



INSTITUTE FOR HIGHER EDUCATION
LEADERSHIP & POLICY

TECHNICAL DIFFICULTIES: Meeting California's Workforce Needs in Science, Technology, Engineering, and Math (STEM) Fields

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Key Findings

STEM jobs are vital to the California economy, but a shortage of skilled workers may decrease the state's strength in STEM fields.

- California has historically benefited from a disproportionately large share of STEM jobs. On average, STEM occupations are higher paying than non-STEM occupations.
- The state faces a future in which there are too few workers skilled in STEM fields to meet the demand. Many STEM jobs require some postsecondary education and the state is currently producing too few graduates to meet projected demand.
- Health Care and Social Assistance and the Professional, Scientific, and Technical Services are the two industry sectors likely to be most affected by STEM skill shortages.

Employment demand in STEM fields is growing faster than employment demand in non-STEM fields.

- Keeping with recent trends, between 2006 and 2016, employment in STEM occupations is expected to grow faster than employment in non-STEM occupations.
- Growth in STEM employment demand is fueled by multiple factors including the increasingly knowledge-based economy and an aging population that will increase the need for health care workers. Job openings will be more difficult to fill because older workers, who are closer to retirement, are better educated than younger workers who will be taking their places.

The supply of STEM-educated workers is not keeping pace with demand.

- The number of degrees and certificates awarded in STEM fields is increasing more slowly than the number of degrees and certificates in non-STEM fields.
- Latinos are the fastest growing segment of the population but are underrepresented in college; moreover, a smaller share of Latinos who earn a college credential do so in a STEM field than white or Asian/Pacific Islander students. A smaller share of women who complete a college credential do so in a non-health care STEM field than is the case for men.
- National and international demand for STEM workers is increasing. In the future, California may no longer be able

to rely on the migration of skilled workers from other states and countries to help meet the demand.

- The state's financial difficulties will likely limit the production of STEM workers by California's educational institutions. Cuts in enrollment will result in fewer students able to attend college; some STEM programs may be disproportionately affected because of higher costs.

Not all STEM graduates become STEM employees.

- As in any field, not all people with a STEM education work in a related occupation. Some STEM graduates may not find employment in their field because some STEM fields have surpluses of workers, even while large shortages exist for others, or because graduates may not have the skills that employers expect. Also, some STEM graduates may choose not to work in STEM fields for a variety of reasons.

State lawmakers can take actions to help the state meet future STEM workforce needs:

1. Better preparation of students, particularly in math and science, would increase the number of STEM graduates by improving the success of students in postsecondary education and by fostering interest in STEM fields.
2. Improving communication about opportunities in STEM and creating clear pathways for students to follow through school to STEM careers would increase interest in and completion of STEM programs.
3. Creating financial incentives for students, colleges, and universities is another way to increase the supply of STEM workers.
4. Increasing STEM achievement by underrepresented groups is necessary to ensure that there are enough STEM workers.
5. Providing needed financial support for educational programs that are critical to meeting workforce needs would ensure the state's long-term prosperity.
6. Better coordination between industry and educational institutions is necessary to ensure that graduates have the skills necessary to succeed at STEM occupations of high need.
7. Encouraging people with STEM degrees to enter and remain employed in STEM fields is another means of meeting workforce needs.

California is Educating Too Few Students in Science, Technology, Engineering, and Mathematics

Education and training in science, technology, engineering, and mathematics (STEM) are vital to the California economy. Jobs that require an education in these areas tend to be higher paying and the innovation that results from having a workforce educated in these fields creates more employment opportunities for all workers.¹

It would be hard to overstate the importance of STEM education and employment for the prosperity of California. Known for its vibrant agricultural, technology, biotechnology, and aerospace industries, California historically has had a disproportionately high share of the nation’s STEM employment. A 2002 study found that while California’s share of national employment has hovered around 11% for several years, its share of employment in science and technology has ranged between 15% and 18% over the same period of time.² The state’s strength in STEM employment has provided its citizens with high paying jobs and a high standard of living (see Table A; median wages for selected occupations are shown in Appendix A). In view of the importance of STEM employment in California, the skills gap now facing the state in STEM fields is cause for concern.

Defining STEM Occupations

In this report we classified occupations as STEM occupations if they were either listed as a STEM occupation or a health science occupation on the Occupational Information Network (O*NET) website. O*NET is a comprehensive system developed by the U.S. Department of Labor to document occupational information.

Multiple studies have warned that California is facing a skills gap because too few Californians are earning college credentials to meet California’s workforce needs.³ In fact, a new report by the Public Policy Institute of California projects that between now and 2025, California will be short at least one million college educated workers.⁴ This is particularly true in STEM occupations, the majority of which require a postsecondary education. As a discomfoting example, California ranks near last in bachelor’s degrees conferred in

Table A
Hourly Wages in STEM Occupations are Higher than Wages in Non-STEM Occupations for Most Levels of Education¹

Minimum Education Required	STEM Wages	Non-STEM Wages
All Education Levels	\$30.66	\$20.49
Occupations Requiring Any Postsecondary Education	\$34.65	\$28.00
Postsecondary Vocational Education	\$22.72	\$19.99
Associate Degree	\$26.34	\$24.34
Bachelor’s Degree	\$39.71	\$32.15
Master’s Degree	\$32.19	\$26.10
Doctoral Degree	\$42.15	NA ²
First Professional	\$50.41	\$54.12

1. Wages are based on an average of median wages for STEM and non-STEM occupations.

2. There were not any non-STEM occupations requiring a doctoral degree with hourly wage information available.

Source: Authors’ calculations based on data from the California Employment Development Department’s Occupational Projections: 2006-16, the California Postsecondary Education Commission’s Custom Data Reports; U.S. Department of Labor, Occupational Information Network, Career Clusters; National Center for Education Statistics, Classification of Instructional Programs: 2000 Edition.

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Table B
California Confers Fewer Bachelor's Degrees than Other New Economy States

	Top Ten Highest Scoring States on the New Economy Index (2007) ¹	Bachelor's Degrees Conferred in Natural Sciences and Engineering per 1000 18-24 year olds (2005)
Massachusetts	96.1	12.2
Maryland	85.0	11.1
Colorado	78.3	11.1
New York	77.4	8.7
Virginia	79.5	8.4
Delaware	79.6	8.3
Washington	84.6	7.3
New Jersey	86.4	7.2
California	82.9	6.9
Connecticut	81.8	6.8

1. The new economy index is based on indicators that capture the degree to which economies are innovative, globalized, information based, and technology driven.

Sources: Atkinson, R. D. & Correa, D., K. (2007). *The 2007 state new economy index: Benchmarking economic transformation in the states*. Kansas City, MO and Washington, DC: Kauffman Foundation and The Information Technology & Innovation Foundation; National Science Board (2008). *Science and Engineering Indicators 2008. Two volumes*. Arlington, VA: National Science Foundation.

natural science and engineering among the top ten states identified in the New Economy Index as having economies that are innovative, globalized, information based, and technology driven (see Table B). Four components of the index on which California ranks particularly high are the number of independent inventor patents (1st), the number of initial public offerings (3rd), deployment of broadband communication (2nd), and the amount of venture capital investment (2nd). In contrast, three components on which the state ranks low are the use of technology in schools (48th), the share of the population online (34th), and the average educational attainment of recent migrants (33rd). Whereas today California has an economy that ranks highly among states in terms of its knowledge base, the state's lower standing in bachelor's degrees conferred in natural science and engineering suggests that it may fair less well in the future (see Appendix B for descriptions of initiatives to increase STEM education in four other states).

