data system that follows groups of students from K–12 through postsecondary education. As a result, this report can offer illuminating but only partial snapshots of K–12 students' course-taking and achievement in math and science, and of how these relate to their paths after high school.

In addition, many important aspects of K–12 math and science education are not addressed in this report. For instance, this report does not investigate questions regarding instructional practice, nor does it explore the professional development of math and science teachers. Key issues in the recruitment, support, and retention of these teachers are discussed in a January 2008 EdSource policy brief, *Math and Science Teachers: Recruiting and Retaining California's Workforce.*

graduate from high school—and UC requires that those courses be lab-based—the state does not recommend a particular course sequence in science. State policy does not require that any particular science course be taken first as a prerequisite to other science courses, though many school districts have their own policies. This means that trends in both course enrollments and proficiency are more variable in high school science than they are in math.

Algebra I is no longer a gatekeeper, but neither is it a clear gateway

When California policymakers decided in 2000 that all students must take Algebra I in order to graduate from high school, they did so in part to increase the number of students—particularly low-income students—who could have access to a college-preparatory math and science curriculum.

Student enrollment patterns in high school math have changed since the policy became fully effective in 2004. Almost all high school students are taking Algebra I, frequently by 9th grade. Almost half are at least attempting the course in 8th grade, compared to just 16% 10 years ago. More students are also completing the high school math sequence, with a substantial portion accomplishing that by the end of 10th grade.

However, a large portion of the students who take Algebra I are not succeeding based on the state's proficiency data. Nor are all the students who take it going on to the next level, as evidenced by the drop in the percentage of students at each step along the math pipeline.

Universal access to Algebra I is undoubtedly improving students' opportunities to take advanced math, but the course is not yet a gateway through which all students pass successfully. The available data make it clear that students' math performance in the middle grades creates obstacles to success in Algebra I and beyond. Even though overall achievement has improved, students continue to lose ground between elementary school and 7th grade, and a substantial group of students enter high school already behind.

Achievement gaps also provide evidence of the continuing challenges. For instance, 24% of 10th graders in 2006–07 did not pass the math section of the CAHSEE on their first attempt. Hispanic/Latino, African American, and economically disadvantaged students, as well as students classified as English learners, fall disproportionately into this category. The mathematics section of the CAHSEE is based on the state's academic content standards for 6th and 7th grades. It also includes questions based on Algebra I, but students do not need to answer the algebra items correctly to pass the exam as long as they are successful on the other math questions.

The analyses of 2005–06 student records conducted by CDE also reveal interesting relationships between students' math and science enrollments. They indicate that students who had completed Algebra I and were taking geometry in 9th grade were more likely to take "college prep" science (i.e., biology) than their peers who took Algebra I in 9th grade. Science courses were even less likely to be "college prep" among those students who were not yet taking Algebra I by 9th grade. Because many higher-level science courses require a certain level of math proficiency, this is yet another way that early and successful completion of Algebra I appears to serve as a gateway to a more rigorous high school education.

Middle and high school guidance counselors, as well as those at community colleges, help students connect their future aspirations with their studies in math and science.

What stands in the way of improved student progress in math and science?

The workforce needs discussed in this report, as well as California's higher standards and expectations for K–12 math and science education, raise important questions about the capacity of California schools to improve student performance in these subjects.

One particular challenge is to ensure the state's capacity to provide quality instruction in these subjects. As noted earlier, research published in March 2007 by CCST and CFTL found that about one in 10 high school math and science teachers in California is underprepared (does not hold the proper credentials). This is a particular problem in low-performing schools. The researchers also note that California's expectation that Algebra I be taught in 8th grade means that middle school teachers must master increasingly specialized math in order to do their work effectively. The researchers project that California will need about 33,000 middle- and high-school math and science teachers over the next 10 years.

The preparation of math and science teachers is one area in which the instructional fortunes of K–12 schools depend strongly on initiatives undertaken at California's colleges and universities. The postsecondary sector plays an important role in providing the training, degrees, and certifications that qualify people to become teachers in these fields. New UC and CSU initiatives are aimed at increasing the number of math and science teachers that these institutions prepare. These initiatives—as well as key issues involved in recruiting and retaining middle- and high-school math and science teachers in California—are summarized in more detail in EdSource's January 2008 policy brief, *Math and Science Teachers: Recruiting and Retaining California's Workforce,* which accompanies this report.

In addition, many students and parents may not fully appreciate the growing relevance of math and science for life after K–12. A 2006 national survey by Public Agenda found that nearly half of the high school students surveyed would be "really unhappy" if they ended up working in an occupation that required "doing a lot of math and science." The study described a gap between, on the one hand, the feelings of high school families regarding the implications of math and science education for "their own personal lives" and, on the other, the urgency felt by business and other leaders.

Middle and high school guidance counselors, as well as those at community colleges, play an important role in this regard. Counselors help students connect their future aspirations with their school experiences—including their studies in math and science—and help them understand the work involved in achieving their goals. This is an area of special challenge for California, which in 2005–06 had the highest K–12 student-to-counselor ratio in the country (920:1), according to the National Center for Education Statistics (NCES). This is also an area of recent legislative activity. The passage of Assembly Bill (AB) 1802, the Middle and High School Supplemental Counseling Program, in July 2006 made $200 million available to California districts to hire an additional 3,000 counselors. Districts apply for the funds through the CDE. Data that might shed light on the bill's overall effects are not yet available, however.

What should be California's goals with regard to math and science education?

The education of a mathematically and scientifically literate citizenry is a valuable goal for California. In addition, in a society that is increasingly technological and in a state with an economy that depends so heavily on math- and science-related skills, these two subjects ought not to represent the kind of formidable barriers to young people that they have traditionally been. This is particularly true when these barriers further contribute to inequalities based on students' racial, socioeconomic, or gender backgrounds. More ambitiously, having the state's top students better versed in math and science before they enter college and more interested in career paths that coincide with the state's growing workforce needs are laudable goals.

Even jobs that don't require math and science on a daily basis likely require some knowledge of those subjects. Every student who leaves a California high school with a strong foundation in math and science will be better prepared for a wider range of opportunities than would otherwise be the case, including students who do not choose to pursue one of the STEM fields. The state's pursuit of that goal is appropriate and its policy actions are contributing to that goal. Increases in high school math and science enrollments and performance are positive developments. But while performance data indicate progress, they also make clear the magnitude of the challenge that California's schools continue to face as they attempt to prepare the state's current citizens for the workforce ahead.

To Learn More

For a summary of the issues involved in recruiting and retaining mathematics and science teachers in California, see EdSource's January 2008 policy brief, *Math and Science Teachers: Recruiting and Retaining California's Workforce:* **www.edsource.org/pub_abs_mathscience_teachers0108.cfm**

For a guide to help parents and students think about how math and science courses relate to their future options in the adult workplace, see EdSource's January 2008 student and parent guide, *Math and Science: Gateways to California's Fastest-growing Careers:* **www.edsource.org/pub_abs_mathscience_QA_0108.cfm**

The workforce projections discussed in this report are available from the California Employment Development Department (EDD) at: **www.labormarketinfo.edd.ca.gov**

For further discussion of California high school curricula and their relationship to postsecondary education, see EdSource's May 2007 publication, *Levers for Change:* **www.edsource.org/pub_abs_hs07.cfm**

The education of a mathematically and scientifically literate citizenry is a valuable goal for California.

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520 San Antonio Rd, Suite 200, Mountain View, CA 94040-1217 · 650/917-9481 · Fax: 650/917-9482 · edsource@edsource.org
www.edsource.org · www.californiaschoolfinance.org · www.ed-data.k12.ca.us