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Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer

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Summary

The term “STEM education” refers to teaching and learning in the fields of science, technology, engineering, and mathematics. It typically includes educational activities across all grade levels—from pre-school to post-doctorate—in both formal (e.g., classrooms) and informal (e.g., afterschool programs) settings. Federal policymakers have an active and enduring interest in STEM education and the topic is frequently raised in federal science, education, workforce, national security, and immigration policy debates. For example, more than 200 bills containing the term “science education” were introduced between the 100^{th} and 110^{th} congresses.

The United States is widely believed to perform poorly in STEM education. However, the data paint a complicated picture. By some measures, U.S. students appear to be doing quite well. For example, overall graduate enrollments in science and engineering (S&E) grew 35% over the last decade. Further, S&E enrollments for Hispanic/Latino, American Indian/Alaska Native, and African American students (all of whom are generally underrepresented in S&E) grew by 65%, 55%, and 50%, respectively. On the other hand, concerns remain about persistent academic achievement gaps between various demographic groups, STEM teacher quality, the rankings of U.S. students on international STEM assessments, foreign student enrollments and increased education attainment in other countries, and the ability of the U.S. STEM education system to meet domestic demand for STEM labor.

Various attempts to assess the federal STEM education effort have produced different estimates of its scope and scale. Analysts have identified between 105 and 252 STEM education programs or activities at 13 to 15 federal agencies. Annual federal appropriations for STEM education are typically in the range of $2.8 billion to $3.4 billion. All published inventories identify the Department of Education, National Science Foundation, and Health and Human Services as key agencies in the federal effort. Over half of federal STEM education funding is intended to serve the needs of postsecondary schools and students; the remainder goes to efforts at the kindergarten-through-Grade 12 level. Much of the funding for post-secondary students is in the form of financial aid.

Federal STEM education policy concerns center on issues that relate to STEM education as a whole—such as governance of the federal effort and broadening participation of underrepresented populations—as well as those that are specific to STEM education at the elementary, secondary, and postsecondary levels. Governance concerns focus on perceived duplication and lack of coordination in the federal effort; broadening participation concerns tend to highlight achievement gaps between various demographic groups. Analysts suggest a variety of policy proposals in elementary, secondary, and postsecondary STEM education. At the K-12 level, these include proposals to address teacher quality, accountability, and standards. At the post-secondary level, proposals center on efforts to remediate and retain students in STEM majors.

This report is intended to serve as a primer for outlining existing STEM education policy issues and programs. It includes assessments of the federal STEM education effort and the condition of STEM education in the United States, as well as an analysis of several of the policy issues central to the contemporary federal conversation about STEM education. **Appendix A** contains frequently cited data and sources and **Appendix B** includes a selection of major STEM-related acts.

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Introduction

The term "STEM education" refers to teaching and learning in the fields of science, technology, engineering, and mathematics. It typically includes educational activities across all grade levels—from pre-school to post-doctorate—in both formal (e.g., classrooms) and informal (e.g., afterschool programs) settings. Federal policymakers have an active and enduring interest in STEM education and the topic is frequently raised in federal science, education, workforce, national security, and immigration policy debates. The purpose of this report is to put various legislative and executive branch STEM education-related policy proposals into a useful context.

Although many observers cite the launch of the Soviet Union's Sputnik satellite in the 1950s as a key turning point for STEM education policy in the United States, federal interest in scientific and technological literacy writ large is longstanding and dates to at least the first Congress.[1] For example, in the first State of the Union address President George Washington called upon Congress to promote scientific knowledge for the sake of the republic and the polity, saying

> Nor am I less persuaded that you will agree with me in opinion that there is nothing which can better deserve your patronage than the promotion of science and literature. Knowledge is in every country the surest basis of public happiness. In one in which the measures of government receive their impressions so immediately from the sense of the community as in ours it is proportionably [sic] essential.[2]

More recent concerns about scientific and technological literacy in the United States focus on the relationship between STEM education and national prosperity and power. Since World War II, the United States has benefitted from economic and military advances made possible, in part, by a highly skilled STEM workforce. However, today the economic and social benefits of scientific thinking and STEM education are widely believed to have broad application for workers in both STEM and non-STEM occupations.[3] As such, many contemporary policymakers consider widespread STEM literacy, as well as specific STEM expertise, to be critical human capital competencies for a 21st century economy.[4]

The primary domestic source of STEM labor in the United States is the education system.[5] Federal legislators have paid close attention the STEM-related outputs of that system—such as

[1] Earlier examples include debate at the Constitutional Convention about whether to empower the federal government "to establish seminaries for the promotion of literature and the arts and sciences." James Madison, "Saturday, August 18," *Notes of Debates in the Federal Convention of 1787*, TeachingAmericanHistory.org website.

[2] U.S. President George Washington, *First Annual Message to Congress on the State of the Union, January 8, 1790*, The American Presidency Project website.

[3] The term "scientific thinking" has many definitions. In general, it refers to the skills, processes, and methods of science (broadly defined).

[4] Although a global competitiveness rationale drives much of the contemporary debate about STEM education policies, STEM illiteracy (particularly innumeracy) has also been linked to other national challenges such as the mortgage crisis and even medication errors. For example, see Kristopher Gerardi et al., *Financial Literary and Subprime Mortgage Delinquency: Evidence from a Survey Matched to Administrative Data*, Working Paper 2010-10, Federal Reserve Bank of Atlanta, April 2010; and Robert Preidt, "Parents' Poor Math Skills May = Medication Errors," National Institutes of Health, U.S. National Library of Medicine, Medline Plus website, April 30, 2012.

[5] Another source of STEM labor in the United States is immigration. For more information about foreign STEM workers, see CRS Report R42530, *Immigration of Foreign Nationals with Science, Technology, Engineering, and Mathematics (STEM) Degrees*, by Ruth Ellen Wasem.

the number of college graduates with degrees in STEM fields or the performance of U.S. students on international mathematics tests—and have sought to increase its functioning and capacity though federal policy and investments. For example, over 225 bills containing the term "science education" were introduced in the 20 years between the 102nd (1991-1992) and 112th (2011-2012) congresses. Agency reauthorization bills often contain STEM education-related provisions and at least 13 federal agencies conduct STEM education programs or activities. The federal investment in STEM education programs is estimated at between $2.8 billion and $3.4 billion annually.[6]

Congressional interest in STEM education heightened in 2007 when the National Academies published a report titled *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*.[10] This influential publication warned federal policymakers that perceived weaknesses in the existing U.S. STEM education system—along with other important factors—threatened national prosperity and power. Although some analysts disputed its assertions, the report helped focus the federal conversation about STEM education and led, in part, to passage of the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act (or America COMPETES Act). Among other things, that act authorized STEM education programs at the National Science Foundation (NSF), National Oceanic and Atmospheric Administration (NOAA), Department of Energy (DOE), and Department of Education (ED).

What Is STEM?

Whether it is visas for foreign workers, scholarships for STEM majors, or funding for scientific research, the question of what we mean by the term "STEM" is central to the federal policy conversation. Some federal agencies, such as the NSF, use a broader definition of STEM that includes psychology and the social sciences (e.g., political science, economics) as well as the so-called core sciences and engineering (e.g., physics, chemistry, mathematics).[7] Others, including the Department of Homeland Security (DHS), U.S. Immigration and Customs Enforcement (ICE), use a narrower definition that generally excludes social sciences and focuses on mathematics, chemistry, physics, computer and information sciences, and engineering.[8] Some analysts argue that field-specific definitions such as these are too static and that definitions of STEM should focus on "an assemblage of practices and processes that transcend disciplinary lines and from which knowledge and learning of a particular kind emerges."[9]

Congress reauthorized the America COMPETES Act in 2010 (P.L. 111-358), thereby advancing it to the implementation phase of the policy cycle. Congress may opt to reauthorize the act in 2013, when many of its provisions will expire. In the meantime the federal conversation about STEM

6 This is a rough estimate. The limitations of this calculation are explained in the section on "The Federal Effort in STEM Education."

7 The America COMPETES Act of 2010 defines the term STEM for the agencies it authorizes, including the NSF. As defined by P.L. 111-358, Section 2, the term STEM means "the academic and professional disciplines of science, technology, engineering, and mathematics." In practice, NSF funds research in the so-called core sciences (e.g., mathematics and physical sciences) and engineering as well as psychology and the social sciences.

8 While the DHS definition of a STEM field is, in general, more narrow than that of the NSF, DHS announced in May 2012 that it was expanding the list of fields it would support to include pharmaceutical sciences, econometrics, quantitative economics, and others. U.S. Department of Homeland Security, "DHS Announces Expanded List of STEM Degrees," press release, May 11, 2012. See also, U.S. Department of Homeland Security, Immigration and Customs and Enforcement, *STEM-Designated Degree Program List: 2012 Revised List*, 2012.

9 Jean Moon and Susan Rundell Singer, "Bringing STEM into Focus," *Education Week*, vol. 31, no. 19 (February 1, 2012), pp. 32, 24.

10 National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, and Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academies Press, 2007).

education continues in the budget and appropriations processes and in the various STEM education-related bills introduced each year.

Given policymakers' ongoing interest in establishing the scope and scale of federal STEM education effort, the first section of this report examines federal agencies, programs, and funding for STEM education. The second section examines the performance of the U.S. STEM education system and includes data and sources frequently cited in federal STEM education policy debates. The third section analyzes various STEM education policy issues and options, including those that relate to STEM education as a whole and those that are specific to the kindergarten-through-grade-12 (K-12) and higher education systems. **Appendix A** and **Appendix B** contain links to sources of STEM education data and publications and to selected major legislation in federal STEM education policy history.

The Federal Effort in STEM Education

At the request of Congress, four inventories of federal STEM education programs and activities have been published in recent years; two by the Government Accountability Office (GAO), one by the Academic Competitiveness Council (ACC),[11] and one by the National Science and Technology Council (NSTC).[12] The first GAO study, in 2005, found 207 distinct federal STEM education programs funded at about $2.8 billion in FY2004 (hereinafter this report is referred to as "GAO-2005").[13] In 2007, the ACC found 105 STEM education programs funded at about $3.1 billion in FY2006 (hereinafter this report is referred to as "ACC-2007").[14] A 2011 report by the NSTC identified 252 "distinct investments" in STEM education funded at about $3.4 billion in FY2010 (hereinafter this report is referred to as "NSTC-2011").[15] A second GAO study, published in 2012, reported 209 programs funded at about $3.1 billion in FY2010 (hereinafter this report is referred to as "GAO-2012").[16]

The discrepancies between these inventories indicate that establishing the federal effort in STEM education is complex and subject to methodological challenges. Differences between the inventories are due, in part, to the lack of a common definition of what constitutes a STEM education program or activity. Auditors have also found STEM education activities performed by science mission agencies difficult to capture because such activities tend to be fiscally and

[11] The ACC was created by the Deficit Reduction Act of 2005 (P.L. 109-171) and charged with conducting a yearlong study to identify all federal STEM education programs. U.S. Department of Education, *Report of the Academic Competitiveness Council*, May 2007.

[12] President Bill Clinton established the NSTC by Executive Order 12881 on November 23, 1993. The NSTC aims to coordinate science and technology policy across the federal government. For more information on the NSTC, see CRS Report RL34736, *The President's Office of Science and Technology Policy (OSTP): Issues for Congress*, by John F. Sargent Jr. and Dana A. Shea.

[13] U.S. Government Accountability Office, *Federal Science, Technology, Engineering, and Mathematics Programs and Related Trends*, GAO-06-114, Washington, DC, October 2005.

[14] In 2010, using a method similar to that of the ACC, the Office of Management and Budget (OMB) found 171 federal STEM education programs funded at about $3.8 billion. Unpublished data from the OMB. Available upon request.

[15] Executive Office of the President, National Science and Technology Council, Committee on STEM Education, Federal Inventory of STEM Education Fast-track Action Committee, *The Federal Science, Technology, Engineering, and Mathematics (STEM) Education Portfolio*, December 2011.

[16] U.S. Government Accountability Office, *Science, Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs across Multiple Agencies*, GAO-12-108, January 2012.

organizationally integrated into what are otherwise primarily scientific programs. Funding calculations and program identification become even more intricate when broad-purpose education programs with a STEM goal are considered (e.g., teacher training programs that focus on mathematics in addition to other fields such as reading). Finally, some estimates of federal STEM education activities depend on agency self-reporting, which is a less-reliable auditing method.

