

U.S. Congress Joint Economic Committee

STEM Education:
Preparing for the Jobs of the Future

**A Report by the Joint Economic Committee Chairman's Staff
Senator Bob Casey, Chairman**

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The Value of STEM Skills in the 21st Century Economy

The United States has traditionally produced the world's top research scientists and engineers, leading to breakthrough advances in science and technology. This technological innovation has been a primary driver of U.S. economic growth, with studies showing that half or more of economic growth in the United States over the past fifty years is attributable to improved productivity resulting from innovation.¹ The late 20th century ushered in vast improvements in computer and information technologies, as well as biomedical technologies. These innovations are changing the way we live, work, and play in marvelous and unforeseen ways. Fully capturing the economic benefits of existing and undiscovered technologies will require a steady stream of Americans equipped with science, technology, engineering, and math (STEM) knowledge, skills, and abilities.

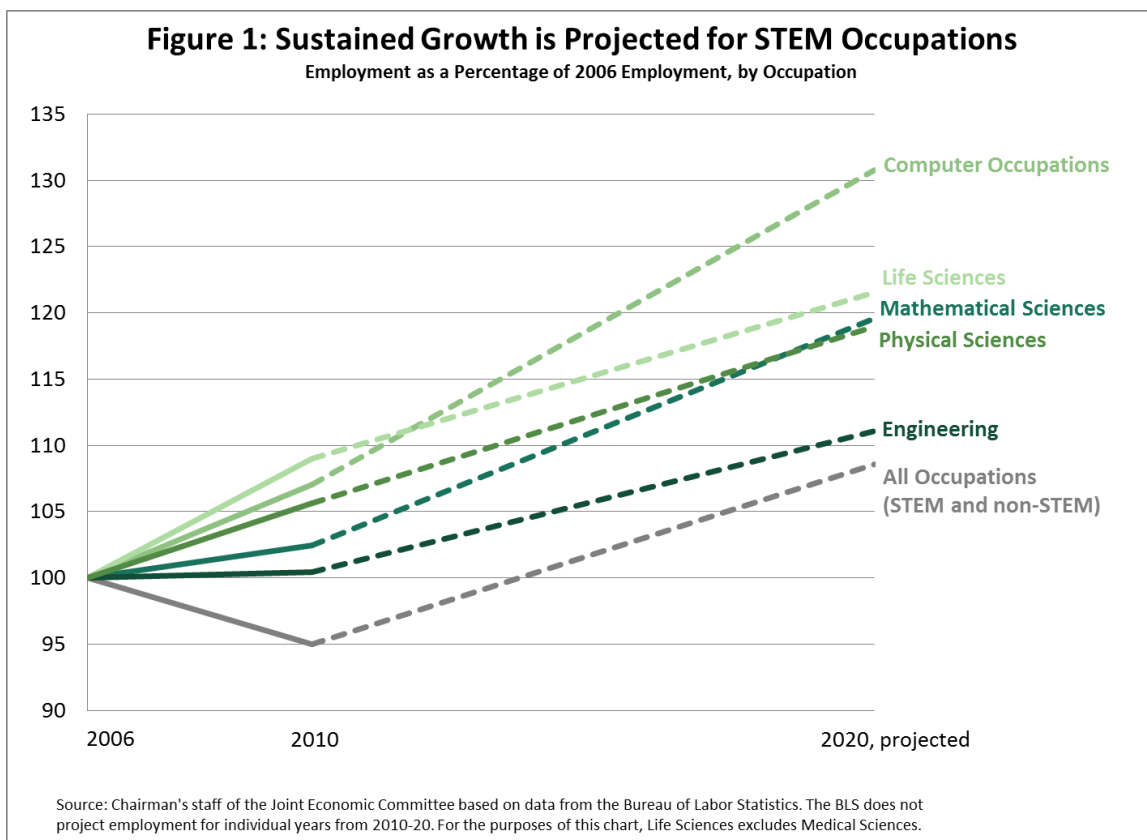
The need for workers with STEM skills is heightened in today's global economy. Technological innovation improves the competitive position of U.S. industries, drives export growth, and supports high-quality jobs.² Additionally, demand for STEM-capable workers has increased even in traditionally non-STEM fields due to the diffusion of technology across industries and occupations.³ Technological progress can improve workers' quality of life by improving working conditions and increasing wages. However, for workers to benefit from the economic gains generated by innovation, they must have the knowledge and skills needed to work effectively in jobs requiring STEM competencies.⁴ Improving access to quality STEM education will strengthen the caliber of the U.S. workforce, drive economic growth, and keep the U.S. competitive.