There are other indications of current and future shortages of

workers with a STEM education. For example:

- The high wages earned by STEM employees suggest greater employer demand for STEM workers than for non-STEM workers.
- California has fewer health care professionals per 100,000 people than the U.S. overall.⁵
- The California labor secretary expects a shortage of 25,000 technical workers over the next seven years.⁶

To better understand the outlook for California's STEM labor market, we identified the occupations facing potential shortages and the industries where these occupations are concentrated. To do this, we compared estimated annual job openings for STEM occupations (including new openings from job growth and openings from experienced workers leaving the occupation, retiring, or moving to a new geographic area) with the number of recent graduates

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Table C
Most STEM Occupations with Expected Shortages in California Require an Associate or Bachelor's Degree

Minimum Required Degree Level	Percent of Occupations with Shortages that Require each Degree Level	Average Annual Number of Job Openings 2006-2016
First Professional Degree	5.8	1,230
Doctoral Degree	7.7	1,570
Master's Degree	7.7	1,690
Bachelor's Degree	34.6	19,560
Associate Degree	36.5	18,460
Postsecondary Vocational Education	7.7	3,590
Total	100.0	46,100

Source: Authors' calculations based on data from: California Employment Development Department's Occupational Projections: 2006-16; California Postsecondary Education Commission's Custom Data Reports; U.S. Department of Labor, Occupational Information Network, Career Clusters; National Center for Education Statistics, Classification of Instructional Programs: 2000 Edition.

in relevant fields.⁷ This method allowed us to estimate shortages based on both demand information (the occupational projections) and available data on the supply of workers (recent numbers of graduates in fields related to occupations).⁸

According to the California Employment Development Department, there are 123 occupations requiring postsecondary education that we classified as STEM occupations using the O*NET taxonomy (see Defining STEM Occupations box on page 3). Of these occupations, nearly half are likely to have shortages. In fact, for occupations with projected shortages, approximately 90% more degrees or certificates in relevant STEM fields are required each year to meet projected demand.⁹ Of the occupations with expected shortages, about one-third requires at least an associate degree and another one-third requires at least a bachelor's degree (see Table C).

Not surprisingly, the industry sectors most heavily impacted by shortages in STEM occupations are Health Care and Social Assistance and Professional, Scientific, and Technical Services.

Figure 1 shows that one-third of the projected shortage of STEM workers is estimated to be in the Health Care and Social Assistance sector, with nearly another one-fourth projected

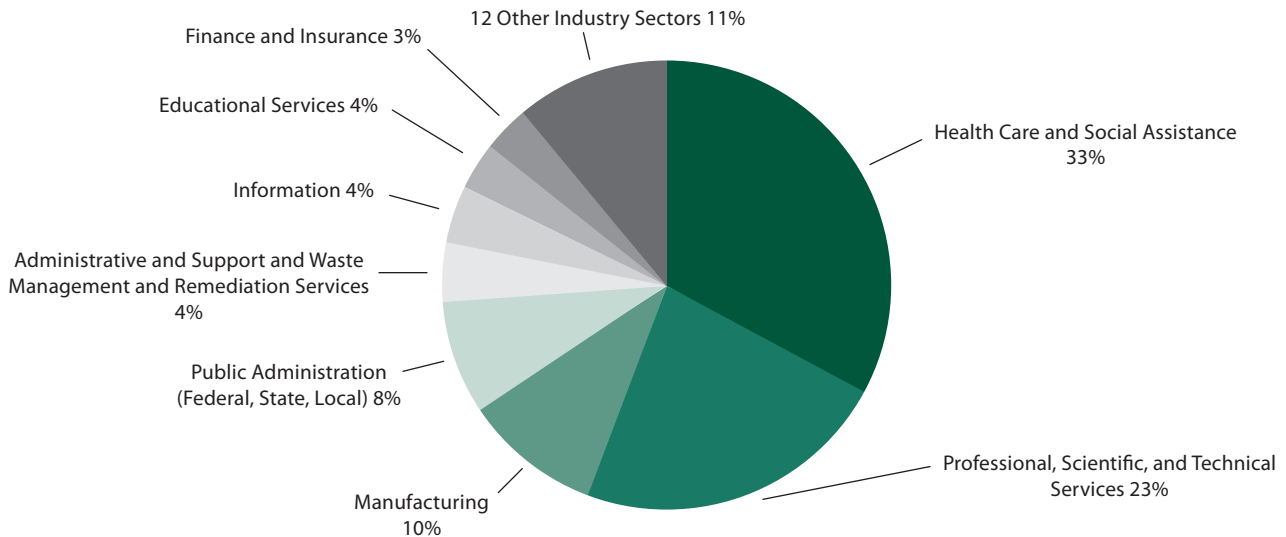
in the Professional, Scientific, and Technical Services sector.¹⁰ Figure 2 shows that these two industries will experience by far the greatest growth in occupations with projected shortages.

There is a diverse range of industries and STEM occupations classified in these two industry sectors. Industries in the Health Care and Social Assistance sector include Child Day Care Services, Community Care Facility for the Elderly, General Medical Surgical Hospitals, and Home Health Care Services. Many STEM workers from a variety of occupations such as accountants, computer programmers, and health care workers, are employed in these industries. Industries in the Professional, Scientific, and Technical Services sector include Accounting and Bookkeeping Services, Architectural Services, Engineering Services, Computer Systems Design and Relevant Services, Management Consulting Services, and Research and Development in Biotechnology. These industries also employ workers in a wide variety of STEM occupations such as operations research analysts, engineers, biochemists and biophysicists, graphic designers, and computer programmers.

The next two sections of this report describe the factors increasing the demand for future STEM workers and the factors constricting the supply of future STEM workers.

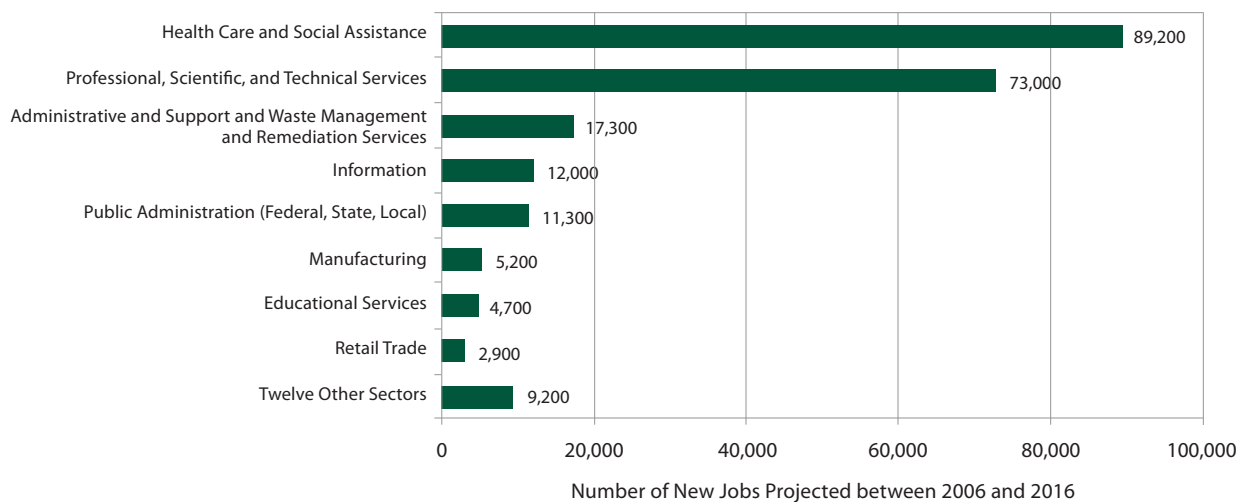
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Figure 1
Distribution of Annual STEM Job Shortfalls by Industry Sector: Largest Shares of Shortfall are in Health Care and Social Assistance and in Professional, Scientific, and Technical Services