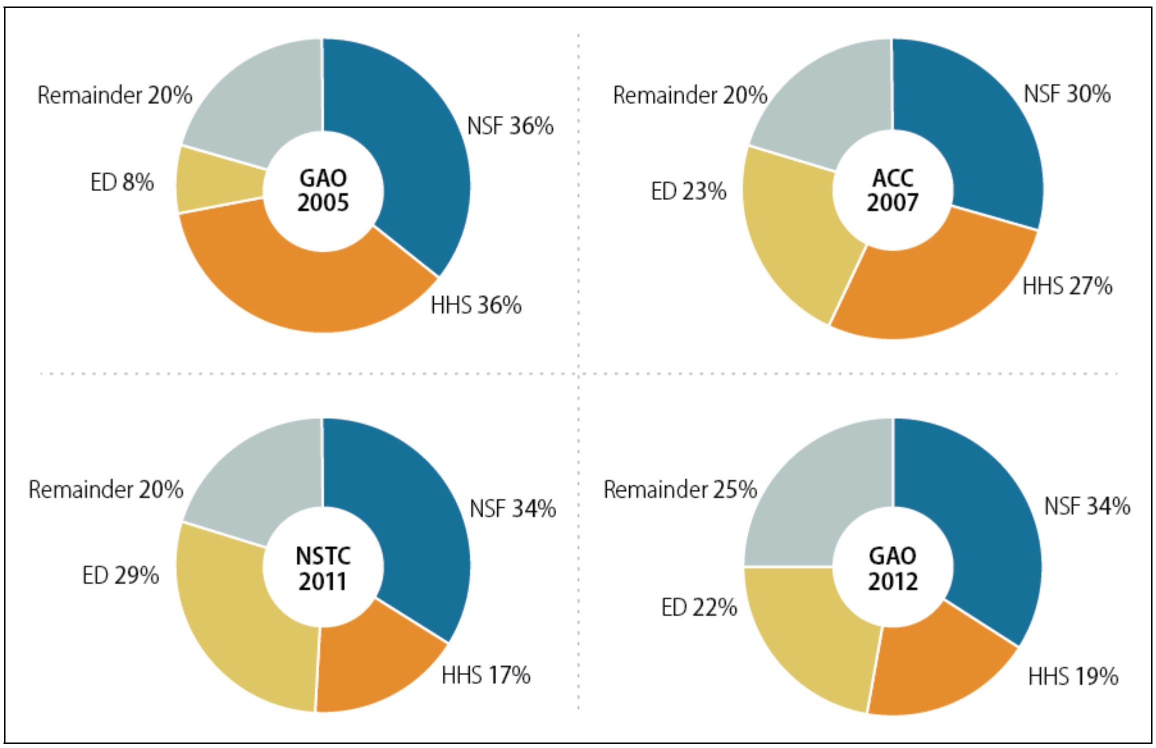
Despite these limitations, these four inventories reveal several general patterns in federal STEM education investments. The next two sections will discuss the inventories' findings by federal agency, population served, and program objective.

Federal Programs by Agency

Each of the four congressionally mandated inventories of the federal STEM education effort found that virtually all federal agencies administer STEM education programs. However, three agencies account for about four-fifths of federal funding for STEM education: the National Science Foundation (NSF) and the Departments of Education (ED) and Health and Human Services (HHS).

As **Figure 1** shows, all four inventories found that about one-third of the federal investment in STEM education is appropriated to the NSF.

Figure 1. Federal STEM Education Funding, by Agency



Source: CRS calculation based on GAO-2005, Figure 1; ACC-2007, Page 21; NSTC-2011, Figure 11; and GAO-2012, Appendix 2.

However, each inventory found different portions of STEM education funding at the other two agencies. The GAO-2005 and ACC-2007 inventories found a larger share of STEM funding at

HHS than the GAO-2012 and NSTC-2011 studies. The GAO-2005 inventory found a much smaller share of funds at ED (8%; compared to 23%, 29%, and 22% in the latter three inventories). This discrepancy is likely attributable to a large increase in the FY2006 ED appropriation (roughly $310 million) for the National Science and Mathematics Access to Retain Talent (SMART) Grant program, which was newly authorized in 2005. Authority for the SMART Grant program ended in FY2010. No funds have been appropriated for the program since then.[17]

Population Served and Program Objectives

Each inventory took a different methodological approach and reported results somewhat incompatibly in terms of population served and program objective. This incompatibility is likely due to overlap between the populations served or program objectives within the individual STEM education programs. That is to say, sometimes the same program serves multiple populations (e.g., high school students and postsecondary students, graduate students and postdoctoral fellows). Additionally, nearly all STEM education programs have multiple objectives (e.g., supporting research and increasing degree attainment, encouraging advanced study and smoothing career transitions). Further, the inventories reported their findings on populations served and program objectives in different ways, thus making it difficult to compare their results on these important program elements.

Each inventory reported on programs by population served (e.g., by education level), although both GAO studies did this only in terms of the number of programs and not their funding level. **Figure 2** presents the percentage of programs primarily serving elementary and secondary schools and postsecondary institutions as a share of the total number of programs identified in each inventory. Of the programs identified by GAO-2005, just fewer than 40% served elementary and secondary schools and just over 60% served postsecondary institutions; compared to 25% and 75% in the ACC-2007 study, 44% and 56% in the NSTC-2011 inventory, and 31% and 69% in the GAO-2012 study. The NSTC-2011 inventory did not include programs serving postdoctoral fellows, thus lowering the share of programs found at the postsecondary level.

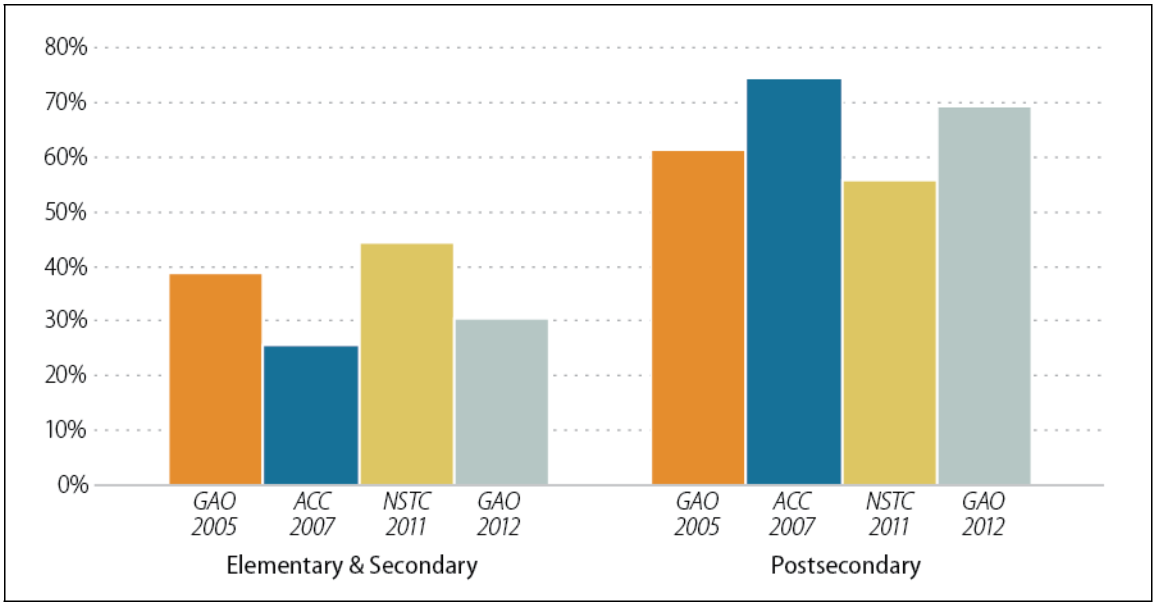
Each inventory also collected information on program objectives. However, only the NSTC-2011 and GAO-2005 inventories reported information that could be summarized. The NSTC-2011 study found that nearly three-quarters of programs (74%) have at least two secondary program objectives in addition to the primary objective.[18] The GAO-2005 study found an even larger share of programs (80%) with more than one goal, with about half supporting four or more goals.[19]

[17] As enacted by the Higher Education Reconciliation Act of 2005 (P.L. 109-171), the SMART Grant program awarded $4,000 grants to students majoring in STEM fields. Congress provided that the program sunset at the end of the 2010-2011 academic year. Approximately $1.4 billion in grants were awarded between FY2006 and FY2010.

[18] NSTC-2011, p. 16.

[19] GAO-2005, p. 13.

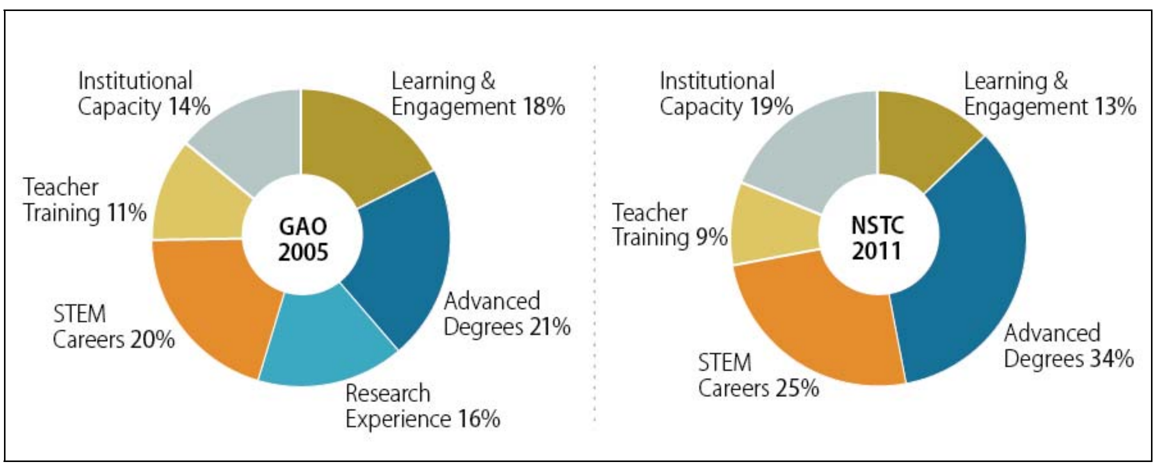
Figure 2. Percentage of STEM Education Programs, by Education Level



Source: CRS calculation based on GAO-2005, Table 8; ACC-2007, Page 2; NSTC-2011, Table 6; GAO-2012, Page 15.

Figure 3 presents the share of federal STEM education programs by primary program objective for the GAO-2005 and NSTC-2011 inventories. In both studies, the majority of programs support degree attainment, research experience, and career development for postsecondary students (57% in the GAO study and 59% in the NSTC study). Fewer than one in five programs support STEM learning and engagement (GAO, 18%; NSTC, 13%). About one in ten programs support the training of STEM educators (GAO, 11%; NSTC, 9%).

Figure 3. Percentage of STEM Education Programs, by Primary Objective



Source: CRS calculation based on GAO-2005, Table 6; NSTC-2011, Figure 7.

Selected STEM Education Programs

In FY2012, the largest federal programs supporting STEM education were the Ruth L. Kirschstein National Research Service Awards ($274 million)[20] administered by HHS, the Graduate Research Fellowships program ($198 million) administered by NSF, and the Mathematics and Science Partnership program ($150 million) administered by ED. Not only are these the largest programs, they also represent two of the major activities receiving federal support, namely fellowships for graduate study and K-12 teacher training.

Ruth L. Kirschstein National Research Service Awards (HHS)

First funded in 1975, the Ruth L. Kirschstein National Research Service Awards (NRSA) constitute just under half (roughly 48%) of HHS spending on STEM education.[21] Most NRSA funds support Institutional Research Training Grants. About 15%-20% of funds support individual fellowships. The Institutional Research Training Grants are awarded to institutions to develop or enhance research training opportunities for individuals, selected by the institution, who are training for careers in specified areas of interest to the institution or principal investigator.[22] The individual fellowships are awarded directly to individuals from various organizations within the National Institutes of Health (e.g., the National Institute on Aging) to support the particular research interests of the individual receiving the award.[23]

Graduate Research Fellowships (GRF)

The Graduate Research Fellowship (GRF) program is the oldest and largest STEM education program at NSF. Established in 1952, the GRF is one of the most prestigious national awards offered to STEM graduate students. Fellows receive three-year portable stipends for graduate study leading to research-based master's and doctoral degrees in fields related to NSF's mission. Applicants are chosen by merit review. The NSF issued 7,800 fellowships (including 2,000 new fellowships) worth up to $42,000 each in FY2012. This amount includes a $12,000 cost-of-education (COE) allowance for the enrolling institution and a $30,000 stipend for the fellow.[24]

Some of the policy concerns associated with the GRF program focus on the number of fellowships offered annually, stipend and COE levels, and source(s) of funding.[25] Historically,

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[20] This amount includes FY2012 enacted funding for Institutional Research Training Grants and individual fellowships. Executive Office of the President, National Science and Technology Council, Committee on STEM Education, Federal Coordination in STEM Education Task Force, *Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report*, February 2012, p. 36.