What is STEM?

The acronym STEM stands for science, technology, engineering, and math. However, there is some disagreement with regard to precisely which degrees and occupations fall into the category of STEM. In general, for the purposes of this report, we consider STEM to include life sciences (except medical sciences), physical sciences, mathematics and statistics, computing, and engineering. We do not include social sciences in our definition of STEM fields. However, sources referenced in this report have differing definitions of STEM. For example, the Department of Commerce includes certain STEM-related managerial occupations in its definition of STEM, and the OECD includes manufacturing and processing, and architecture and building. These differences in definitions across sources can complicate comparisons or analyses of trends in STEM.

Demand for Qualified STEM Workers Is Projected to Increase in the Future

While it is difficult to project trends in the labor market, the demand for STEM-skilled workers is expected to continue to increase in the future, as both the number and proportion of STEM jobs are projected to grow.⁵ New Bureau of Labor Statistics data show that employment in STEM occupations is expected to expand faster than employment in non-STEM occupations from 2010 to 2020 (by 17 versus 14 percent).⁶ While the projected difference between the STEM and non-STEM employment growth rates does not appear to be particularly dramatic, this small difference is due in large part to the Great Recession and the severe job losses concentrated in non-STEM occupations. (See **Figure 1.**) For example, while jobs in both construction and extraction and computer and mathematical occupations are expected to grow by over 20 percent over the course of the current decade, the employment growth in construction is a result of recovery from job losses over the past few years, while the projected growth in computing and mathematics is in addition to jobs gained in those occupations despite the recession.⁷



In addition to government projections of employment growth in STEM fields, business organizations and other groups have issued numerous reports and surveys that suggest that there is a heightening need for qualified STEM workers – both those with highly specialized skills as well as those with a more general knowledge of STEM concepts. For example, even at the height of

the recession, a survey of manufacturers found that over one-third were experiencing shortages of engineers and scientists – and most of them anticipated greater shortages in the future.⁸ In addition, an earlier survey found that over half of manufacturers believe that the public education system insufficiently prepares students with the math and science skills necessary to succeed in the workplace.⁹ Furthermore, concerns regarding shortages of skilled workers are compounded by the pending retirements of many baby boomers, an issue cited by both private industry and government officials.¹⁰

High Demand for STEM Workers Leads to Lower Levels of Unemployment and Higher Wages for Those Workers

Lower unemployment rates and higher relative wages in STEM occupations indicate the strong demand for STEM workers. The relative strength of the labor market for STEM workers pre-dated the recent recession, and it persisted during and after the recession. The STEM unemployment rate peaked at 5.5 percent in 2009, while the unemployment rate in non-STEM occupations was still climbing, reaching nearly 10 percent in 2010.¹¹ Employment in some STEM sectors has been particularly recession-proof, including computer and mathematical occupations, where the unemployment rate was 4.1 percent in 2011 – less than half of the overall unemployment rate of 8.9 percent.¹² The life, physical, and social sciences, and architecture and engineering occupations – which predominately consist of STEM workers – also had lower unemployment rates in 2011, of 3.8 percent and 5.1 percent, respectively.¹³

Employees in STEM occupations typically have higher average salaries than other workers. In 2010, STEM workers earned 26 percent more than non-STEM workers, even after accounting for other factors that affect pay, such as age, gender, race, location, industry, and union status.¹⁴ This so-called “STEM premium” is persistent and has grown over time – in 1994, the STEM premium was just 18 percent. While the size of this premium varies with education, it exists for all levels of education. The differential is greatest among workers with less than a bachelor’s degree, who make, on average, a bit over 30 percent more per hour than non-STEM workers with a similar level of education.¹⁵ Among more highly-educated individuals, bachelor’s degree recipients make about 23 percent more, and those with a graduate degree or higher earn 12 percent more than their counterparts in non-STEM occupations.¹⁶