Source: Authors' calculations based on data from: California Employment Development Department's Occupational Projections: 2006-16 and Industry and Occupation Matrix; California Postsecondary Education Commission's Custom Data Reports; U.S. Department of Labor, Occupational Information Network, Career Clusters; National Center for Education Statistics, Classification of Instructional Programs: 2000 Edition.

Figure 2
Most Employment Growth in Occupations with Shortages will be in the Health Care and Social Assistance and the Professional, Scientific, and Technical Services Sectors



Note: Employment growth only reflects new positions created from 2006-2016. The number of job openings due to replacements is not available for occupations within industries.

Source: Authors' calculations based on data from: California Employment Development Department's Occupational Projections: 2006-16 and Industry and Occupation Matrix; California Postsecondary Education Commission's Custom Data Reports; U.S. Department of Labor, Occupational Information Network, Career Clusters; National Center for Education Statistics, Classification of Instructional Programs: 2000 Edition.

The Demand for College Educated STEM Workers is Growing

Multiple factors are working to increase demand for a STEM educated labor force: (1) California's economy is becoming more knowledge based; (2) an aging population will increase demand for health care services; and (3) older, more educated workers will retire.

(1) California's Economy is becoming More Knowledge-Based

As California's economy is becoming more knowledge-based, STEM employment is increasing at a faster rate than non-STEM employment. Between 1999 and 2007, STEM employment increased by 25%, while non-STEM employment increased by 16% (see Figure 3). Furthermore, the California Employment Development Department projects that the number of STEM jobs will grow 20% between 2006 and 2016 whereas non-STEM jobs will grow by 14%.

(2) An Aging Population will Increase the Need for Health Care Workers

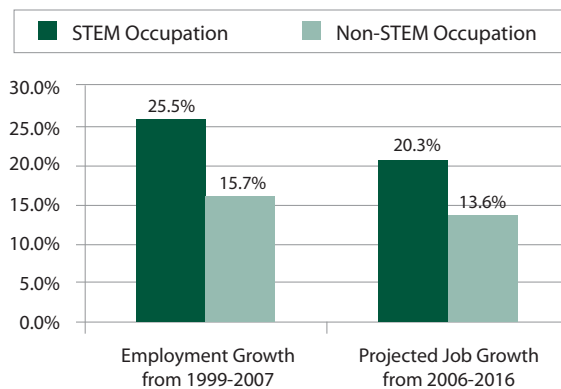
The size of California's population that is 65 or older is expected to grow from 4.1 million to 6.5 million between

2000 and 2020, and increase further to 10.4 million by 2040. By 2040 the median age of the population will have increased from 34.7 to 40.2. The impact of this population change alone will increase healthcare expenditures by 15%.¹¹ Further complicating the situation, the current health care workforce is aging and like all areas of the economy, large numbers of educated health care workers are expected to retire in the near future.¹² Undoubtedly, the state will need a larger health care workforce to provide adequate care to its aging population.

(3) Older, More Educated Workers will Retire

By one estimate, 2.4 million Californians will retire between 2006 and 2016.¹³ In comparison to younger Californians, a greater percentage of Californians approaching retirement age are white and better educated. Fifty-nine percent of Californians between ages 55 and 64 are white and 21% are Latino.¹⁴ In comparison, 43% of Californians age 25 to 54 are white and 37% are Latino. Older Californians are also more likely to have earned a college degree than younger Californians. Forty-two percent of Californians between ages 55 and 64 have earned at least an associate degree compared to 37% of Californians between 25 and 34 (see Figure 4). In contrast to California, the reverse trend is found for the US overall, where younger cohorts of citizens have higher levels of educational attainment than older cohorts (with the exception of the youngest age range).

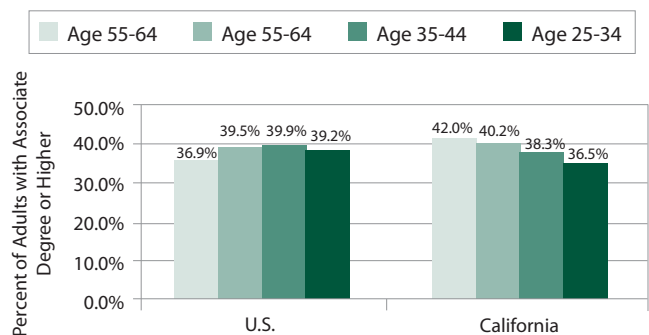
Figure 3
Growth in STEM Employment is Greater than Growth in Non-STEM Employment in California



Note: The Bureau of Labor Statistics notes that occupational comparisons over time should be made with caution because of changes to occupational definitions over the years, changes in the way data are collected, and changes to the reference period of the surveys.

Sources: Authors' calculation based on Bureau of Labor Statistics, U.S. Department of Labor, Occupational Employment and Wage Estimates; U.S. Department of Labor, Occupational Information Network, Career Clusters; National Center for Education Statistics, Classification of Instructional Programs: 2000 Edition.

Figure 4
Educational Attainment is Lower for Younger Cohorts of Californians than for Older Cohorts



Source: Organization for Economic Cooperation and Development, *Education at a Glance 2007*.

The Supply of College Educated STEM Workers is not Keeping Pace with Demand

In California, more than three-quarters of the expected job openings in STEM occupations between 2006 and 2016 will require some postsecondary education. Half of the expected job openings will require at least a bachelor's degree. On average, each year there will be approximately 46,100 job openings in STEM occupations that require a postsecondary education, including 24,000 jobs requiring at least a bachelor's degree, between 2006 and 2016.¹⁵ Clearly postsecondary education is critical to meeting the state's STEM workforce needs.

The majority of certificates, associate degrees, and bachelor's degrees awarded in the state are granted by the public systems: the California Community Colleges (CCC), the California State University (CSU), and the University of California (UC; see Figure 5).