[21] FY2012 funding for the NRSA is $273.5 million. Total STEM education funding at NIH, according to the NSTC-2011 inventory (updated), is $560.4 million. See Executive Office of the President, National Science and Technology Council, Committee on STEM education, Federal Coordination in STEM Education Task Force, *Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report*, February 2012, p. 36.

[22] NRSA offers several types of Institutional Research Training Grants. Institutional eligibility varies.

[23] More information about the NRSA is available at http://grants.nih.gov/training/nrsa.htm.

[24] National Science Foundation, *FY2013 Budget Request to Congress*, February 13, 2012, pp. NSF-wide Investments-68-69. GRF program rules require institutions of higher education to exempt GRF fellows from tuition and fees. The COE provides funds to the institution for the cost of educating the student. The institution is responsible for tuition and fees in excess of the COE. Stipends are a form of salary and may be treated as taxable income.

[25] Ibid. NSF raised the COE from $10,500 to $12,000 in FY2012. For FY2013, the NSF seeks to increase the stipend (continued...)

funding for the GRF came primarily from NSF's main education account. Section 2 of the America COMPETES Reauthorization Act of 2010 (P.L. 111-358) directed NSF to fund the GRF equally from both the main education *and* research accounts. Funding for the GRF program increased after this change.[26] Some analysts propose expanding the GRF by creating a new NSF-industry fellows program, the funding for which would come equally from the private and public sectors.[27]

Mathematics and Science Partnerships (MSP)

The Mathematics and Science Partnership (MSP) program accounted for more than half (52%) of ED's STEM education portfolio in FY2012 ($150 million of $284 million). First authorized by the No Child Left Behind Act of 2001 (P.L. 107-110), the MSP program provides formula grants to states to increase the academic achievement of students in mathematics and science by enhancing the content knowledge and teaching skills of classroom teachers. With these funds, each State administers a grant competition in which awards are made to partnerships between high-need school districts and institutions of higher education. Grantees typically provide summer institutes and ongoing professional development designed to improve teachers' content knowledge through direct collaboration with scientists, mathematicians, and engineers.

In addition to ED's MSP, the 107th Congress created a companion program through the National Science Foundation Authorization Act of 2002 (P.L. 107-368). NSF's companion program is also called the Mathematics and Science Partnership (NSF-MSP) program.[28] Funded at $55 million in FY2012, NSF-MSP is a research and development effort that supports projects to serve as models of innovation for K-12 STEM education through competitive grants to institutions of higher education or nonprofit organizations in partnership with local education agencies. The NSF Director is required to report annually to Congress on how the program has been coordinated with ED's MSP program.[29]

(...continued)

level to $32,000. The FY2013 NSF budget request also seeks to increase the number of awards to 8,900 (2,000 new).

[26] Between FY2003 and FY2008, funds for the GRF came principally from NSF's main education account. Funding levels for the GRF during this period ranged between $85 million and $96 million. Starting in FY2009, the NSF increased the main research account contribution to the GRF program from less than $10 million per year to between $34 and $56 million per year. For FY2013 the NSF seeks a total of $243 million for the GRF. The main research and education accounts would each provide about half of this amount.

[27] Robert Atkinson et al., *Innovation Policy on a Budget: Driving Innovation in a Time of Fiscal Constraint*, Information Technology and Innovation Foundation, September 2010, p.10.

[28] In its report on legislation authorizing the MSP program at NSF, the House Committee on Science noted "The Committee believes that the Partnership program in this Act is complementary to, and not duplicative of a similarly titled math and science partnership program in H.R. 1, 'The No Child Left Behind Act of 2001.' … The Committee anticipates that the two programs will draw on each others' strengths and that the most promising NSF-funded projects will be used as models and brought to full scale by the Department of Education's partnership program." See H.Rept. 107-134.

[29] For more information on NSF's MSP program, see National Science Foundation, Directorate for Education and Human Resources, *National Impact Report: Mathematics and Science Partnership Program*, NSF 2010-046, 2010, p. 18.

The Condition of U.S. STEM Education

No single fact or statistic can wholly capture the condition of STEM education in the United States and for a variety of reasons the question "what is the condition of STEM education in the United States?" may be unanswerable. However, some trends appear to have held over time and in the most general sense, the condition of STEM education in the United States may be characterized as having more or less held constant or improved over the course of the last four decades. This is not the end of the story though. Looking at STEM education from this broad perspective disguises trends that concern many analysts and drive policy in this area. Among these concerns are persistent achievement gaps between various demographic groups, U.S. student performance on international mathematics and science tests, foreign student enrollments in U.S. institutions of higher education, global STEM education attainment, U.S. STEM teacher quality, and the U.S. STEM labor supply.

Upward Trends

According to the U.S. Census Bureau, the percentage of U.S. bachelor's degree holders with undergraduate degrees in science and engineering (S&E) was 36.4% in 2009 (approximately 20 million people).[30] This percentage is roughly consistent with the annual domestic production of S&E bachelor's degrees. The NSF estimates that the percentage of bachelor's degrees in S&E fields has held relatively constant—at between approximately 30% and 35% of all bachelor's degrees—for the past four decades. However, because the U.S. college-age population grew during these years, the total number of S&E bachelor's degrees awarded annually more than doubled between 1966 and 2008 (from 184,313 to 494,627).[31]

At the graduate level, S&E degrees predominate doctorate degree production. Since 1966, the percentage of doctorates in S&E fields has ranged between approximately 56% and 67% of all graduate degrees (where a field of study has been reported).[32] The total number of doctoral degrees in S&E fields has nearly tripled, growing from 11,570 in 1966 to 32,827 in 2008.[33] Graduate enrollments show similar upward trends. In 2010 there were 556,532 graduates enrolled in S&E fields (an historic peak), up from 413,536 in 2000.[34] **Figure 4** displays the number of S&E degrees awarded, by degree level, over the last four decades.

[30] Julie Siebens, *Science and Engineering Degrees: 2009*, U.S. Department of Commerce, Economics and Statistics Administration, U.S. Census Bureau, American Community Survey Briefs, ACSCR/09-14, October 2010.

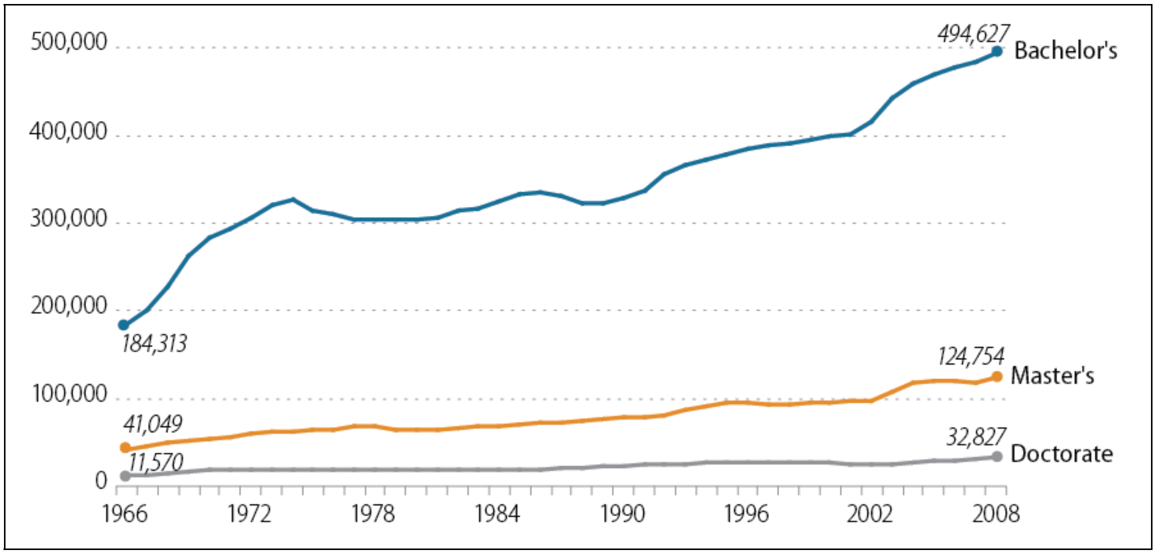
[31] The low was 30.5% in 1991 and the high was 35.6% in 1968 and 1970. National Science Foundation, National Center for Science and Engineering Statistics, "Table 1," *S&E Degrees: 1966-2008*, NSF 11-316, June 2011.

[32] Ibid. The low was 56.1% in 1976 and the high was 67.5% in 2008.

[33] Ibid.

[34] Kelly Kang, NCSES *Infobrief: Graduate Enrollment in Science and Engineering Grew Substantially in the Past Decade but Slowed in 2010*, National Science Foundation, National Center for Science and Engineering Statistics, NSF 12-317, May 2012.

Figure 4. Number of S&E Degrees Awarded from 1966-2008, By Degree Level



Source: National Science Foundation, National Center for Science and Engineering Statistics, "Table 1. S&E Degrees 1966-2008," *Detailed Statistical Tables* (NSF 11-316).

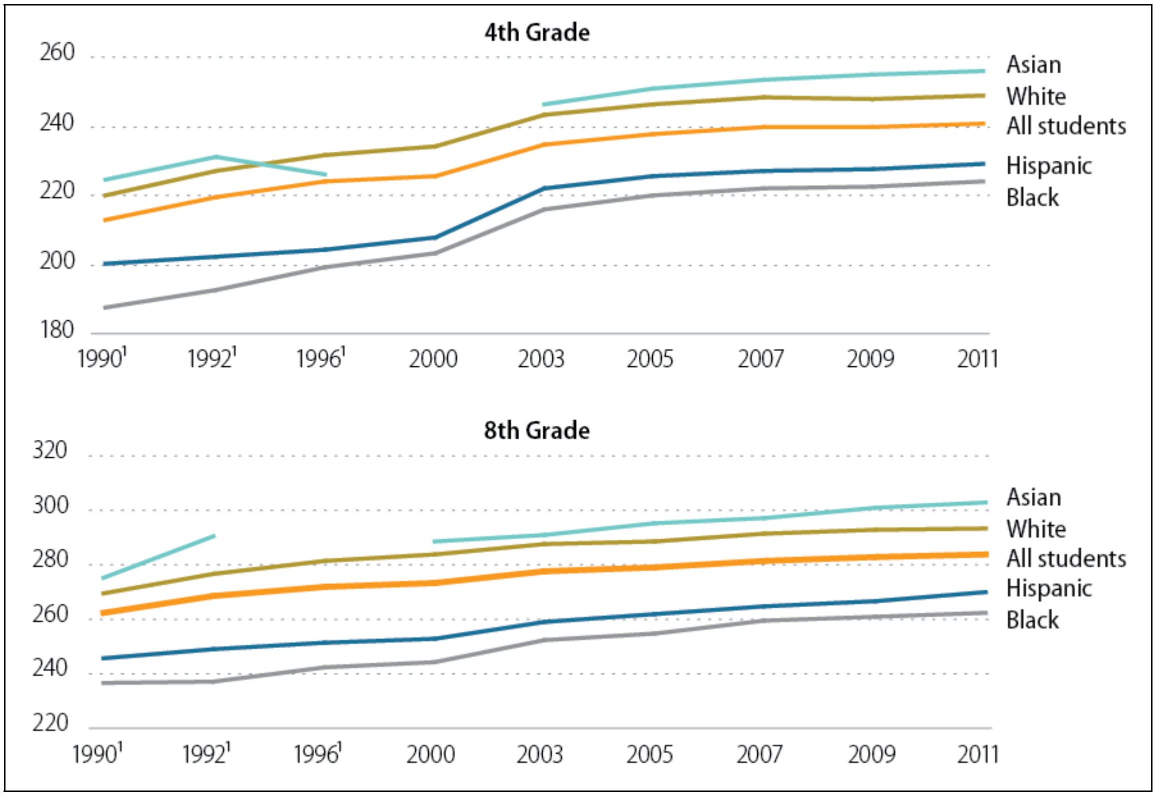
Notes: Includes only degrees where field of study is known. Includes degrees awarded in the social sciences and psychology.