The Supply of STEM Talent Is Not Keeping Up With Demand

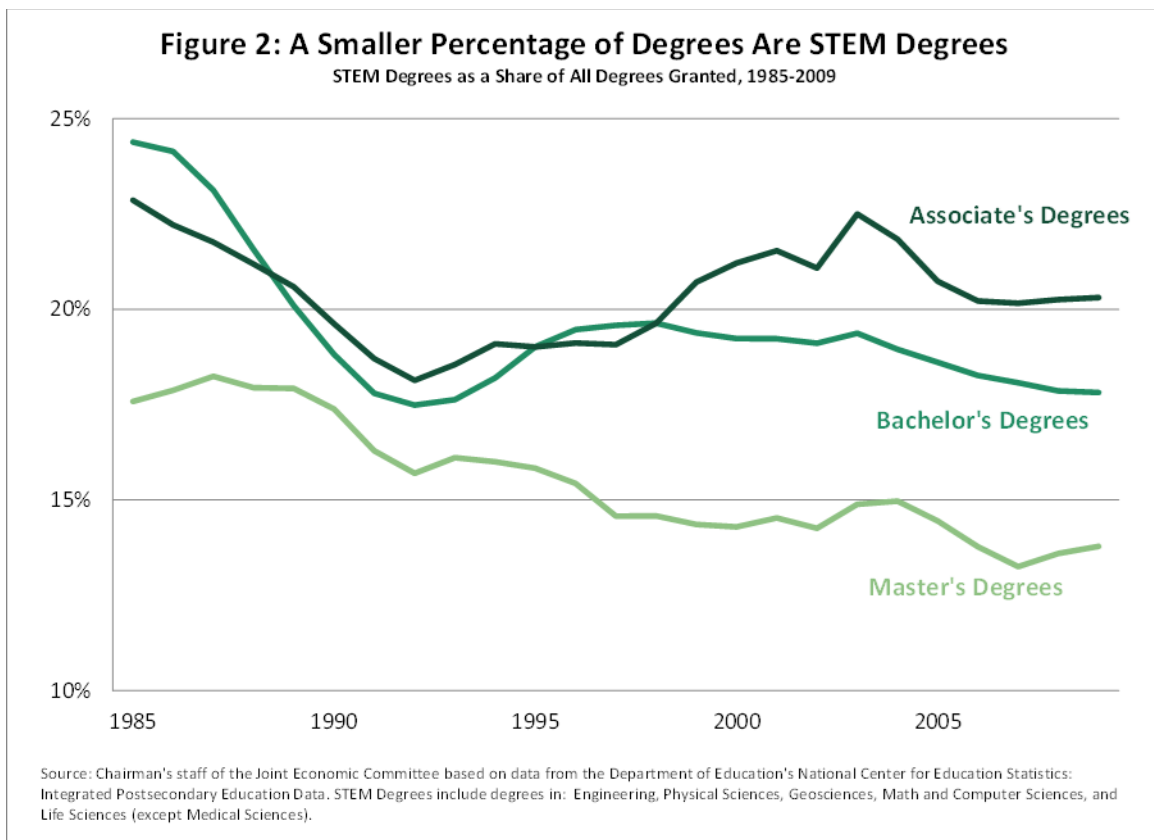
Despite the clear demand for STEM talent by domestic employers, the U.S. is failing to produce an ample supply of workers to meet the growing needs of both STEM and non-STEM employers. The existing STEM pipeline leaves too many students without access to quality STEM education, and without the interest and ability to obtain a degree or work in STEM. Current statistics on STEM