Although each of the state's public education systems has an important role to play, arguably the largest role is played by the community colleges (see Table D). The CCC is the only segment that awards pre-baccalaureate certificates and associate degrees; 70% of students receiving associate or bachelor's degrees from the state's public colleges are either CCC students or UC/CSU students who transferred from the CCC.¹⁶

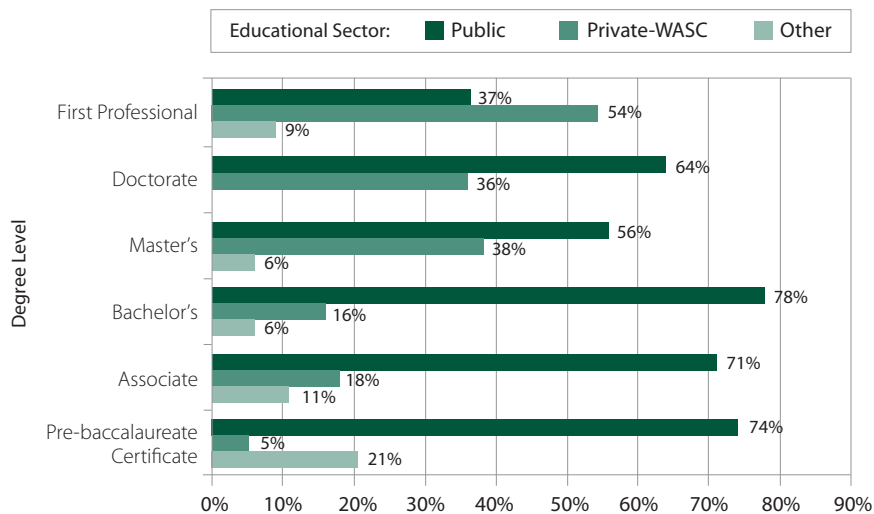
There are several factors limiting the supply of workers with STEM degrees in California: (1) stagnant production of

STEM degrees, (2) demographic changes, (3) increasing competition with other states and countries, and (4) budget cuts to higher education.

(1) The Number of STEM Degrees Awarded is Increasing More Slowly than Non-STEM Degrees

Although there has been an increase in the number of certificates and degrees awarded in STEM fields over the past ten years, these increases have not been as large as the increases in non-STEM fields (see Figures 6 and 7). The decline in the *share* of degrees and certificates awarded in STEM fields is particularly notable in the CCC, where the difference in the increase between STEM and non-STEM certificates and associate degrees exceeds 30 percentage points. The low rate of production of STEM certificates and associate degrees overall is driven primarily by stable or declining numbers of STEM degrees in non-health fields. In particular, the number of associate degrees and certificates declined in computer and information services and support services, as well as in engineering and engineering technology.¹⁷ These two educational fields are related to occupations that our analysis indicates will experience shortages in the number of workers with associate and bachelor's degrees (e.g., engineering technicians, computer software engineers, computer support

Figure 5
The Public Sector Awards the Majority of STEM Degrees at Most Levels



Note: Private-WASC institutions are private schools that are regionally accredited by the Western Association of Schools and Colleges.

Source: Authors' calculations based on 2007 data from the California Postsecondary Education Commission's Custom Data Reports.

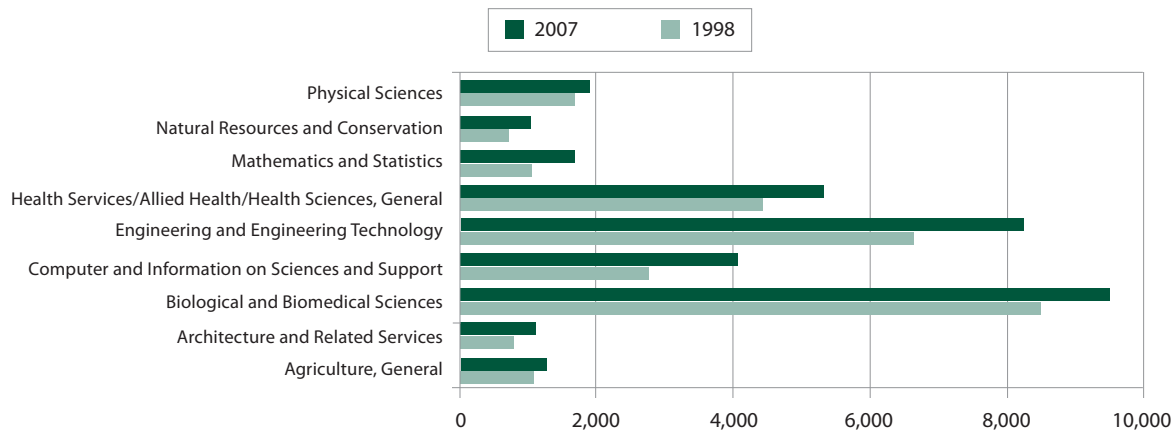
The Supply of College Educated STEM Workers is not Keeping Pace with Demand

Table D
The CCC Plays a Central Role in Postsecondary STEM Education

Degree Level	Relevant Systems	STEM Occupations with Largest Shortages
Postsecondary Vocational Education (Certificate)	CCC	Licensed Practical and Licensed Vocational Nurse, Surgical Technologists, Health Technologists and Technicians, Medical Transcriptionists
Associate Degree	CCC	Computer Support Specialists, Registered Nurses, Dental Hygienists, Biological Technicians, Medical Records and Health Information Technicians, Engineering Technicians
Bachelor's Degree	CCC (transfer), CSU, UC	Computer Software Engineers, Accountants/Auditors, Computer Systems Analysts, Industrial Engineers, Medical Laboratory Technologists
Master's Degree	CSU, UC	Mental Health and Substance Abuse Social Workers, Health Educators, Operations Research Analysts
Doctoral Degree	UC	Medical Scientists, Biochemists and Biophysicists
First Professional Degree	UC	Pharmacists, Surgeons

Source: Authors' calculations based on data from: California Employment Development Department's Occupational Projections: 2006-16; California Postsecondary Education Commission's Custom Data Reports; U.S. Department of Labor, Occupational Information Network, Career Clusters; National Center for Education Statistics, Classification of Instructional Programs: 2000 Edition.

Figure 6
The Largest Increases in the Number of Bachelor's Degrees between 1998 and 2007 were in Health, Computer and Information, Biological, and Engineering Fields



Source: Authors' calculations based on 2007 data from the California Postsecondary Education Commission's Custom Data Reports.

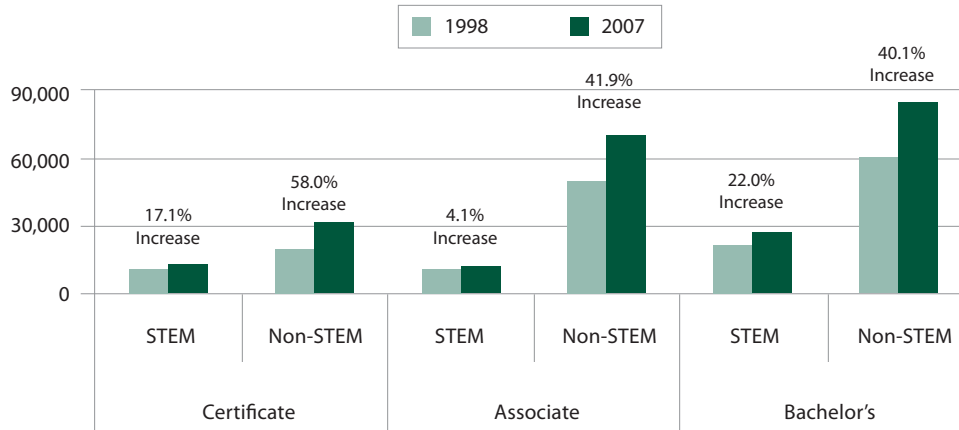
specialists). In contrast to non-health fields, certificates and associate degrees in health have increased 27% and 44% respectively.