Similar consistency in performance over time may also be found in the lower grades. The performance of U.S. K-12 students on standardized national mathematics tests has held constant or improved over the past four decades. For example, the average National Assessment of Educational Progress (NAEP) mathematics scores of students in 4th and 8th grades, grades in which students have been tested for decades, increased by 28 and 21 points—respectively—between 1990 and 2011.[35] **Figure 5** presents average NAEP math scores by various student subpopulations. Although all group scores have improved over time, sizable gaps remain.

[35] Out of a possible 500 points, the average scores of 4th graders have gone from 213 in 1990 to 241 in 2011; 8th graders have gone from 263 to 284. The 1990 scores are statistically significant ($p < .05$) from 2011. U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, *The Nation's Report Card: Mathematics 2011*, NCES 2012-458, November 2011; and, U.S. Department of Education, Institute of Education Sciences, National Center on Education Statistics, *2011 Condition of Education*, NCES 2011-033, May 2011, p. 46.

Figure 5. Trends in 4th and 8th Grade Average Mathematics Scores

Main NAEP, 1990 to 2011



Source: CRS analysis of data from U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress, various years.

Notes: The NAEP Mathematics scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant. Time series are broken for years in which sample size was insufficient.

[1]Accommodations for students with disabilities were not permitted prior to 1996.

The average scores of 12th grade students on the main NAEP mathematics assessment were three points higher in 2009 than they were in 2005, when the test was first administered to this age group.[36]

Areas of Concern

In some respects, the overall trends paint a fairly optimistic picture for STEM education in the United States. Why, then, are so many observers so concerned about it? Analysts with concerns about STEM education cite a variety of data and trends as alarming. Among these are persistent achievement gaps between various demographic groups, U.S. student performance on international mathematics and science tests, foreign student enrollments in U.S. institutions of higher education, global STEM education attainment, U.S. STEM teacher quality, and the U.S. STEM labor supply.

[36] Comparable data for the NAEP science assessment are not available. The science assessment was changed in 2009 to reflect changes in curriculum standards, assessments, research, and science. As such, the 2009 results are not comparable with results from prior years.

Academic Achievement Gaps

A central topic in the conversation about STEM education focuses on so-called achievement gaps among various racial and ethnic groups and between women and men in certain STEM education outcomes. These gaps can be seen in a wide variety of STEM data, which show disparities by race, ethnicity, and gender in test scores, degree attainment, and employment. For example, there was at least a 20-point gap between the average scores of white students and their black and Hispanic counterparts on the 2011 4th and 8th grade NAEP mathematics assessments.[37] At the higher education level, only 18.5% of bachelor's degrees in engineering went to women in 2008.[38] Some STEM achievement gaps appear to hold relatively constant over time.

Although achievement gaps appear to be both pervasive and persistent, some evidence points to various types of improvement over time and in certain fields. For example, in the decade between 2000 and 2010, graduate enrollments in S&E fields grew by 35%. Further, among U.S. citizens and permanent residents, S&E graduate enrollments among Hispanic/Latino, American Indian/Alaska Native, and black/African America students grew at a higher rate than that of whites (not of Hispanic origin) and Asians.[39] While women account for relatively small percentages of degree recipients in certain STEM fields (as noted above), they accounted for 77.1% of the psychology degrees and 58.3% of the biological and agricultural sciences degrees in 2008.[40] Finally, although the 20+ point gap between the average scores of white students and their black and Hispanic counterparts on both the 4th and 8th grade NAEP mathematics tests has persisted for two decades, students of all ethnicities and races have higher average scores in 2011 than they did in 1990.[41]

Teacher Quality

Many observers look to the nation's teaching force as a source of shortcomings in student mathematics and science achievement. Research on teacher quality conducted over the last 20 years reveals that, among those who teach mathematics and science, having a major in the subject positively affects student achievement.[42] Unfortunately, many U.S. mathematics and science teachers lack this credential. For example, nearly all high school teachers have at least a baccalaureate degree; however, mathematics teachers are less likely than teachers of other subject areas to have majored in the subject they teach. In the 2007-2008 school year, roughly 17% of all

[37] The 2011 gap between the average scores of Hispanics and whites on the NAEP mathematics test was 20 points; for black and white students, the gap was 25 points. For more information on NAEP results and scoring, see U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, *The Nation's Report Card: Mathematics 2011*, NCES 2012-458, November 2011, p. 13.

[38] National Science Foundation, National Center for Science and Engineering Statistics, "Table 11," *S&E Degrees: 1966-2008*, NSF 11-316, June 2011, p. 15.

[39] The rates for Hispanic/Latino, American Indian/Alaska Native, and black/African American S&E graduate enrollments between 2000 and 2010 were 65%, 55%, and 50%, respectively. Kelly Kang, NCSES *Infobrief: Graduate Enrollment in Science and Engineering Grew Substantially in the Past Decade but Slowed in 2010*, National Science Foundation, National Center for Science and Engineering Statistics, NSF 12-317, May 2012.

[40] National Science Foundation, National Center for Science and Engineering Statistics, "Table 11," *S&E Degrees: 1966-2008*, NSF 11-316, June 2011, p. 15.

[41] For more information on student achievement, see CRS Report R40514, *Assessment in Elementary and Secondary Education: A Primer*, by Rebecca R. Skinner.

[42] Michael B. Allen, *Eight Questions on Teacher Preparation: What Does the Research Say?*, Education Commission of the States, July 2003.

high school teachers did not major in the subject they taught, while 28% of mathematics teachers did not major in mathematics.[43] Moreover, among those who majored in the subject they taught, mathematics teachers are less likely to be subject-certified than other teachers.

International Assessment Rankings

Another area often of concern is how U.S. students compare with their peers in other nations in their knowledge of mathematics and science. While U.S. students usually outscore the all-country average on international mathematics and science tests, they typically score below the average of industrialized nations. For example, U.S. 15 year-olds ranked below the Organization for Economic Cooperation and Development (OECD) average in mathematics—and ranked at the OECD average in science—on the 2009 Program for International Student Assessment (PISA).[44] U.S. students fare better on the Trends in International Mathematics and Science Study (TIMSS); U.S. 8th graders ranked 9th in mathematics and 11th in science on the 2007 TIMSS assessment.[45]

Many observers caution against using student assessments to compare nations. A variety of factors may influence test results, including translation issues, differences in test administration, student effort,[46] and the selection and diversity of test takers. The latter issue is often raised by critics of international assessments when looking at U.S. student performance. Some observers say that low performance in the United States is closely related to poverty, though the same reasoning applies to other countries. One analysis of the 2009 PISA results found that the richest U.S. areas (especially areas with less than 10% poverty) perform better than most other nations.[47]

Foreign Student Enrollment[48]

Although the number of degrees awarded in STEM fields has increased over time, many analysts are concerned about the percentage of STEM degrees that go to foreign students. For example,

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[43] U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, "Table 2," *Education and Certification Qualifications of Departmentalized Public High School-Level Teachers of Core Subjects: Evidence from the 2007-08 Schools and Staffing Survey,* NCES 2011-317, May 2011, p. 14.

[44] Organization for Economic Cooperation and Development, *PISA 2009 Results: What Students Should Know and Can Do: Volume I*, December 2010.

[45] Ina V.S. Mullis et al., *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*, Boston College, Lynch School of Education, TIMSS & PIRLS International Study Center, 2008; and Michael O. Martin, et al., *TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*, Boston College, Lynch School of Education, TIMSS & PIRLS International Study Center, 2008.

[46] Some research has found that U.S. students do not try very hard on low-stakes standardized tests and that this affects scores. For example, research on financial incentives to improve student performance found that "The large effects of these relatively modest financial incentives [$10 to $20] suggest that at baseline this population of students [e.g., students in the study sample] puts forth low effort in response to low (perceived) returns to achievement on standardized tests." Steven D. Levitt et. al., *The Behavioralist Goes to School: Leveraging Behavioral Economics to Improve Educational Performance*, National Bureau of Economic Research, Working Paper no. 18165, June 2012.

[47] National Association of Secondary School Principals, "NASSP Responds to International Assessment Results," press release, December 10, 2010; and Cynthia McCabe, "The Economics Behind International Education Rankings," *NEAToday*, December 9, 2010.

[48] For more information on issues related to foreign students and foreign technical workers, see CRS Report R42530, *Immigration of Foreign Nationals with Science, Technology, Engineering, and Mathematics (STEM) Degrees*, by Ruth Ellen Wasem; and CRS Report 97-746, *Foreign Science and Engineering Presence in U.S. Institutions and the Labor Force*, by Christine M. Matthews.

foreign students earn roughly one-third of all U.S. S&E doctoral degrees and earn half (or more) of U.S. doctoral degrees in the specific fields of engineering, physics, computer sciences, and economics.[49] Further, the percentage of doctoral degrees going to foreign students has been more or less increasing since the mid-1970s.[50]

The presence of foreign students in U.S. graduate S&E programs has been and continues to be of concern to some analysts because foreign graduates may not be eligible for work in the United States or for certain jobs requiring security clearance. Other observers suggest that these trends may mean missed opportunities or depressed wages for U.S. citizens and permanent residents who may be displaced by foreign graduates. Other analysts say that federal policymakers should encourage foreign STEM students to study and stay in the United States, arguing that policies meant to attract the world's best and brightest are key to ensuring U.S. competitiveness.[51]

Global STEM Education Attainment

In addition to concerns about foreign students obtaining STEM graduate degrees at U.S. institutions, some observers assert that the United States is falling behind other nations in the production of total STEM degrees. Of the 5 million first university degrees (e.g., undergraduate degrees) awarded globally in S&E in 2008, students in China earned about 23%, European Union students earned about 19%, and U.S. students earned about 10%. Further, while the United States awarded the largest number of total S&E doctoral degrees in 2008 (about 33,000), in 2007 China overtook the United States to become the world leader in the number of doctoral degrees awarded in the specific fields of natural sciences and engineering.[52]

Some analysts challenge these degree production numbers, arguing that at least in some cases (e.g., engineering) the United States produces higher quality graduates and that country-level comparisons are misleading because the statistics are not based on common methodologies or definitions.[53] However, attention to degree attainment trends has been amplified by scale differences between the sizes of the United States' and Chinese and Indian populations (i.e., about 300 million in the United States compared to about a 1.34 billion in China and 1.22 billion in India).

[49] In 2009, there were 611,629 graduate students in science and engineering fields in the United States. Of these, 168,850 (27.6%) were temporary residents. National Science Board, *Science and Engineering Indicators: 2012*, NSB 12-01, National Science Foundation, January 13, 2012, p. 2-28.

[50] National Science Foundation, "Figure 3.7—Citizenship Status of Ph.D.'s: 1960-1999," *U.S. Doctorates in the 20th Century*, NSF 06-319, October 2006; and Mark K. Feigener, *Number of Doctorates Awarded in the United States Declined in 2010*, National Science Foundation, NSF 12-303, November 2011.

[51] The House Committee on the Judiciary examined foreign student policy issues in an October 5, 2011, hearing titled, "STEM the Tide: Should America Try to Prevent and Exodus of Foreign Graduates of U.S. Universities with Advanced Degrees?" A video of the hearing, as well as written testimony from witnesses, is available at http://judiciary.house.gov/hearings/hear_10052011_2.html.

[52] These totals include foreign students. China expanded its domestic production of S&E doctoral degrees from about 2,700 in 1994 to almost 28,500 in 2008. National Science Board, *Science and Engineering Indicators, 2012*, NSB 12-01, National Science Foundation, January 13, 2012, pp. 2-5 and 2-34 to 2-37.

[53] Gary Gereffi et al., "Getting the Numbers Right: International Engineering Education in the United States, China, and India," *Journal of Engineering Education*, vol. 97, no. 1 (January 2008), p. 13-25.

U.S. STEM Labor Supply[54]

A primary rationale behind federal STEM education policies relies on their perceived impact on the U.S. S&E workforce—and through it, on U.S. economic competitiveness and national security. Many business, academic, and policy leaders assert that U.S. STEM education weaknesses have contributed (or will soon contribute) to national S&E workforce shortages and that this labor supply problem has diminished U.S. global economic competitiveness and threatened national security (or will do so in the future).[55] However, some analysts argue that perceived limitations in the U.S. S&E workforce are overstated and that U.S. competitiveness is not threatened by across-the-board S&E labor shortages and does not require a supply-side response.[56] A third view holds that perceptions of S&E workforce shortages are accurate if the increasing numbers of jobs that are technically non-STEM, but that require STEM competencies (e.g., analytical skills), are included in labor demand calculations.[57]

Data and Methodological Limitations

Data are a big part of the current STEM education policy debate. Those who advocate for or against various STEM education policy proposals cite a variety of data and statistics in support of their assertions. However, in some cases data showing the impact of policy changes may lag behind those changes by years or decades, making accurate evaluation and policy assessment difficult. In other cases, data may be interpreted or used in ways that do not reflect potentially important research or methodological limitations. For example, one 2010 editorial stated that "the World Economic Forum ranked [the United States] 48th out of 133 developed and developing nations in quality of mathematics and science instruction."[58] The editorial did not explain that the source of the 48th place ranking was an opinion survey of global business executives. Although opinion surveys are often relevant in policy debate, policymakers may interpret their results differently than they would other kinds of evidence. These and other data limitations may challenge federal policymaking in this area.