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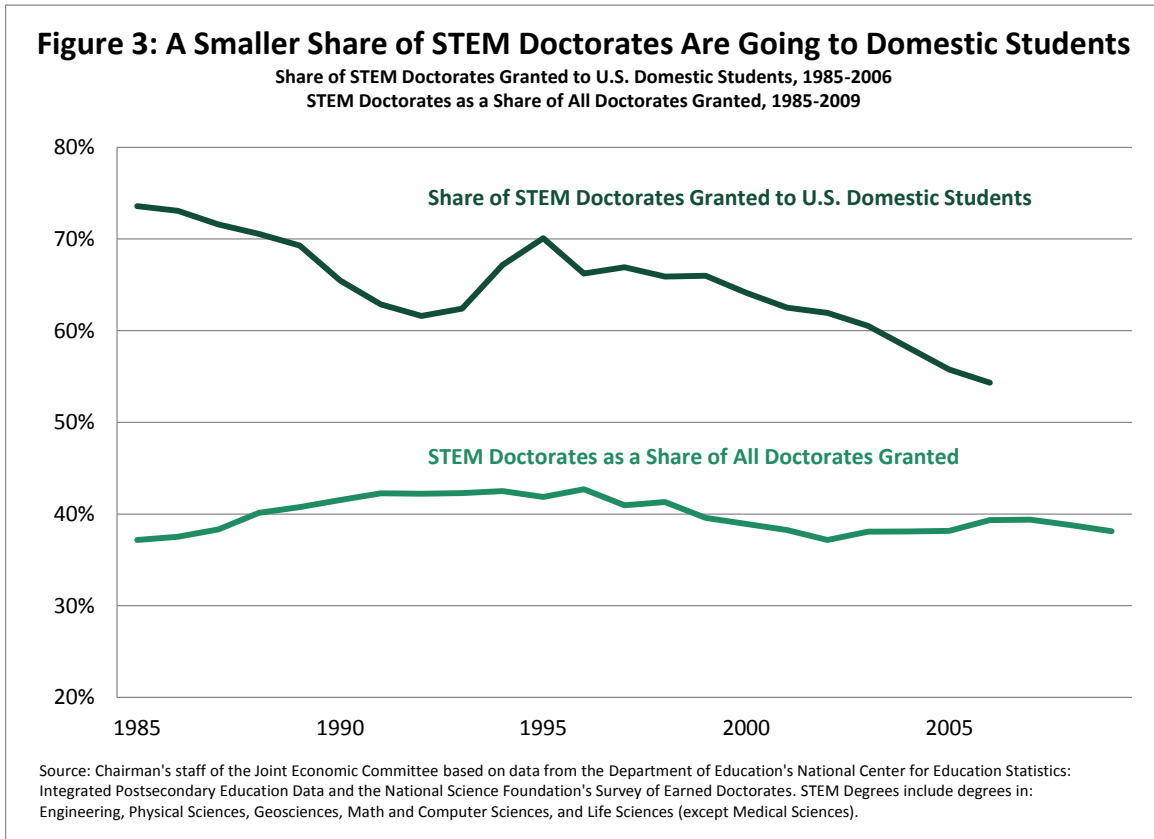
education in the U.S. highlight the challenge facing educators and policymakers, making it clear that the United States must do more to build a strong STEM workforce if it is to remain competitive in the global economy.

A Smaller Percentage of Students Are Pursuing Post-Secondary STEM Degrees

While the number of students receiving degrees from four-year institutions has increased in the U.S. as access to higher education has expanded over the past several decades, the share of students graduating with STEM degrees has declined. The share of bachelor's degrees awarded in STEM fields peaked at 24 percent in 1985; by 2009, the share had fallen to 18 percent.¹⁷ The share of master's degrees in STEM fields dropped from 18 percent to 14 percent over the same period.¹⁸ (See **Figure 2.**) However, the core competencies obtained by STEM graduates are increasingly in demand by non-STEM employers. This has led to a growing number of STEM graduates working in non-STEM fields – while STEM employers continue to cite a shortage of qualified workers.



The share of doctorates in STEM fields was more stable between 1985 and 2009.¹⁹ (See **Figure 3.**) However, the share of those degrees going to domestic students dropped from roughly three-fourths (74 percent) to a little more than half in 2006 (54 percent).²⁰ Foreign-born doctorates may take their expertise back to their home countries rather than filling the shortage of STEM workers.



Gender, Racial, and Ethnic Gaps Impact the Supply of STEM Workers

Of particular concern are the persistent STEM participation and achievement gaps across different demographic groups. In particular, women are less likely than men to pursue degrees in STEM, and black and Hispanic students are less likely than white students. If these disparities were corrected, the United States would be better able to fulfill the demand for STEM workers.