No declines occurred in the number of bachelor's degrees in any STEM field between 1998 and 2007, and increases in degrees were less concentrated in health care than was

the case for associate degrees and certificates. The largest increases in the number of bachelor's degrees awarded in STEM fields by the CSU and UC from 1998 to 2007 were in engineering, health, computer and information sciences, and biology (see Figure 6). However, the pattern across these fields was not one of constant annual increase. The number of degrees awarded in computer and information

The Supply of College Educated STEM Workers is not Keeping Pace with Demand

Figure 7
The Number of Degrees and Certificates Awarded in STEM Fields Has Increased Less than in Non-STEM Fields in the CCC, CSU, and UC



Source: Authors' calculations based on the California Postsecondary Education Commission's Custom Data Reports.

sciences has declined each year since 2003. Degrees in health and biological fields declined from 1998 to 2003 and then increased through 2007. In percentage terms, the largest increase over the ten-year period was in Mathematics and Statistics (a 60% increase), but because of the smaller size of this field, the increased number of degrees (639) was lower than in other STEM fields.

The recent increases in the numbers of certificates, associate degrees, and bachelor's degrees in health care fields have probably occurred as a result of warnings of workforce shortages in these areas. However, although there have been gains in recent years in health care education, these gains have to be considered in the context of the large increases in demand expected in these fields, as discussed earlier in this report. Recent research still warns of shortages in health fields.¹⁸

(2) Ethnicity and Gender Differences Contribute to Growing Shortages of STEM Degrees

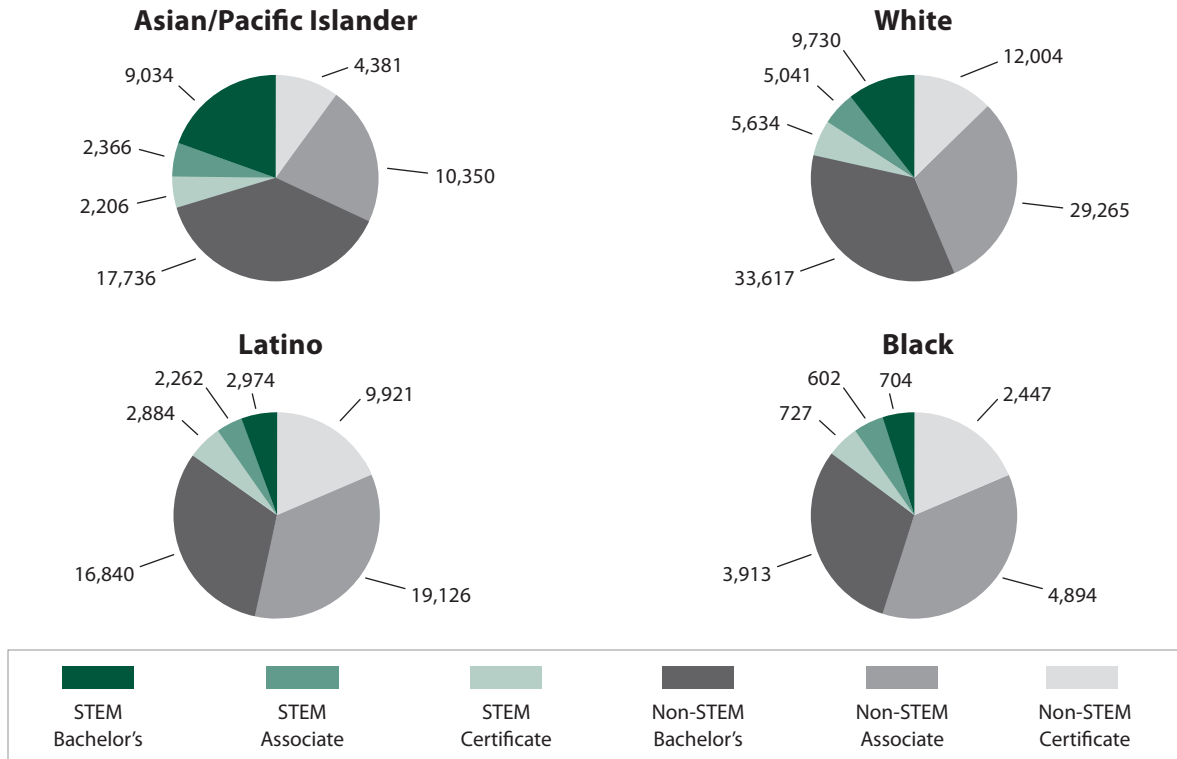
By 2021, the share of high school graduates who are Latino will increase over 12 percentage points.¹⁹ The growth of the Latino population may restrict the supply of STEM educated workers because Latinos have historically been less likely to enroll in and complete college than whites.²⁰ While Latinos make up 43% of the college age population,

they represent only 13%, 23%, and 30% of the students enrolled at the UC, CSU, and CCC respectively. Additionally, only 10% of Latinos in California over age 25 have a bachelor's degree compared to 47% and 38% for Asian/Pacific Islander and white Californians.²¹ In addition to lower college completion rates, a smaller percentage of the degrees awarded to Latinos were in STEM fields than was the case for whites or Asians/Pacific Islanders (see Figure 8). For example, only 15% of bachelor's degrees awarded to Latinos in 2007 were in STEM fields compared to 22% of degrees awarded to whites and 34% of degrees awarded to Asians/Pacific Islanders. If Latinos continue to earn fewer degrees and certificates in STEM fields, this will constrict the future supply of STEM workers as Latinos become an increasingly larger share of the workforce.

Gender differences in STEM education also limit the supply of STEM workers. Although women earned more bachelor's degrees in any field than men (57.8% of bachelor degrees in 2007 were awarded to women), a smaller proportion of degrees awarded to women were in STEM fields than was the case for men (see Figure 9). Women also earned more associate degrees and certificates in any field than men (62.5% of associate degrees and 53.9% of certificates in 2007 were awarded to women). In this case, a larger proportion of those

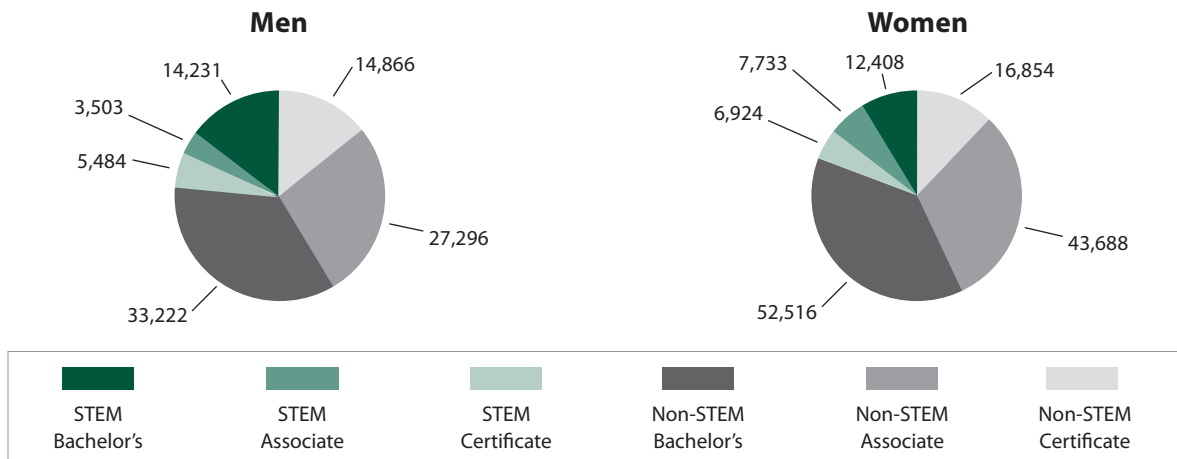
The Supply of College Educated STEM Workers is not Keeping Pace with Demand

Figure 8
Blacks and Latinos Earn a Smaller Share of STEM Bachelor's Degrees
Number of Degrees and Certificates that were Awarded in STEM and Non-STEM Fields for Each Racial/Ethnic Group in 2007



Source: Authors' calculations based on the California Postsecondary Education Commission's Custom Data Reports.