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[54] For more information on issues related to the U.S. STEM labor supply, see CRS Report RL34091, *Globalization, Worker Insecurity, and Policy Approaches*, by Raymond J. Ahearn; CRS Report RL32292, *Offshoring (or Offshore Outsourcing) and Job Loss Among U.S. Workers*, by Linda Levine; CRS Report R42141, *Computer-Related Occupations Under the Fair Labor Standards Act (FLSA)*, by Gerald Mayer; and CRS Report R42411, *The Tool and Die Industry: Contribution to U.S. Manufacturing and Federal Policy Considerations*, by Bill Canis.

[55] Multiple reports from a variety of respected U.S. academic, scientific, and business organizations have made this argument. For example, see National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, and Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academies Press, 2007); and, Frederick M. Hess, Andrew P. Kelly, and Olivia Meeks, *The Case for Being Bold: A New Agenda for Business in Improving STEM Education*, U.S. Chamber of Commerce, Institute for a Competitive Workforce, April 2011.

[56] For example, see Richard Freeman, "The Market for Scientists and Engineers," *NBER Reporter*, no. 3 (Summer 2007), pp. 6-8; Ron Hira, "U.S. Policy and the STEM Workforce System," *American Behavioral Scientist*, vol. 53, no. 7 (March 2010), pp. 949-961; Testimony of Institute for the Study of International Migration Director of Policy Studies B. Lindsay Lowell in U.S. Congress, House Committee on the Judiciary, Subcommittee on Immigration Policy and Enforcement, *"STEM" the Tide: Should America Try to Prevent an Exodus of Foreign Graduates of U.S. Universities with Advanced Science Degrees?*, hearings, 112th Cong., 1st sess., Serial No. 112-64, October 5, 2011; and B. Lindsay Lowell and Harold Salzman, *Into the Eye of the Storm: Assessing the Evidence on Science and Engineering Education, Quality, and Workforce Demand*, Urban Institute, October 2007.

[57] Anthony P. Carnevale, Nicole Smith, and Michelle Melton, *STEM: Science, Technology, Engineering, and Mathematics*, Georgetown University Center on Education and the Workforce, October 20, 2011, p.7.

[58] New York Times Editorial Board, "48th is Not a Good Place," *New York Times*, October 26, 2010, p. A28.

STEM Education Policy Issues

Stakeholders with an interest in improving STEM education suggest a wide and disparate set of policy options for Congress. Some of these recommendations address governance concerns about the administration of federal programs—e.g., removing duplication and improving program coordination within and across agencies. Other policy options focus attention on elements of the elementary and secondary school system—e.g., improving the quality and quantity of mathematics and science teachers and strengthening school accountability measures. Additional recommendations look to make improvements at the post-secondary level—e.g., enhancing retention of undergraduate STEM majors and strengthening incentives to pursue advanced STEM education. Many options focus on improving the STEM education outcomes of underrepresented populations.

Governance Concerns

Governance concerns are central to the contemporary debate about the federal STEM education effort. The scope and scale of the federal STEM education portfolio has some analysts concerned that federal agencies may be duplicating effort. In response to these concerns, some policymakers have proposed consolidating or eliminating STEM education programs. Other stakeholders support the broad and diffused nature of the federal STEM education effort and are more concerned with an apparent lack of coordination. Proponents of this view have argued for the development of an overarching federal STEM education strategy.

Duplication and Consolidation

Program consolidation is a widely debated policy option for federal STEM education programs. Advocates for this approach perceive duplication in the federal effort and assert that merging programs would result in cost savings. Proposals to consolidate STEM education programs have been made by both members of Congress and the Administration.[59] Some policymakers see program consolidation as a means to increase program flexibility and responsiveness because (under certain models of consolidation) federal program managers would have greater authority to shift priorities.[60] However, other policymakers may object to this change because it typically transfers program control from the legislative to the executive branch, shifting the balance of power.

Consolidation (particularly in the form of block grants) has also been proposed as a strategy to transfer control to the states and as a means to reduce program costs. Shifting control to the states could increase their ability to respond to local conditions and needs, but might make it more difficult to drive a national STEM education agenda[61] or to leverage unique assets of federal

[59] For example, see Senator Tom Coburn, *The National Science Foundation: Under the Microscope*, April 2011, p. 54; and U.S. Department of Education, *A Blueprint for Reform: The Reauthorization of the Elementary and Secondary Education Act,* March 2010.

[60] This argument is, for example, part of the rationale for Administration-proposed program consolidations at ED. For more information, see CRS Report R41355, *Administration's Proposal to Reauthorize the Elementary and Secondary Education Act: Comparison to Current Law*, by Rebecca R. Skinner et al.

[61] This difficulty in driving a national agenda would depend on how the grants to states were structured. Federal policymakers could still drive a national STEM education agenda if they made receipt of consolidated program funds (continued...)

science agencies.[62] On the question of cost, the GAO has found that program consolidation can be more expensive in the short term and may not result in long term savings (if workloads are not also reduced) because administrative costs in federal STEM education programs tend to be less than 10% of total program costs.[63] Consolidation opponents raise general concerns about the potential impact of merging programs, arguing that certain programs (such as STEM education programs) need specified funding streams to avoid being passed over in favor of competing education priorities. It is unclear if this assertion would hold true in practice.

The impact of program consolidation on the federal STEM education effort would depend on what programs are consolidated, how the consolidation is accomplished, how funding streams are affected, and the degree to which programs are duplicative.[64] Congress could, for example, seek either a full or a partial consolidation of STEM education programs at individual agencies or across the entire portfolio. If Congress both consolidates programs and reduces funding levels, it may achieve savings from both administrative and program costs. Savings and program impacts from these changes would vary, depending on which of these strategies policymakers pursue.

Duplication or Overlap?

Published assessments of duplication in the federal STEM education portfolio are somewhat contradictory. Preliminary findings from April 2011 GAO testimony appeared to suggest the potential for duplication in federal teacher quality programs, including some STEM teacher programs.[65] However, the NSTC-2011 inventory specifically examined the duplication question within the federal STEM education portfolio and found "little overlap and no duplication."[66] The GAO-2012 inventory concluded that 83% of federal STEM education programs overlapped "to some degree," but stated that this overlap would "not necessarily be duplicative."[67]

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contingent on meeting certain defined national goals. However, some states may reject such efforts as overly prescriptive.

[62] For example, the National Aeronautics and Space Administration (NASA) has both unique workforce needs (e.g., astrobiologists) and unique assets that it can bring to the national STEM education effort (e.g., teaching from space).

[63] GAO states, "over 90% of STEM education programs that reported administrative costs estimated having administrative costs lower than 10% of their total program costs." U.S. Government Accountability Office, *Science, Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs Across Multiple Agencies*, GAO-12-108, January 2012, p. 22.

[64] For example, programs that appear duplicative by some measures (e.g., target group) may have different intangible assets that could affect program implementation and outcomes. In this sense, they may not be *strictly* duplicative.

[65] U.S. Government Accountability Office, *Opportunities to Reduce Potential Duplication in Federal Teacher Quality Programs*, GAO-11-510T, April 13, 2011.

[66] Executive Office of the President, National Science and Technology Council, Committee on STEM Education, Fast-Track Action Committee on Federal Investments in STEM Education, *The Federal Science, Technology, Engineering, and Mathematics (STEM) Education Portfolio*, December 2011, p. 37.

[67] See U.S. Government Accountability Office, *Science, Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs Across Multiple Agencies*, GAO-12-108, January 2012, p. 20.

Coordination and Strategy

Some stakeholders maintain that duplication in the federal portfolio is limited. They tend to focus instead on a perceived lack of coordination among and within agencies. To address this concern, some analysts call for an overarching STEM education strategy. Until recently, the federal STEM education effort was primarily undertaken in a distributed fashion that responded to the specific needs of agencies and STEM constituencies. That is, in general, programs were not part of a defined government-wide system with clear roles played by individual federal agencies. Some view this distributed approach as particularly sensitive to the unique workforce needs or STEM education assets of federal science agencies; other observers suggest that an overarching strategy may improve the efficiency of federal STEM education investments.[68]

Both the Congress and the President have moved to develop a federal STEM education strategy. Section 101 of the America COMPETES Reauthorization Act of 2010 (P.L. 111-358) directed the NSTC to develop and implement a five-year federal STEM education strategy. Although the NSTC had not published this strategy by mid-November 2012, it issued a status report in February 2012.[69] That status report identifies two common federal STEM education agency goals—STEM workforce development and STEM literacy—as well as policy and administrative strategies designed to accomplish these goals. In particular, the status report identifies four priority policy areas for the federal effort: "effective K-12 teacher education, engagement, undergraduate STEM education, and serving groups traditionally underrepresented in STEM fields."[70] The status report notes that strong arguments can be made for other STEM education policy areas, but states that these four were chosen as the priority areas for enterprise-wide coordination (agencies may still maintain their own STEM education priorities as well) because they represent the convergence of "national needs, Presidential priorities, and federal assets."[71]

To further enhance coordination at the federal level, some advocates maintain that Congress consider creating an Office of STEM Education and designating an Assistant Secretary for STEM Education at ED. Advocates for this approach claim that it would raise the profile of STEM education and improve administration of the various programs and policies at ED.[72]

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[68] The NSTC-2011 inventory stated that "the primary issue [instead of duplication] is how to strategically focus the limited federal dollars available within the vast landscape of opportunity so they will have the most significant impacts possible in areas of national priority." (Executive Office of the President, National Science and Technology Council, Committee on STEM Education, Fast-Track Action Committee on Federal Investments in STEM Education, *The Federal Science, Technology, Engineering, and Mathematics (STEM) Education Portfolio*, December 2011, p. 37.) In its January 2012 report, GAO recommended not only that a federal STEM education strategy plan be drafted, but that NSTC should also develop policies to ensure compliance. In particular, the GAO recommended that the NSTC develop (1) guidance for agencies on how to incorporate STEM education efforts into agency performance plans; (2) a framework for how agencies will be monitored to ensure they collect and report on strategic plan goals; and (3) guidance to help agencies determine the types of evaluations that may be feasible and appropriate for different types of STEM education programs. Additionally, GAO recommended that the NSTC work with agencies to identify programs that might be candidates for consolidation or elimination. (U.S. Government Accountability Office, *Science, Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs Across Multiple Agencies*, GAO-12-108, January 2012, p. 31.)

[69] Executive Office of the President, National Science and Technology Council, Committee on STEM Education, Federal Coordination in STEM Education Task Force, *Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report*, February 2012.

[70] Ibid. p. 13.

[71] Ibid. p. 17.

[72] Triangle Coalition for Science and Technology Education, "Doing What's Best for Science, Technology, (continued...)

Elementary and Secondary Schooling

Policymakers often express interest in making improvements in the early part of the STEM education pipeline—e.g., from kindergarten to 12th grade (also referred to as the "K-12" pipeline). Some analysts assert that mathematics and science achievement will not easily be raised unless the quality of K-12 teaching is improved. Other observers suggest low or unequal student achievement may be best addressed by adjustments to the K-12 system's accountability structure and standards for performance.

Teacher Quality

To many observers, mathematics and science teachers' lower likelihood of possessing subject-specific professional credentials, compared to teachers of other subjects, identifies a deficit of mathematics and science teacher quality. Although most teaching positions may be staffed, the K-12 system's stock of fully credentialed mathematics and science teachers is in short supply.[73] A variety of solutions to the shortage of STEM teachers have been proposed.[74] One set of proposals is directed at teachers currently in the classroom, while another set of solutions targets new or prospective teachers.