In 2009, women earned 57 percent of all bachelor's degrees awarded, up from 54 percent in 1993.²¹ However, at the same time, the share of bachelor's degrees awarded to women in mathematics and statistics declined by 4 percent and in computer science by 10 percent.²² Consequently, while women have comprised a growing share of the college-educated workforce,²³ their share of the STEM workforce has not increased.²⁴ Only 14 percent of engineers are women, as are just 27 percent of individuals working in computer science and math positions.²⁵ Women's increased participation in the STEM workforce is essential to alleviating the shortage of STEM workers.

There is a similar underrepresentation of Hispanic and black non-Hispanic workers in the STEM workforce. Each of these groups accounts for only six percent of STEM workers, but 14 and 11 percent of overall employment, respectively.²⁶ From 2000 to 2009, Hispanics as a share of the overall workforce increased by four percent, while their representation among STEM occupations increased by only one percent.²⁷ Non-Hispanic black workers increased as a percentage of the overall workforce by one percent over this time period, while their share of STEM workers held constant.²⁸ In part, this can be attributed to the lower college graduation rates among these groups and the education credentials required for many STEM jobs. However, among college graduates, Hispanics and black non-Hispanics are less likely to major in STEM fields, and, among STEM majors, individuals in these groups are less likely to ultimately end up in STEM jobs.²⁹

International Comparisons Suggest the U.S. Is Trailing in Developing a STEM Workforce

The United States is falling behind in international comparisons when it comes to providing an adequate supply of STEM workers. While we should be cautious in making international comparisons of countries which have dramatically varying sizes, diversity of populations, and industrial policies, the U.S. continues to fall behind key international competitors across a wide set of different measures of STEM preparedness.

While the U.S. produces by far the greatest number of STEM degree recipients among OECD countries (348,484 in 2008), adjusting for the overall number of degrees and for the population paints a different picture. By one measure – the share of students receiving degrees in STEM fields – the U.S. compares unfavorably with other global competitors. For example, NAFTA members Canada and Mexico, and many European nations including economic powerhouse Germany, graduate more STEM students as a share of all degrees than the United States does.³⁰ (See **Table** below.) This is also true when looking at STEM graduates as a share of the employed 25-34 year old population, where the U.S. ranks 23rd among OECD countries. American students' performance on international standardized tests suggests problems earlier in the STEM pipeline. For example, U.S. 15-year-olds rank 25th in math and 17th in science in PISA scores among OECD nations. As discussed below, other international comparisons as well as performance on domestic examinations suggest that problems in U.S. STEM education may begin as early as elementary school and continue through students' secondary and post-secondary education.

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STEM Education in an International Perspective

	Standardized Test Scores		STEM Graduates		
	Average PISA Math Score (15-year-olds) (2009)	Average PISA Science Score (15-year-olds) (2009)	STEM Graduates: Bachelor's Degree Equivalent (2008)	STEM Graduates as a Share of All Bachelor's Degree Equivalent Graduates (2008)	STEM Graduates per 100,000 employed 25-34 year-olds (2008)
United States	487	502	348,484	0.15	1,472
U.S. Rank in OECD ¹	T-25th	17th	1st	27th	23rd
OECD Average²	496	501	53,612	0.21	1,829
Remaining Top 15 OECD Countries (by nominal GDP)					
Australia	514	527	45,020	0.19	2,362
Canada	527	529	49,208	0.22	2,146
France	497	498	112,398	0.27	2,717
Germany	513	520	106,986	0.29	1,796
Italy	483	489	50,877	0.22	N/A
Japan	529	539	160,993	0.24	1,643
Korea, South	546	538	130,468	0.33	3,555
Mexico	419	416	97,410	0.25	1,085
Netherlands	526	522	17,372	0.14	1,039
Spain	483	488	51,309	0.24	1,488
Sweden	494	495	12,736	0.24	1,596
Switzerland	534	517	10,285	0.23	2,010
Turkey	445	454	50,911	0.18	1,536
United Kingdom	492	514	121,269	0.23	2,380

Sources: Chairman's staff of the Joint Economic Committee using data from the Programme on International Student Assessment (PISA), the Organisation for Economic Co-operation and Development (OECD), and the CIA World Factbook.