Figure 9
Women Earn a Smaller Share of STEM Bachelor's Degrees
Number of Degrees and Certificates that were Awarded in STEM and Non-STEM Fields for Men and Women in 2007



Source: Authors' calculations based on the California Postsecondary Education Commission's Custom Data Reports.

The Supply of College Educated STEM Workers is not Keeping Pace with Demand

associate degrees and certificates were in a STEM field compared to men. However, this gender difference is primarily explained by the larger number of women who earned awards in health fields. About 80% of the associate degrees and certificates awarded to women in STEM fields were in health fields compared to 41% of the associate degrees and 51% of the certificates in the case of men.

(3) National and International Competition for STEM Workers is Increasing

California has benefited from the migration of college educated people from other states and countries to the state.²² However, a recent report by the Public Policy Institute of California concluded that migration of college educated workers to California would have to increase dramatically to meet the expected demand, a prospect the authors consider unlikely.²³ National and global competition for STEM-trained workers will increase with growth in knowledge-based economies, making it less likely that California will continue to be able to import a skilled labor force.

(4) California's Financial Problems will Affect Education

The cuts to education that result from the current state budget shortfall are also likely to limit the size of the future STEM workforce. Currently, all three systems of higher education have to plan for substantial reductions in enrollment beginning in Fall 2009. Furthermore, the higher cost of education in some STEM fields such as health care courses and sciences requiring laboratory work may result in budget cuts disproportionately affecting STEM education.²⁴ Limiting enrollment at public sector institutions threatens the state's longer-term prosperity by reducing the education level of the future workforce.

Not all STEM Graduates Become STEM Employees

As in any field, not all college graduates in STEM fields enter and stay employed in the field they were trained for. This can occur because graduates are (1) unable to find STEM employment or (2) choose not to work in STEM occupations.

(1) Some Graduates Do Not Find Employment in STEM Fields

Some STEM graduates may not be employed in a STEM field because there is not a high demand for graduates of all STEM fields. Our analysis found several occupations with projected surpluses of workers. Similarly, in a presentation to the President's Council of Advisors on Science and Technology, Teitelbaum argued that shortages exist in some STEM fields simultaneously with surpluses in other fields.²⁵ Additionally, a 2002 report on California's science and engineering workforce found that wages and unemployment rates indicate that there may be a surplus of graduates holding master's degrees and doctorates in the biological sciences.²⁶

Another factor leading to non-STEM employment of STEM graduates is that not all STEM graduates are hired for jobs in STEM occupations. Despite their degree or certificate, some graduates lack skills sought by employers. Workforce shortages can occur despite a supply of graduates in STEM fields if employers find too few candidates with specific technical skills, or with strong "soft skills" such as communication or management skills, or if candidates lack sufficient experience. While some employer complaints may be based on unrealistic expectations, it is likely that not all college graduates are acquiring all of the skills necessary to perform well at work. For example, a recent report by the Carnegie Foundation for the Advancement of Teaching concluded that engineering graduates were unprepared for the workforce because of an over-emphasis on theory rather than application.²⁷

(2) Graduates May Choose Not to Work in STEM Fields

STEM graduates may choose not to enter or remain employed in STEM fields for a variety of reasons such as not being able to find desirable employment in their specific area of expertise, the fear of losing a job due to off-shoring, the potential for downward pressure on wages if government answers calls from the business community to increase the number of foreign worker visas, a change of interests, or finding higher wages in non-STEM fields. Notably, research on health care workers has found that multiple forces increase job separations including the high-pressure nature of the work, differences in employer and employee expectations for hours worked and other working conditions, and the inability of small and rural health care providers to pay market rates.²⁸

Conclusions and Recommendations for Meeting STEM Workforce Needs

The State is Producing Too Few Graduates to Meet STEM Workforce Demands

California has a strong employment base in STEM occupations and the state is projecting continued growth in these occupations. The generally high pay of STEM jobs makes them economically important to the state. STEM occupations enrich the state's tax base and offer the opportunity of well-paying employment to Californians. The state's public colleges and universities play a critical role in preparing the future STEM workforce. The majority of STEM jobs require a postsecondary education and most STEM degrees in California are awarded by the CCC, UC, and CSU. However, the state faces multiple challenges in developing the workforce needed to fill the projected growth in demand.

- Current rates of degree production indicate that the number of workers with the education necessary for STEM employment will fall short of demand.
- Increases in the number of degrees and certificates awarded in STEM fields between 1998 and 2007 have not been as large as awards in non-STEM fields.
- In the CCC, increases in the degrees awarded in STEM fields have been particularly concentrated in health fields. Despite the great importance of education in health fields in the CCC, increases are necessary in other fields as well, particularly because of the important transfer function served by the colleges.
- Latinos are the fastest growing segment of the population but Latinos are less likely to complete college and those Latinos who do complete earn a smaller share of their degrees and certificates in STEM fields than white and Asian/Pacific Islander students.
- Although more degrees are earned by women than by men, a smaller share of degrees earned by women are in non-Health STEM fields.

It is critical for the state to address these challenges in order to supply enough STEM educated graduates to meet its STEM workforce needs. Fortunately, these challenges are surmountable (see recommendations 1-5).

More STEM Graduates can be Employed in STEM Occupations

For a variety of reasons, not all STEM graduates are employed in STEM occupations. While it is very unlikely all STEM graduates will work in a STEM field, workforce shortages could potentially be eased somewhat through steps to increase the employment of STEM graduates in high demand STEM fields (see recommendations 6-7).

Recommendations

To overcome the challenges of insufficient STEM graduates and to better match STEM graduates with STEM employment opportunities, the state should develop a statewide public agenda for higher education. This agenda should focus on setting specific goals for meeting workforce needs in critical areas as part of enhanced planning for higher education. To meet these goals we offer the following recommendations:

1. Preparing students better, particularly in math and science, would increase the number of STEM graduates by improving the success of students in postsecondary education and by fostering interest in STEM fields.²⁹
 - Increase the capacity of teacher preparation programs and improve teacher professional development programs to better meet the increasing need for subject knowledge and pedagogical skill in science and math³⁰
 - Improve the alignment of K-16 standards so that students complete high school with the skills needed to succeed in college
 - Expand the use of early assessment in K-12 beyond CSU and those CCCs volunteering in the pilot early assessment project authorized by Senate Bill 946 (Chapter 473, Statutes of 2008)
 - Improve developmental education for underprepared students who enter the CCC and CSU with an interest in STEM fields, through adoption of models that integrate student support services and instruction
2. Improving communication about opportunities in STEM and creating clear pathways for students to follow through school to STEM careers would increase interest in and completion of STEM programs.