Some advocates feel that it is important to focus on performance, and that current teachers who are less than fully effective in the classroom are not provided the support and training they need to succeed and want to see federal funding for professional development (PD) specifically designed for STEM teachers maintained and expanded.[75] Other stakeholders propose establishing a STEM Master Teacher Corps that would reward experienced and effective mathematics and science teachers with increased career prestige and pay in return for mentoring and providing PD for less effective teachers.[76] Still others support increased use of online education, especially in rural schools that struggle to attract new teachers in any subject.[77] Additionally, some researchers support reforms that would ease the removal of ineffective teachers who do not sufficiently improve with PD and may not be cut out for the profession.[78]

Other stakeholders think improved recruitment and retention of high-quality new teachers is the primary solution to the mathematics and science teacher quality problem. Many who take this approach argue that federal teacher policies should assist state and local efforts to improve non-

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Engineering, and Mathematics Education," talking points, January 2011.

[73] Richard M. Ingersoll and David Perda, *The Mathematics and Science Teacher Shortage: Fact and Myth*, Consortium for Policy Research in Education, CPRE Research Report #RR-62, Philadelphia, PA, March 2009.

[74] For a discussion of teacher issues, see CRS Report R41267, *Elementary and Secondary School Teachers: Policy Context, Federal Programs, and ESEA Reauthorization Issues*, by Jeffrey J. Kuenzi.

[75] For example, the Triangle Coalition for Science and Technology Education advocates for maintaining current funding for ED's MSP program and increased funding for professional development support under ED's Teacher Quality State Grant program. Triangle Coalition for Science and Technology Education, "Doing What's Best for Science, Technology, Engineering, and Mathematics Education," talking points, January 2011.

[76] Letter from STEM Education Coalition to Senators Tom Harkin and Michael B. Enzi, June 20, 2011.

[77] Jerry Johnson and Marty Strange, *Why Rural Matters 2009: State and Regional Challenges and Opportunities*, The Rural School and Community Trust, October 30, 2009.

[78] Saba Bireda, *Devil in the Details: An Analysis of State Teacher Dismissal Laws*, Center for American Progress, June 3, 2010.

traditional routes to teaching—e.g., alternative certification policies and incentives for mid-career transition of STEM professionals.[79] Analysts have identified options for attracting new STEM teachers through traditional preparation programs by subsidizing their education costs—e.g., through direct grants, student loan repayment, or tax credits[80]—and encouraging colleges and universities to develop concurrent STEM and teaching degree programs.[81] Such recruitment strategies may also serve as retention tools when paired with requirements that new teachers fulfill service agreements. Some proponents prefer policies designed to attract and retain STEM teachers through financial incentives such as differential pay, housing subsidies, and signing bonuses.

Alternatively, some education analysts have criticized the federal policy focus on teacher quality, as measured by credentials, calling into question its link to student achievement and advocating instead for proposals to improve teacher effectiveness.[82] Specifically, those in this camp suggest reforming teacher evaluation systems to identify multiple levels of effectiveness; rewarding those at the top with performance pay and removing those at the lowest level of performance.[83] Related proposals would reform the structure of teacher preparation by rewarding teacher training programs, both traditional and non-traditional, on the basis of their graduates' classroom effectiveness rather than on certification exam results.[84]

Accountability and Standards

The accountability movement has been a powerful force in the federal education policy debate for some time, reaching particular prominence with the passage of the No Child Left Behind Act of 2001 (NCLB, P.L. 107-110).[85] NCLB reforms were based on the premise that, to improve outcomes from the K-12 system, student achievement must be accurately assessed and schools must be held accountable for measurable results. The law required that states establish achievement benchmarks, set annual goals (referred to as Adequate Yearly Progress, or AYP), and have all students reach "proficiency" in reading and mathematics by 2014.[86] NCLB also requires that students be assessed for their academic proficiency in science. However, these results are not tied to the accountability system. Some stakeholders are in favor of amending the law to mandate that schools ensure students also be proficient in science.[87]

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[79] National Council on Teacher Quality, *Tackling the STEM Crisis*, Summer 2009.

[80] For more information about higher education grants, loans, and tax benefits, see CRS Report R42446, *Federal Pell Grant Program of the Higher Education Act: How the Program Works, Recent Legislative Changes, and Current Issues*, by Shannon M. Mahan; CRS Report R40122, *Federal Student Loans Made Under the Federal Family Education Loan Program and the William D. Ford Federal Direct Loan Program: Terms and Conditions for Borrowers*, by David P. Smole; and CRS Report R41967, *Higher Education Tax Benefits: Brief Overview and Budgetary Effects*, by Margot L. Crandall-Hollick.

[81] National Science Teachers Association, *NSTA Position Statement: Science Teacher Preparation*, July 2004.

[82] For example, see Dan Lips and Jena Baker McNeill, *A New Approach to Improving Science, Technology, Engineering, and Mathematics Education*, The Heritage Foundation, Backgrounder no. 2249, April 15, 2009.

[83] National Center on Performance Incentives, *Teacher Performance Pay: A Review*, November 2006.

[84] The Education Schools Project, *Educating School Teachers*, September 2006.

[85] More information on ESEA accountability can be found in CRS Report R41533, *Accountability Issues and Reauthorization of the Elementary and Secondary Education Act*, by Rebecca R. Skinner and Erin D. Lomax.

[86] More information assessment in ESEA can be found in CRS Report R40514, Assessment in Elementary and Secondary Education: A Primer, by Rebecca R. Skinner.

[87] NSTA Reports, "Should Science Count Toward AYP?," *National Science Teachers Association website—NSTA Web* (continued...)

Independent of federal involvement, states have begun development of a so-called common core of academic standards across the K-12 system.[88] This effort intends to create nationally consistent standards of knowledge and skills that students need in order to graduate from high school and succeed in entry-level, credit-bearing college courses or workforce training programs. So far, standards have been developed for reading and mathematics and adopted by 45 states and the District of Columbia.[89] Pointing to the perceived "mediocre" state of current state science standards, some analysts say the inclusion of science in the common core "is long overdue."[90]

Other K-12 Policy Issues

Some analysts argue that the current "STEM for all" approach is not working.[91] Those in this camp urge policymakers to focus limited federal resources on high-achieving students with an interest in STEM by, among other things, using federal education funding to create new specialty STEM high schools.[92] Other analysts seek to expand programs such as Advanced Placement and International Baccalaureate (AP/IB)—including grants to pay the AP/IB testing fees of low-income students—or seek to increase STEM education achievement among demographic groups with historically low participation rates in STEM fields.[93] (See section on "Broadening Participation.")

Post-Secondary Education

As a proportion of all federal STEM education funding, the majority of the federal investment in STEM education supports undergraduate, graduate, and post-graduate education and research. In each of the recent program inventories, post-secondary education accounted for more than half of the federal STEM education portfolio. However, some analysts argue that current U.S. STEM degree production rates are insufficient.[94] Proposals to improve post-secondary STEM education include those that seek to address remediation in the early college years or increase retention rates

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News Digest, February 7, 2011.

[88] The Common Core State Standards Initiative is a state-led effort coordinated by the National Governors Association and the Council of Chief State School Officers. More information may be found at http://www.corestandards.org/.

[89] The National Research Council's Board on Science Education is currently developing a conceptual framework to guide the development of new science education standards. More information may be found at http://www7.nationalacademies.org/bose/Standards_Framework_FAQs.html.

[90] Lawrence S. Lerner et al., *The State of State Science Standards 2012*, Thomas B. Fordham Institute, January 31, 2012, p. 4-5.

[91] The "STEM for all" approach asserts that STEM competencies are central to contemporary work, life, and citizenship and that all U.S. students should have some mastery of these subjects and skills. In general, a "STEM for all" approach seeks to distribute STEM education resources widely, across all student skill levels, rather than targeting federal resources at high-achieving students.

[92] Robert D. Atkinson and Merrilea Mayo, *Refueling the U.S. Innovation Economy: Fresh Approaches to STEM Education*, Information Technology and Innovation Forum, December 7, 2010.

[93] Eric W. Robelen, "Latest Wave of STEM Schools Taps New Talent," *Education Week*, vol. 31, no. 3 (September 14, 2011), p.1, and published online under the title, "New STEM Schools Target Underrepresented Groups," *Edweek.org*.

[94] For example, the President's Council of Advisors on Science and Technology calculates that the United States will need, over the next decade, "approximately one million more college graduates in STEM fields than expected under current assumptions." Executive Office of the President, President's Council of Advisors on Science and Technology, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, cover letter, February 2012.

in STEM majors through graduation. Other proposals seek increased support for graduate study and post-doctoral research. Some analysts favor lowering barriers for foreign STEM students seeking entry into U.S. institutions of higher education.

Remediation and Retention

Researchers cite poor pre-college mathematics and science preparation and high rates of attrition among STEM majors as two major challenges for undergraduate STEM education in the United States.[95] In addition to the K-12 improvements discussed above, some observers propose additional federal investment in remedial education for students as they enter college. For example, some stakeholders advocate for increased funding for ED's Upward Bound Mathematics and Science program.[96] Others analysts see community colleges playing an important role in counteracting the perceived failings of secondary schools. For example, some stakeholders have called for partnerships between business and two-year colleges to prepare students for STEM careers.[97] Other analysts argue that proprietary, non-degree-granting institutions are well suited to provide STEM remediation and training.[98]

Some policymakers are concerned with low retention rates at undergraduate STEM programs. Although attrition in STEM fields may be due, in part, to poor K-12 preparation and to overall college attrition patterns, there are likely multiple reasons why students complete a non-STEM degree after showing initial interest in STEM.[99] Some analysts advocate for STEM education research programs that focus on improving undergraduate STEM education practices for all students, such as NSF's Widening Implementation and Demonstration of Evidence-based Reforms (WIDER) and Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES) programs.[100] Others support efforts to improve retention among groups traditionally underrepresented in STEM fields (including ethnic and racial minorities, the disabled, and females).[101]

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[95] One-quarter of first-year college students were required to take remedial courses because they were not ready for college-level work. (Hart Research Associates, *One Year Out: Findings from a National Survey Among Members of the High School Graduating Class of 2010*, The College Board, August 18, 2011.) Two-fifths of students entering college intending to major in a STEM field complete a STEM degree. (Executive Office of the President, President's Council of Advisors on Science and Technology, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, February 2012.)

[96] Council for Opportunity in Education, "2011 Capitol Hill Talking Points: Upward Bound Math-Science," talking points, 2011.

[97] Business Roundtable, *Taking Action for America: A CEO Plan for Jobs and Economic Growth*, March 1, 2012.

[98] Robin Wilson, "For-Profit Colleges Change Higher Education's Landscape," *The Chronicle of Higher Education*, February 7, 2010.

[99] For example, one widely cited study of STEM attrition found that poor teaching quality is a factor. (Elaine Seymour and Nancy M. Hewitt, *Talking About Leaving: Why Under-Graduates Leave the Sciences* (Boulder, CO: Westview Press, 1997). Other analysts cite the influence of grades on students' decisions to leave STEM majors. (Ben Ost, "The Role of Peers and Grades in Determining Major Persistence in the Sciences," *Economics of Education Review*, vol. 29, no. 6 (December 2010), pp. 923-934. Some observers assert that certain institutional practices, such as using introductory STEM courses to "weed out" or limit the number of students seeking STEM majors, contribute to perceived attrition challenges. (Jeffrey Mervis, "Weed-out Courses Hamper Diversity," *Science*, vol. 334, no. 6961 (December 2011), p. 1333.)

[100] Executive Office of the President, President's Council of Advisors on Science and Technology, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, February 2012.

[101] For example, see National Academy of Sciences, National Academy of Engineering, and Institute of Medicine; (continued...)

Broadening Participation of Underrepresented Populations

The demographic profile of the U.S. student-age population is changing. The youth population is more racially and ethnically diverse than previous generations of Americans. In addition, more than half of U.S. college students are now female, and over half of all bachelor's, master's, and doctoral degrees awarded in the United States go to women.[102] Some observers say that these trends are problematic for the U.S. scientific and technological enterprise, which has historically relied mostly on a white male labor supply (particularly in fields such as mathematics and engineering). However, because the growth in the student-age population (and therefore future labor supply) is in segments that have typically been underrepresented in STEM,[103] these observers argue that underrepresented groups "embody a vastly underused resource and a lost opportunity for meeting our nation's technology needs."[104] The solution to this challenge, many stakeholders argue, is to increase (or broaden) the participation of women and ethnic and racial minorities in STEM education and employment.[105]

General agreement about the problems posed by racial, ethnic, and gender disparities in STEM education and employment has not translated into widespread agreement on either the causes of underrepresentation or policy solutions. Further, causes and solutions may be different for different population subsets.

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Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline; Committee on Science, Engineering, and Public Policy; Policy and Global Affairs, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* (Washington, DC: National Academies Press, 2011).

[102] Based on 2009 enrollment in four-year, two-year, and less-than-two-year Title VI eligible institutions. U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, *Digest of Education Statistics: Table 196*, May 2011.