¹ The sources used for this table vary with regard to the number of OECD countries for which data is available. For the PISA scores, 34 countries are included. For the STEM graduates, STEM share of graduates, and STEM graduates as a share of the young workforce data, 30 countries are included.

² PISA provides OECD average test scores, and these are the averages listed in the table. The average number of STEM graduates was calculated by the Chairman's staff by taking the average of the 30 countries for which there is available data. The OECD average STEM share of degrees is calculated as the overall share of STEM degrees for the 30 countries (total STEM degrees as a share of total degrees). For the purposes of this chart, STEM degrees are defined as degrees in science (OECD educational category 400) and engineering, manufacturing, and construction (category 500), and bachelor's equivalent degrees are defined as Tertiary Type-A and Advanced Research Programs degrees. The OECD provides an OECD average figure for STEM graduates as a share of the young workforce, and this is the figure included above. The data for the last column are available at <http://dx.doi.org/10.1787/888932460192>.

Why Are We Falling Short in STEM?

There are a number of issues with the educational pipeline in the United States that can lead to a shortage of STEM professionals. Without a strong foundation in math and science from elementary and secondary school, students may find themselves unprepared to train for and pursue careers in STEM fields. However, science and technology curriculums are often thin in K-12 education, and may not be enough to provide students with a solid foundation in STEM upon which to build.³¹ Part of the problem is that it is challenging to attract and retain STEM-trained individuals to teach STEM subjects at the K-12 level when higher wages and employment opportunities outside of the education sector make working in a STEM profession an attractive alternative.³² Furthermore, while the quality of math and science teaching is the greatest factor in improving student achievement in STEM fields, not enough K-12 math and science teachers have hands-on experience working in STEM.³³ Teachers may also lack an educational background in STEM. For example, the National Science Foundation (NSF) found that 36 percent of middle school science teachers and approximately 30 percent of middle school math teachers lack in-field training.³⁴

In addition to improving the quality and quantity of STEM educators, a greater emphasis on communicating the benefits of STEM education to students is needed. College students may not have the information necessary regarding career prospects to make educated decisions in selecting a course of study.³⁵ Younger students may lack appropriate mentors, or there may be inadequate hands-on activities in the classroom to pique their interest. Having a mentor significantly influences students' decisions to pursue STEM degrees and occupations, especially for women and minorities.³⁶ Further, those with more opportunities to engage in STEM-related activities, such as science fairs, projects, and clubs, are more likely to go onto STEM careers and have accomplishments in STEM fields.³⁷ Finally, there is the matter of culture. While not easy to quantify, to the extent that math and science are not considered "cool" among image-conscious high school students, inevitably many talented young people will be turned off from pursuing degrees and careers in STEM fields. Women may be particularly unlikely to pursue STEM as a result of gender and cultural norms.³⁸

Inadequate STEM Achievement at the K-12 Level

Results on international tests suggest that there are deficiencies in the current education system. On the most recent Trends in International Mathematics and Science Study (TIMSS), from 2007, U.S. fourth grade students ranked eleventh in math and eighth in science out of 36 countries, and U.S. eighth grade students ranked ninth in math and eleventh in science out of students in 48 countries.³⁹ Scores on the 2009 Programme for International Student Assessment (PISA) test were more discouraging, as U.S. 15-year-olds ranked below students in 24 other OECD countries in math and 16 other OECD countries in science.⁴⁰ The poor results on the PISA examination are particularly problematic because, as the NSF notes, the PISA tests (in contrast to the TIMSS exams) "emphasize students' abilities to apply skills and information learned in school (or from life experiences) to solve problems or make decisions they may face at work or other

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circumstances.”⁴¹ Moreover, the World Economic Forum ranks the United States 48th in the world in quality of mathematics and science education.⁴²