Conclusions and Recommendations for Meeting STEM Workforce Needs

- Improve counseling in K-12, CCC, CSU, and UC on STEM careers and what courses students need to prepare for those careers
 - Streamline the structure of pathways from K-12 and remedial education to certificates and degrees in STEM fields in community colleges through more comprehensive implementation of well-defined STEM career pathways
 - Consider the development of transfer associate degrees in certain STEM fields to improve the transfer pathways from CCC to CSU/UC; improvement in transfer could be particularly important to increasing the numbers of engineers³¹
 - Increase students' understanding of STEM occupations through guest lectures and industry field trips
 - Build linked data systems that report student enrollment by discipline and monitor student progress through STEM disciplines beginning in high schools
3. Creating financial incentives for students, colleges, and universities is another way to increase the supply of STEM workers.
- Create incentives for students who complete degrees in STEM fields and enter high need occupations, such as the nursing student loan assumption program for nursing faculty³²
 - Use incentives for colleges and universities to offer STEM programs and to graduate students from those programs, such as higher per-student funding in high-need STEM fields and supplemental funding per STEM graduate; such incentives would encourage colleges to offer sufficient sections of the courses that students need to enter and complete STEM disciplines in a timely manner
4. Increasing STEM achievement by underrepresented groups is necessary to ensure that there are enough STEM workers.
- Encourage the formation of student interest groups that appeal to women and minorities around STEM fields
 - Improve guidance counseling by increasing the numbers of counselors and providing counselors with professional development so that they can better identify students with interests in STEM fields and aptitude in math and science
5. Providing needed financial support for educational programs that are critical to meeting workforce needs would ensure the state's long-term prosperity.
- Maintain funding for students, colleges, and universities in times of financial crisis
 - Provide higher per-student funding for high-cost, high-need fields such as nursing and computer engineering
6. Better coordinating educational programs with industry needs to ensure that graduates have the skills necessary to succeed at STEM occupations of high need.
- Encourage partnerships leading to the development of programs in the specific fields where workers are needed
 - Solicit more input from industry advisors to guide curriculum content to ensure that students are learning the necessary skills in STEM programs for success in the workplace
 - Increase internship opportunities and other applied experiences for students
7. Encouraging people with STEM degrees to enter and remain employed in STEM fields is another means of meeting workforce needs.
- Create continuing education programs that allow individuals with backgrounds in science and mathematics to earn certificates or re-specialize in areas of high need
 - Recruit people with STEM degrees into teaching certification programs to meet the needed supply of teachers in STEM fields

Historically, California has benefited from a disproportionately high share of the nation's STEM employment. Today, however, the state is challenged with a potential skills gap that could diminish the state's capacity to generate, retain, and attract STEM jobs. Fortunately, this challenge is surmountable. Through changes to policy and practice, such as those recommended in this report, the state's public higher education institutions can educate and train sufficient numbers of students in high need fields to insure that STEM workforce needs are met.

Appendix A

Wages for Occupations with Largest Shortages for Each Degree Level

Minimum Education Requirement	STEM Occupations with the Largest Shortages	Median Hourly Wage (2008)	Percent Increase in Employment from 2006-2016
Certificate	Health Technologists and Technicians	\$19.83	22.1%
Certificate	Licensed Practical and Licensed Vocational Nurse	\$22.59	17.5%
Certificate	Medical Transcriptionists	\$19.44	10.7%
Certificate	Surgical Technologists	\$21.64	26.8%
Associate Degree	Biological Technicians	\$20.50	29.8%
Associate Degree	Computer Support Specialists	\$23.26	17.2%
Associate Degree	Dental Hygienists	\$41.71	35.7%
Associate Degree	Engineering Technicians	\$27.36	15.8%
Associate Degree	Medical Records and Health Information Technicians	\$15.98	19.0%
Associate Degree	Registered Nurses	\$37.71	25.0%
Bachelor's Degree	Accountants/Auditors	\$29.88	23.3%
Bachelor's Degree	Computer Software Engineers, Systems Software	\$48.40	28.2%
Bachelor's Degree	Computer Systems Analysts	\$37.32	28.2%
Bachelor's Degree	Industrial Engineers	\$39.57	27.3%
Bachelor's Degree	Medical Laboratory Technologists	\$34.57	16.3%
Master's Degree	Health Educators	\$19.45	24.2%
Master's Degree	Mental Health and Substance Abuse Social Workers	\$17.79	22.8%
Master's Degree	Operations Research Analysts	\$34.31	6.5%
Doctoral Degree	Biochemists and Biophysicists	\$42.93	24.4%
Doctoral Degree	Medical Scientists	\$37.80	26.6%
First Professional Degree	Pharmacists	\$57.17	26.1%
First Professional Degree	Surgeons	N/A	5.3%

Source: Authors' calculations based on data from the California Employment Development Department's Occupational Projections: 2006-16, the California Postsecondary Education Commission's Custom Data Reports; U.S. Department of Labor, Occupational Information Network, Career Clusters; National Center for Education Statistics, Classification of Instructional Programs: 2000 Edition.

Appendix B

Examples of Initiatives from Other States to Improve STEM Education

Massachusetts

Massachusetts STEM Pipeline Fund:

<http://www.mass.edu/forinstitutions/prek16/pipeline.asp>

Massachusetts STEM Scholar Internship Match Program:

<http://www.mass.edu/currentinit/currentinitscholarintern.asp>

Massachusetts State STEM Plan:

<http://www.massachusetts.edu/stem/stateplan.html>

Massachusetts developed two programs to increase the number of its citizens with a STEM education. The purpose of the first of these, the STEM Pipeline Fund, is to increase the number of students prepared for STEM careers, increase the number of STEM teachers, and to improve STEM education at public and private schools. The state is pursuing these goals through grants to fund a variety of projects at the state's schools, colleges, and universities and through regional PreK-16 networks that bring together education, business, and community organizations. Additionally, the state has created a STEM scholarship program that matches funds provided by corporate internships or scholarships. In 2008, the state adopted a state STEM plan to move the state towards a more systematic approach to STEM education.

Texas

Texas Science, Technology, Engineering and Mathematics Initiative

http://ritter.tea.state.tx.us/ed_init/sec/thsp/tstem.html

The Texas Science, Technology, Engineering and Mathematics Initiative (T-STEM) creates 35 high school academies focusing on STEM education, establishes a professional development center to improve STEM high school instruction, seeks to develop a network to foster the spread of successful STEM instruction methods, and promotes alignment between high schools, postsecondary institutions, and economic development activities.

Georgia

The Georgia Partnership for Reform in Science and Mathematics

<http://www.gaprism.org>

Georgia launched an initiative to improve STEM education called the Partnership for Reform in Science and Mathematics (PRISM). The focus is on science and math achievement in P-12 to increase levels of preparedness for postsecondary education and careers. The initiative has ten strategies for increasing math and science achievement such as increasing professional development to improve P-12 teaching quality, creating incentives for improved working conditions and teaching in math and science, and alignment of P-14 curriculum and standards in math and science.

Indiana

I-STEM Resource Network

<http://www.istemnetwork.org>

To improve STEM education, Indiana launched the I-STEM Resource Network. The network is a partnership between K-12, public and private postsecondary higher education institutions, government and business. It is focused on improving STEM education in K-12 through the use of professional development to improve K-12 teaching, increasing experiential learning opportunities for students, and to promoting STEM education throughout the state.