[103] Generally, analysts consider a demographic group to be "underrepresented" in STEM if the group's rate of participation in the STEM field is inconsistent with the group's presence in some broader population. For example, if women make up over half of all college students but are only a quarter of the engineering majors, then some observers would consider women to be underrepresented in college engineering enrollments.

[104] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine; Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline; Committee on Science, Engineering, and Public Policy; Policy and Global Affairs, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* (Washington, DC: National Academies Press, 2011), pp. 1-2. Also, although not specific to STEM, one 2009 report found that the U.S. Gross Domestic Product (GDP) could have been between two to four percent higher if the achievement gap between Latino/black and white students were narrowed. McKinsey & Company, Social Sector Office, *The Economic Impact of the Achievement Gap in America's Schools*, April 2009.

[105] For example, see David Beede et al., *Education Supports Racial and Ethnic Equality in STEM,* U.S. Department of Commerce, Economics and Statistics Administration, ESA Issue Brief #05-11, September 2011; Irwin Kirsch et al., *America's Perfect Storm: Three Forces Changing Our Nation's Future*, Educational Testing Service, Policy Information Center, Policy Evaluation and Research Center, January 2007; and National Academy of Sciences, National Academy of Engineering, and Institute of Medicine; Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline; Committee on Science, Engineering, and Public Policy; Policy and Global Affairs, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* (Washington, DC: National Academies Press, 2011).

Race and Ethnicity

Researchers have identified dozens of school and non-school variables that may contribute to racial and ethnic achievement gaps in STEM. For example, in 2011 researchers reviewed over 400 books, book chapters, journal articles, and policy reports on factors that influence minority student success in STEM (hereinafter referred to as the "2011 review").[106] The 2011 review found that the following factors positively influence the success of minority students in STEM:

- *K-12*—parental involvement and support, availability of bilingual education, culturally relevant pedagogy, early exposure to STEM fields, interest in STEM careers, self-efficacy in STEM subjects,[107] and STEM-related educational opportunities and support programs.[108]

The 2011 review also identified the following school-based factors as contributing to minority under-preparedness in elementary and secondary STEM education:

- *K-12*—a lack of resources (underfunding) and less qualified teachers at schools that serve minority students, limited access to Advanced Placement courses, disproportionate tracking of minority students into remedial education, teachers' low expectations, stereotype threat,[109] racial oppression and oppositional culture,[110] and premature departure from high school.[111]

At the post-secondary education level, the 2011 review identified the following factors as associated with varying levels of minority student STEM success in college:

[106] Each of the terms and factors from the 2011 review (as summarized in this report) are described in greater detail in Samuel D. Museus et al., "Racial and Ethnic Minority Students' Success in STEM Education," *ASHE Higher Education Report,* vol. 36, no. 6 (January 2011).

[107] The term "self-efficacy" refers to a student's confidence in his or her ability to learn STEM subjects.

[108] Samuel D. Museus et al., "Racial and Ethnic Minority Students' Success in STEM Education," *ASHE Higher Education Report,* vol. 36, no. 6 (January 2011), p. viii.

[109] "Stereotype threat" is a theory developed by some social psychologists to explain the perceived effects of negative group stereotypes on the academic performance of the targets of those stereotypes. In essence, the theory asserts that when confronted with negative group stereotypes (e.g., girls are bad at math), individuals perform more poorly than they are otherwise capable of doing on intellectual tests. (Claude M. Steele and Joshua Aronson, "Stereotype Threat and the Intellectual Test Performance of African Americans," *Journal of Personality and Social Psychology*, vol. 69. no. 5 (1995), pp. 797-811.)

[110] "Oppositional culture" is a theory developed by some social scientists to explain the academic disengagement of black students. In essence, the theory postulates that black Americans have formed a culture that opposes mainstream values (as reaction to racial oppression and discrimination) and that this oppositional culture leads black Americans to devalue academic success because it is associated with "acting white." (Signithia Fordham and John Ogbu, "Black Students' School Success: Coping with the Burden of Acting White," *Urban Review*, vol. 18, no. 3 (December 1985), pp. 176-206.) Some researchers criticize oppositional culture theory, arguing that African Americans actually maintain more pro-school values than whites, but that they lack the material conditions that foster the development of skills, habits, and styles rewarded by teachers. (James W. Ainsworth-Darnell and Douglas B. Downey, "Assessing the Oppositional Culture Explanation for Racial/Ethnic Differences in School Performance," *American Sociological Review*, vol. 63, no. 4 (August 1998), pp. 536-553.) In reflecting on the debate about oppositional culture theory, the authors of the 2011 review conclude, "this theory could plausibly be used to explain the negative educational outcomes of racial and ethnic minorities in K-12, particularly in STEM education." (Museus et. al., p. 37.)

[111] Samuel D. Museus et al., "Racial and Ethnic Minority Students' Success in STEM Education," *ASHE Higher Education Report,* vol. 36, no. 6 (January 2011), pp. vii-viii.

- *Higher Education*—colorblind meritocracy, financial aid and employment, institutional type, campus culture and climate, institutional agents, self-concept and self-efficacy, and STEM opportunity and support programs.[112]

In addition to these school-based factors described in the 2011 review, other researchers have identified non-school factors that contribute to achievement gaps in both STEM and non-STEM fields. Some scholars argue that these non-school factors have been overlooked and that too much emphasis is placed on schools.[113] Non-school factors that have been identified as contributing to achievement gaps include concentrated poverty and single-parent households,[114] early childhood development,[115] and health.[116]

Policy solutions for broadening participation in STEM are also numerous. In 2010, Congress directed the National Academies to examine diversity in the STEM workforce and make recommendations for broadening participation.[117] Of the many recommendations in the resulting report, the Academies identified several policy options as top priorities. These include increased financial support for minority undergraduate STEM students, improved teacher preparation, more and better advanced courses and academic advising for minority K-12 students, improved transition to graduate school for minority undergraduates in STEM fields, and increased availability of research assistantships for minority graduates students in STEM.[118] Other researchers have proposed solutions such as charter schools and school choice,[119] faith-based schooling,[120] improved transfer pathways from community colleges and reducing undergraduate debt,[121] and participation in undergraduate research.[122] Some analysts propose increased

[112] Samuel D. Museus et al., "Racial and Ethnic Minority Students' Success in STEM Education," *ASHE Higher Education Report,* vol. 36, no. 6 (January 2011), p. viii.

[113] James J. Heckman, *The American Family in Black and White: A Post-Racial Strategy for Improving Skills to Promote Equality*, National Bureau of Economic Research, Working Paper no. 16841, March 2011.

[114] Irwin Kirsch et al., *America's Perfect Storm: Three Forces Changing Our Nation's Future*, Educational Testing Service, Policy Information Center, Policy Evaluation and Research Center, January 2007.

[115] Educational Testing Service, Policy Evaluation and Research Center, *Positioning Young Black Boys for Educational Success*, Policy Notes: News from the ETS Policy Information Center, vol. 19, no. 3 (Fall 2011); and Eugene E. Garcia et al., "Early Academic Achievement of Hispanics in the United States: Implications for Teacher Preparation," *New Educator*, vol. 2, no. 2 (2006), pp. 123-147.

[116] Kevin Fiscella and Harriet Kitzman, "Disparities in Academic Achievement and Health: The Intersection of Child Education and Health Policy," *Pediatrics*, vol. 123, no. 3 (March 2009).

[117] P.L. 110-69, Section 7032.

[118] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine; Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline; Committee on Science, Engineering, and Public Policy; Policy and Global Affairs, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* (Washington, DC: National Academies Press, 2011).

[119] Matthew Ladner and Lindsey Burke, *Closing the Racial Achievement Gap: Learning from Florida's Reforms*, The Heritage Foundation, Backgrounder no. 2468, October 4, 2010.

[120] The White House Domestic Policy Council and U.S. Department of Education, *Preserving a Critical National Asset: America's Disadvantaged Students and the Crisis in Faith-Based Urban Schools*, September 2008, p. 7.

[121] Alicia C. Dowd, Lindsey E. Malcolm, and Elsa E. Macias, *Improving Transfer Access to STEM Bachelor's Degrees at Hispanic Serving Institutions through the America COMPETES Act*, University of Southern California, Rossier School of Education, Center for Urban Education, March 2010; and Steve Olsen and Jay B. Labov, rapporteurs, *Community Colleges in the Evolving STEM Education Landscape*, National Research Council and National Academy of Engineering; Division on Policy and Global Affairs, Board on Higher Education and Workforce; Division on Earth and Life Studies, Board on Life Sciences; Division on Behavioral and Social Sciences and Education, Board on Science Education; National Academy of Engineering, Engineering Education Program Office; and Division on (continued...)

investments in minority serving institutions (MSIs)—such as Historically Black Colleges and Universities (HBCU) or Tribal Colleges and Universities (TCUs)—as an option to broaden participation in STEM fields.[123]

Gender

Although the number of women earning colleges degrees has been increasing, they hold less than a quarter of STEM jobs nationally.[124] Scholars debate the causes of gender disparities in STEM. Some analysts assert that self-efficacy, institutional culture, discrimination, and bias limit female participation in science.[125] Other observers do not find evidence of widespread, contemporary discrimination against women in STEM fields; instead, they primarily attribute disparities to family formation and child rearing, gendered expectations, lifestyle choices, career preferences, and personal choice, among other complex factors.[126]

Differences in beliefs about the causes of gender disparities in STEM lead to different emphases in proposed solutions. Scholars who generally align with the discrimination hypothesis suggest a variety of policy options. Among these are policies that seek to increase girls' interest in STEM; create college environments (e.g., institutional culture) that attract and retain female students and faculty; and counteract bias by, among other things, creating clear and transparent criteria for success.[127] Scholars who generally align with the preferences hypothesis recommend so-called family friendly policies at academic institutions (e.g., part-time tenure track positions and childcare) and propose federal funding for research "on the differing lifecourses of women's and

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Behavioral and Social Sciences and Education, Teacher Advisory Council; Planning Committee on Evolving Relationships and Dynamics Between Two- and Four-Year Colleges, and Universities (Washington, DC: National Academies Press, May 8, 2012); and Alicia C. Dowd and Lindsey E. Malcom, *Reducing Undergraduate Debt to Increase Latina and Latino Participation in STEM Professions*, University of Southern California, Rossier School of Education, Center for Urban Education, May 2012.

[122] Gina A. Garcia and Sylvia Hurtado, *Predicting Latina/o STEM Persistence at HSIs and Non-HSIs*, University of California, Los Angeles, Graduate School of Education and Information Studies, Higher Education Research Institute, April 2011.

[123] For example, a March 16, 2010, congressional hearing on broadening participation in STEM included testimony on the role of MSIs in producing minority STEM graduates. U.S. Congress, House Committee on Science and Technology, Subcommittee on Research and Science Education, *Broadening Participation in STEM*, hearings, 111th Cong., 2nd sess., Serial No. 111-85 (Washington, DC: GPO, 2010).

[124] U.S. Department of Commerce, Economics and Statistics Administration, *Women in STEM: A Gender Gap to Innovation*, ESA Issue Brief #04-11, August 2011.

[125] Catherine Hill, Christianne Corbett, and Andresse St. Rose, *Why So Few: Women in Science, Technology, Engineering, and Mathematics*, American Association of University Women, February 2010; and National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, Committee on Maximizing the Potential of Women in Academic Science and Engineering, *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering* (Washington, DC: National Academies Press, 2007).

[126] Stephen J. Ceci and Wendy M. Williams, "Understanding Current Causes of Women's Underrepresentation in Science," *Proceedings of the National Academy of Sciences*, vol. 108, no. 8 (February 7, 2011), p. 3157-3162.

[127] Corinne A. Moss-Racusin, et al, "Science Faculty's Subtle Gender Biases Favor Male Students," *Proceedings of the National Academy of Sciences*, vol. 109, no. 41 (October 9, 2012), p. 16474-16479; and Catherine Hill, Christianne Corbett, and Andresse St. Rose, *Why So Few: Women in Science, Technology, Engineering, and Mathematics*, American Association of University Women, February 2010, pp. 90-96.

men's careers to determine whether the traditional timing of hiring, tenure and promotion may deny society and science the contributions of talented women."[128]

Other Factors

Some researchers argue that income is the most critical variable in achievements gaps and that gaps between children from high- and low-income families have grown substantially in recent decades. The income achievement gap, these researchers argue, is as determinative (if not more) than race.[129] Researchers have identified summer learning loss as one of the possible contributors to achievement gaps by income.[130] Studies show that students lose skills over the summer, especially in mathematics, and that the effects of these losses appear to accumulate over time. Further, losses appear to disproportionately affect low-income students.[131]

Other researchers have observed mathematics achievement gaps by urbanization level (e.g., between rural, urban, and suburban youth), finding that urban and rural youth have lower average mathematics achievement levels than their suburban peers and that this gap appears to widen between kindergarten and 8th grade. These findings, say the researchers, are not solely attributable to differences in socio-economic status.[132]

[128] Stephen J. Ceci and Wendy M. Williams, "Understanding Current Causes of Women's Underrepresentation in Science," *Proceedings of the National Academy of Sciences*, vol. 108, no. 8 (February 7, 2011), p. 3161.