Further, National Assessment of Educational Progress (NAEP) math scores have remained roughly level over the past decade, even after the No Child Left Behind Act sought to emphasize achievement as measured by standardized test scores in math and reading.⁴³ The 2011 NAEP math examination found that 60 percent of fourth-graders and 66 percent of eighth-graders were not proficient in math.⁴⁴ Eighteen percent and 28 percent, respectively, failed to score at even the basic level of competency.⁴⁵ In science, the most recent iteration of the NAEP examination (2009) found that 28 percent of fourth-graders, 37 percent of eighth-graders, and 40 percent of twelfth-graders did not meet basic standards of science knowledge.⁴⁶

The racial and ethnic gaps in STEM degree recipients and STEM workers correspond to achievement gaps on the NAEP math and science examinations, with white students outperforming black and Hispanic students by large margins on the fourth, eighth, and twelfth grade tests.⁴⁷ While these gaps have shown some movement toward closing in recent years, their persistence suggests that more work needs to be done to provide a broad cross-section of American students with the basic knowledge needed to pursue STEM.⁴⁸

Policies to Improve STEM Education

In order to reap the full gains to be had from technological innovation, the U.S. must employ a multifaceted approach to fostering an environment where innovation can flourish. Ultimately, improving STEM education and boosting the size and caliber of the STEM workforce in the United States will not be sufficient if research and development budgets are slashed or if proper incentives are not in place for businesses to invest in innovation. Thus, in considering policies to reduce deficits and debt, policymakers should take care to preserve funding for research and development, and to continue to support programs authorized under the *America COMPETES Act*. Additional policy actions could include making the research and development tax credit permanent, or passing further legislation to incentivize R&D, such as the *Life Sciences Jobs and Investment Act* (S. 1410).

Moreover, improving STEM education at the K-12 level and moving more young people into the STEM pipeline will not be enough if college is unaffordable or out of reach, or if the postsecondary education system more generally does not function effectively to take talented, STEM-interested young people and provide them with the degrees, certifications, and skills to succeed. This will require a continued commitment to maintaining Pell Grants and other federal supports for higher education, as well as a focus on career and technical education to provide young people with the opportunity to obtain STEM skills and certifications that prepare them for 21st century jobs, even if not culminating in a bachelor's or higher degree.

However, improving math and science education in our nation's elementary and secondary schools is a prerequisite to achieving the economic gains to be had from technological innovation and to improving the distribution of those gains. Unfortunately, education budgets have been under severe stress in the aftermath of the recession, with "at least 23 states [having] enacted identifiable, deep cuts in pre-kindergarten and/or K-12 spending."⁴⁹ Science may be more likely to be cut as funding becomes tight, since it is not tested under No Child Left Behind.⁵⁰ While policymakers should take care to reduce duplication and streamline programs when possible, significant cuts to federal education programs will undercut our ability to prepare our children to work and compete in the global economy.

In order to strengthen STEM education, policymakers should consider many of the recommendations included in recent reports on the topic. Just in the past two and a half years, these reports include the National Research Council's "A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas" and "Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics," the President's Council of Advisors on Science and Technology's "Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future," and the Information Technology & Innovation Foundation's "Refueling the U.S. Economy: Fresh Approaches to Science, Technology, Engineering, and Mathematics (STEM) Education."

Specific legislation currently under consideration that would enhance economic competitiveness by supporting K-12 STEM education includes:

- *Innovate America Act* (S. 239) – Directs the Secretary of Education to award grants to state educational agencies in order to expand STEM secondary schools (schools with a strategic focus and expanded curricular offerings in STEM) and requires the Director of the National Science Foundation to provide awards for colleges with dramatic increases in students getting STEM degrees.
- *Effective STEM Teaching and Learning Act of 2011* (S. 463) – Creates a program to provide competitive grants to states to improve preschool through grade 12 education in STEM, including bolstering professional development for STEM teachers and materials used in the STEM curriculum. It would permit states to use up to 20 percent of their grant for state-level STEM activities, including the development, implementation, or improvement of a comprehensive state STEM plan.
- *STEM 2 Act* (S. 619) – Directs the Secretary of Education to award competitive planning grants to states, Indian tribes or tribal organizations, nonprofit organizations, or institutions of higher education to develop effective STEM networks that coordinate STEM education efforts by (1) facilitating communication and collaboration among public and private STEM stakeholders, and (2) identifying STEM occupational skills needed in the future. It would also establish a competitive grant program for efforts to develop,

implement, and evaluate STEM education training programs for teachers and administrators at the K-12 level.