Notes

- ¹ Augustine, NR. (chair) (2005). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: National Academy Press.
- ² California Council on Science and Technology (2002). *Critical path analysis of California's S&T education system*. Sacramento, CA: Author.
- ³ For example, Shulock, N., Moore, C., Offenstien, J., & Kirlin, M. (2008). *It could happen: Unleashing the potential of California's Community Colleges to Help Students Succeed and California Thrive*. Sacramento, CA: Institute for Higher Education Leadership & Policy.; Reed, D. (2008). *California's future workforce. Will there be enough college graduates?* San Francisco, CA: Public Policy Institute of California.
- ⁴ Johnson, H. & Sengupta, R. (2009). *Closing the Gap. Meeting California's need for college graduates*. San Francisco, CA: Public Policy Institute of California.
- ⁵ Health Workforce Solutions (2007). *Closing the health workforce gap in California: The education Imperative*. Los Angeles, CA: The Campaign for College Opportunity.
- ⁶ Pitt, D. (2008). Technology worker shortage has businesses, educators worried. USA Today, Retrieved from http://www.usatoday.com/tech/techinvestor/industry/2008-06-22-worker-shortage_N.htm on January 27th, 2009.
- ⁷ To match the degrees produced each year to the occupational projections we used data on the number of degrees awarded in 2006 from the California Postsecondary Education Commission's Custom Data Reports and data on the estimated annual growth in occupations from the California Employment Development Department's California Occupational Projections: 2006-16. To match degrees to occupations we used a crosswalk provided by the National Center for Educational Statistics (<http://nces.ed.gov/pubs2002/cip2000/>, Retrieved October 2008).
- ⁸ Given the complexity of the labor market, this method has some limitations. It may underestimate or overestimate supply because some workers with the necessary skills will migrate to California from other states and nations and some workers with the necessary skills will leave the state. Additionally, because a degree in one field can qualify a person to work in multiple jobs, the method probably overestimates supply because the same degree is counted towards the supply for each related job. Similarly, the supply of the STEM educated workforce may also have been overestimated because some degrees qualify individuals to work in one or more STEM occupations and in one or more non-STEM occupations. For example, a bachelor's degree in Business Administration and Management, by far the most common bachelor's degree that qualifies individuals for one or more STEM occupations, also qualifies people to work in many non-STEM occupations. Thus, of the 21,685 bachelor's degrees awarded in Business Administration and Management in 2006, only a subset works in a STEM occupation.
- ⁹ To arrive at this number, we began with the list of occupations that we identified as having expected shortages. For these occupations we then created two pools: the projected annual number of job openings and the projected annual number of degrees. We created the pool of projected annual number of jobs by summing up the California Employment Development Department's projected annual number of job openings (i.e., new jobs plus net replacements) through 2016. We created the pool of projected annual number of degrees and certificates using the number of degrees awarded in 2006 and assuming that the number of degrees produced would grow 2.1% a year (consistent with growth in STEM degrees for the preceding ten years).
- Based on these calculations, the numbers of degrees and certificates would have to increase by 88% annually in order for the number of degrees and certificates produced to equal the number of expected job openings.
- ¹⁰ This projection assumes that shortages within STEM occupations will occur across sectors in the same proportion that sectors employ workers within each occupation. For example, if the Health Care sector employs 30 percent of all computer programmers, then we assume that 30 percent of the projected shortages in computer programmers will be in the Health Care sector.
- ¹¹ Kominski, G. F., Fielding, J. E., Hayes-Bautista, D. E., & van Meijgaard, J. (2007). *Forecasting the impact of an aging population on medical expenditures in California*. Los Angeles, CA: UCLA Health Forecasting Project.
- ¹² Health Workforce Solutions, 2007.
- ¹³ Center for the Continuing Study of the California Economy (2007). California's coming retirement wave. *Numbers in the News*, February 2007. Palo Alto, CA: Author.
- ¹⁴ U.S. Census Bureau (n.d.) American Community Survey 2007. Table retrieved March 11th, 2009 using American Fact Finder.
- ¹⁵ Authors' calculations using data from the California Employment Development Department's California Occupational Projections: 2006-16.
- ¹⁶ Shulock et al., 2008.
- ¹⁷ The number of associate degrees awarded in computer and information sciences and support services fell to 771 in 2007 from a ten-year peak of 1,712 in 2003. In engineering and engineering technology, the number of associate degrees fell to 587 degrees in 2007 from a ten-year peak of 1,206 in 1998. Similarly, 1,243 fewer certificates in computer and information sciences and support services were awarded in 2007 falling from a ten-year peak of 2,660 in 2002 and 764 fewer certificates were awarded in engineering and engineering technology in 2007 falling from a ten-year peak of 2,021 in 1998.
- ¹⁸ Health Workforce Solutions, 2007.
- ¹⁹ A recent report by the Western Interstate Commission for Higher Education found that the graduating class for the 2004-05 academic year was 39.6% white, 36.5% Latino, 14.1% Asian/Pacific Islander, and 7.5% black. By 2021-22, the authors project that the graduating class will be 48.6% Latino, 23.8% white, 17.6% Asian/Pacific Islander, and 5.1% black. Western Interstate Commission for Higher Education (2008). *Knocking at the college door: Projections of High School Graduates by State and Race/Ethnicity: 1992-2022*. Boulder, CO: Author.
- ²⁰ The National Center for Public Policy and Higher Education (2008). *Measuring up 2008- California*. San Jose, CA: Author
- ²¹ Moore, C. & Shulock, N. (2009). *The grades are in—2008: Is California higher education measuring up?* Sacramento, CA: Institute for Higher Education Leadership and Policy.
- ²² Johnson, H. P., & Reed, D. (2007, May). Can California import enough college graduates to meet workforce needs? *California Counts: Demographic Trends and Profiles*, 8(4). San Francisco: Public Policy Institute of California.
- ²³ Ibid.

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- ²⁴ Health Workforce Solutions, 2007.
- ²⁵ Teitelbaum, M. (2008, September 16). *Mysteries and misalignments: U.S. STEM workforce and education*. Presented at a meeting of the President's Council of Advisors on Science and Technology. <http://www.ostp.gov/galleries/PCAST/PCAST%20Sep.%202008%20Teitelbaum%20slides.pdf>. Retrieved January 26th, 2009.
- ²⁶ California Council on Science and Technology, 2002.
- ²⁷ Baskin, P. (2009). Engineering schools prove slow to change. *The Chronicle of Higher Education*, 55 (3), http://chronicle.com/weekly/v55/i21/21a00401.htm?utm_source=wb&utm_medium=en, Retrieved January 26th, 2009.
- ²⁸ Health Workforce Solutions, 2007
- ²⁹ Research on career choice has found that students' choice of occupations is based in part on their performance in related subjects in school (e.g., Lent, R.W., Lopez, F. G., & Bieschke, K. J. (1991). Mathematics Self-Efficacy: Sources and relation to science-based career choice. *Journal of Counseling Psychology*, 38, 424-430) .
- ³⁰ California Council on Science and Technology (2007). *Critical path analysis of California's science and mathematics teacher preparation system*. Sacramento, CA: Author.
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- ³² California Student Aid Commission. (N.D.) *State nursing assumption program of loans for education for nursing faculty (SNAPLE NF)*. Retrieved from <http://www.csac.ca.gov/doc.asp?id=1261>, January, 2009.



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