- *STEM Master Teacher Corps Act of 2011 (S. 758)* – Establishes a competitive matching grant program to support states and consortia of local educational agencies in creating a STEM Master Teachers Corps, which would provide specialized training and mentorship, and supplemental compensation, for select STEM teachers, with a focus on those in high-need public schools. The Corps members would then inform STEM education policy at the national, state, and local levels.
- *National STEM Education Tax Incentive for Teachers Act of 2011 (S. 1055)* – Allows certain STEM teachers to claim a refundable tax credit for the undergraduate tuition expenses they incurred in obtaining their degree, up to \$1,000 in any taxable year, for up to 10 years.
- *Computer Science Education Act of 2011 (S. 1614)* – Authorizes grants for states to develop plans to strengthen elementary and secondary computer science education; authorizes five-year implementation grants to states to carry out plans for developing computer science standards, curriculum and assessments, improving access to underserved populations, developing and offering teacher professional development, and developing online courses; and implements an independent evaluation of state programs to inform further efforts to expand and improve computer science education.
- *Preparing Students for Success in the Global Economy Act of 2011 (S. 1675)* – Allots formula grants to states and, through them, awards competitive subgrants to high-need local educational agencies to improve preschool and elementary and secondary school STEM education. It would require subgrants to be used for activities that include: (1) recruiting, supporting, evaluating, and training STEM teachers; (2) developing and improving high-quality STEM curricula and instructional supports to improve student achievement in those subjects; and (3) integrating STEM instruction with instruction in reading, English language arts, or other academic subjects.

A Note on STEM Data Sources

There are numerous sources of data on trends in STEM education and STEM occupations. The National Center for Education Statistics' Integrated Postsecondary Data System is the principal source for information on STEM bachelor's and master's degrees, while the National Science Foundation's (NSF) Survey of Earned Doctorates provides the most reliable data on STEM doctorates. Both of these sources are compiled in the NSF's online data system, WebCaspar. The OECD also compiles data on STEM degree completions. Standardized test score data is available for the U.S.-based National Assessment of Educational Progress and the international Trends in International Mathematics and Science Study and Programme for International Student Assessment exams. The Bureau of Labor Statistics publishes biennial estimates of projected employment growth across industries, including in STEM fields, and disseminates information on current unemployment rates and median salaries. This and related information on STEM occupations is collected through the BLS/Census Bureau's Current Population Survey.

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⁶ Chairman's Staff of the Joint Economic Committee. Calculations using data from the Bureau of Labor Statistics. "Employment Projections: 2010-20." Table 1.7 Occupational Employment and Job Openings Data, Projected 2010-20, and "Worker Characteristics, 2010." February 2012. Available at bls.gov/emp/. For the purposes of this calculation, STEM occupations are defined as in the U.S. Department of Commerce's Economics and Statistics Administration

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¹¹ U.S. Department of Commerce, Economics and Statistics Administration. “STEM: Good Jobs Now and for the Future.” ESA Issue Brief #03-11. July 2011. Available at esa.doc.gov/sites/default/files/reports/documents/stemfinalyuly14_1.pdf. The Department of Commerce defined STEM as including professional and technical support occupations in computer science and mathematics, engineering, and life and physical sciences, as well as certain related managerial occupations.

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¹⁶ *Ibid.*

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¹⁹ Chairman’s Staff of the Joint Economic Committee. Calculations using data from the National Science Foundation’s Division of Science Resources Statistics: Survey of Earned Doctorates. Available through the National Science Foundation’s WebCASPAR data system at webcaspar.nsf.gov/.

²⁰ *Ibid.*

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²¹ NCES IPEDS data, *supra* note 17.

²² *Ibid.*

²³ From 2000 to 2009, women as a share of all college-educated workers increased from 46 to 49 percent. *See* U.S. Department of Commerce, Economics and Statistics Administration. “Women in STEM: A Gender Gap to Innovation.” ESA Issue Brief #04-11. August 2011. Available at esa.doc.gov/sites/default/files/reports/documents/womeninstemmagaptoinnovation8311.pdf.

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