[129] Sean Reardon, "The Widening Achievement Gap Between the Rich and the Poor: New Evidence and Possible Explanations," *Whither Opportunity*, ed. Greg J. Duncan and Richard J. Murnane (New York, NY: Russell Sage Foundation, September 2011), p. 91.

[130] Other factors associated with summer learning loss include demographic characteristics. For example, one 2006 study found that high-performing African-American and Hispanic students lost more achievement than their European-American peers over the summer and that low-performing African-American and Hispanic students grow less than low-performing students in all groups. See Martha S. McCall et. al., *Achievement Gaps: An Examination of Differences in Student Achievement and Growth*, Northwest Evaluation Association, November 2006.

[131] Jennifer Sloan McCombs et al., *Making Summer Count: How Summer Programs Can Boost Children's Learning*, RAND Corporation, 2011.

[132] Suzanne E. Graham and Lauren E. Provost, *Mathematics Achievement Gaps Between Suburban Students and Their Rural and Urban Peers Increase Over Time*, University of New Hampshire, Carsey Institute, Issue Brief No. 52, Summer 2012.

Appendix A. Data Sources and Major Publications

Federal STEM education analysts rely on a number of sources and major publications for data about the federal STEM education effort and the condition of STEM education in the United States and around the globe. This appendix includes links to sources and publications where readers can find the most up-to-date STEM education data and information.

National and International Assessments

- **National Assessment of Educational Progress (NAEP)**—The NAEP is the largest nationally representative and continuing assessment of U.S. K-12 students. There are two NAEP assessments: Main NAEP and Long-Term Trends (LTT). The Main NAEP administers assessments in 12 subject areas, including mathematics and science. The LTT assesses mathematics and reading. More information about these assessments is available at
    - *Main NAEP Science*—http://nces.ed.gov/nationsreportcard/science/.
    - *Main NAEP Mathematics*—http://nces.ed.gov/nationsreportcard/mathematics/.
    - *LTT Mathematics*—http://nationsreportcard.gov/ltt_2008/.
- **Trends in International Mathematics and Science Study (TIMSS)**—TIMSS is an international test that assesses the mathematics and science achievements of U.S. 4th and 8th grade students in a manner that is comparable across countries. More information about TIMSS is available at http://nces.ed.gov/timss/.
- **Program for International Student Assessment (PISA)**—PISA assesses the reading, mathematics, and science literacy of 15-year-old students in dozens of industrialized and developing nations. More information about PISA is available at http://nces.ed.gov/surveys/pisa/.

Federal Programs and Inventories

- **U.S. Government Accountability Office, Science, *Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs Across Multiple Agencies* (GAO-12-108)**—This 2012 GAO report on federal STEM education programs includes an inventory of federal STEM education programs and policy recommendations. The report is available at http://gao.gov/products/GAO-12-108.
- **National Science and Technology Council, *A Report from the Federal Inventory of STEM Education Fast-Track Action Committee* (NSTC 2011) and *A Report from the Federal Coordination in STEM Education Task Force* (NSTC 2012)**—These reports provide an inventory of federal STEM education investments from FY2008 to FY2010 actual (in the 2011 report) and an update with information from FY2011 enacted to FY2013 requested (in the 2012 report).
    - *NSTC 2011*—This report is available at http://www.whitehouse.gov/sites/default/files/microsites/ostp/costem__federal_stem_education_portfolio_report.pdf.

    - *NSTC 2012*—This report is available at http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc_federal_stem_education_coordination_report.pdf.

- **U.S. Department of Education, Academic Competitiveness Council (ACC), *Report of the Academic Competitiveness Council***—The 2007 ACC report provides an inventory of federal STEM education programs with funding data from FY2005 actual to the FY2007 President's budget request. Includes policy recommendations and an assessment of STEM education program evaluations from across the federal enterprise. The 2007 ACC report is available at http://www2.ed.gov/about/inits/ed/competitiveness/acc-mathscience/index.html.
- **U.S. Government Accountability Office, *Higher Education: Federal Science, Technology, Engineering, and Mathematics Programs and Related Trends* (GAO-06-114)**—This 2005 GAO report includes an inventory of federal STEM education programs and assesses program goals and constituencies served. The 2005 GAO report is available at http://www.gao.gov/products/GAO-06-114.

Condition of STEM Education

- **National Science Board, *Science and Engineering Indicators 2012***—This publication provides, among other things, one of the most comprehensive collections of key STEM indicators. It is published every two years. More information about *Science and Engineering Indicators* is available at http://www.nsf.gov/statistics/seind12/front/fronts6.htm.
- **National Science Foundation, National Center for Science and Engineering Statistics (NCSES)**—NCSES compiles and analyzes a variety of STEM data. Much of this data may be found in *Science and Engineering Indicators*, but the NCSES website includes separate, detailed, and timely publications on various STEM education data. More information about NCSES is available at http://www.nsf.gov/statistics/.

Appendix B. Selected Major Legislation

Depending on how broadly the term is defined, federal interest in STEM education may be traced to the 1st Congress. Several institutions that would become central parts of the federal STEM education effort—such as Health and Human Services (1798, 1 Stat. 605),[133] the Smithsonian Institution (1846, 9 Stat. 103), the National Academy of Sciences (1863, 12 Stat. 806), and Department of Education (originally the Office of Education, 1867, 14 Stat. 434)—were in place before the United States celebrated its first centennial.

Federal STEM education policymaking intensified after World War II. The desire to maintain the scientific achievements of the war led to the creation of the National Science Foundation in 1950. By 1952, NSF was issuing GRF awards to promising STEM graduate students. The Soviet Union's launch of the first artificial satellite, *Sputnik*, triggered fears that the United States was falling behind in mathematics and science education and led to the National Defense Education Act of 1958, which some analysts cite as the first federal foray into STEM education policy in the modern era.

This appendix includes selected historical federal STEM education measures arranged by date.[134]

Land Ordinance of 1785[135] and Northwest Ordinance of 1787[136]

The Land Ordinance of 1785 was one of a series of three measures providing for the political and geographic incorporation of the Northwest Territories in the Union. These measures were passed by the Continental Congress after the Revolutionary War and prior to the adoption of the Constitution. Drafted primarily for the purpose of disposing of land in the territories, the Land Ordinance of 1785 directed surveyors to establish townships in the territories. These townships were to be subdivided into lots, one of which (lot number 16) was to be preserved for the maintenance of a public school. The Land Ordinance's more famous cousin, the Northwest Ordinance of 1787, established governments in the territories and provided for the civil liberties of the inhabitants. On the question of education the Northwest Ordinance said, "Religion, morality and knowledge, being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged."[137]

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133 The Department of Health and Human Services (HHS) traces its history to establishment of the federal Marine Hospital Service, forerunner of the contemporary U.S. Public Health Service, in 1798. More information about HHS history is available at http://www.hhs.gov/about/hhshist.html.

134 Unless otherwise indicated, historical STEM education measures in this section are described *as originally passed*. Most of these measures have been amended, in some cases quite significantly (including repeal), since they became law.

135 John C. Fitzpatrick, ed., *Journals of the Continental Congress 1774-1789*, edited from the original records in the Library of Congress, vol. 28 (Washington, DC: GPO, 1933), p. 375, http://memory.loc.gov/cgi-bin/query/r?ammem/hlaw:@field%28DOCID+@lit%28jc0281%29%29.

136 Library of Congress, *Primary Documents in America History: Northwest Ordinance*, Library of Congress/Virtual Services Digital Reference Section/Web Guides website, April 25, 2012, http://www.loc.gov/rr/program/bib/ourdocs/northwest.html.

137 Library of Congress, *An Ordinance for the Government of the Territory of the United States, North-West of the River Ohio*, Library of Congress/American Memory/Documents from the Continental Congress and Constitutional Convention 1774-1789 website, no date, http://memory.loc.gov/cgi-bin/query/r?ammem/bdsdcc:@field(DOCID+@lit(bdsdcc22501)).

Marine Hospital Service Act of 1798 (1 Stat. 605)[138]

Congress established the Marine Hospital Service (MHS) in 1798 to provide medical care for merchant seaman. Many federal health agencies trace their origin to the establishment of the MHS; including the National Institute of Health (NIH), which began as the Hygienic Laboratory within the MHS in 1887. The Ransdell Act of 1930 (P.L. 71-251) re-designated the Hygienic Laboratory as the NIH and authorized fellowships at the institute. Although NIH education and training funding in the 1930s, 1940s, and 1950s primarily focused on post-doctoral researchers and clinical traineeships for physicians, in 1948 the National Institute of Cancer began awarding funds to institutions to improve undergraduate education.[139] In 1974 Congress established the National Research Service Award (NRSA) at NIH. The National Research Service Award Act (P.L. 93-348) consolidated and established under a single authority existing research and fellowship authorities. P.L. 107-206 re-named the NRSA the "Ruth L. Kirschstein National Research Service Award" in 2002.

Morrill Acts of 1862 (12 Stat. 503)[140] and 1890 (26 Stat. 417)

The Morrill Act of 1862 authorized the sale of federal lands and distribution of the proceeds to the states for the purpose of establishing colleges in the "mechanic arts" (e.g., engineering, manufacturing, inventions), agriculture, and military tactics. The original Morrill Act did not apply to the "states in rebellion," but in 1890 Congress passed a subsequent measure to provide for colleges in Southern states.[141] The 1890 Morrill Act also expanded the purposes of the colleges to include "agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science." These provisions were repealed in 1981 and replaced with "food and agricultural sciences."[142] Colleges funded by these acts include the Massachusetts Institute of Technology, Clemson University, and many U.S. Historically Black Colleges and Universities.[143]

National Science Foundation Authorization Act of 1950 (P.L. 81-507)[144]

The NSF was established in 1950 to—in part—"develop and encourage the pursuit of a national policy for basic research and education in the sciences."[145] Congress passed the act authorizing

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[138] The statute establishing the MHS does not include a formal title for the act. For the sake of consistency with other headings in this section, CRS used the title "Marine Hospital Service Act of 1789" to describe 1 Stat. 605. A copy of this statute is available at http://memory.loc.gov/cgi-bin/ampage?collId=llsl&fileName=001/llsl001.db&recNum=728.

[139] U.S Congress, Senate Committee on Labor and Public Welfare, *National Research Service Award Act*, report to accompany H.R. 7724, 93rd Cong., 1st sess., S. Rept. 93-381.

[140] National Archives and Records Administration, *Morrill Act (1862)*, National Archives and Records Administration/100 Milestone Documents website, no date, http://www.ourdocuments.gov/doc.php?doc=33, http://www.ourdocuments.gov/doc.php?doc=33.

[141] The 1890 measure required states that accepted funds to either (a) discount race in admissions, or (b) provide separate colleges for white and black students.

[142] Agriculture and Food Act of 1981 (P.L. 97-98).

[143] Library of Congress, *Primary Documents in America History: Morrill Act*, Library of Congress/Virtual Services Digital Reference Section/Web Guides website, July 30, 2010, http://www.loc.gov/rr/program/bib/ourdocs/Morrill.html.

[144] For more information on STEM education at the NSF, see CRS Report R42470, *An Analysis of STEM Education Funding at the NSF: Trends and Policy Discussion*, by Heather B. Gonzalez.

the Foundation after several years of debate and a veto in 1947.[146] NSF distributed its first fellowships to pre- and post-doctoral STEM students in 1952. As early as 1953 the Foundation began supporting teacher institutes as a means of improving STEM education in the lower grades.[147] Although both the Congress and the President have made changes to the NSF since its founding, STEM education has remained a core function of the agency.

National Defense Education Act of 1958 (P.L. 85-864)

Passed in 1958 in response to the Soviet Union's launch of *Sputnik*, the National Defense Education Act (NDEA), sought to address concerns about "existing imbalances in our educational programs which have led to an insufficient proportion of our population educated in science, mathematics, and modern foreign languages and trained in technology."[148] Among its many provisions, the NDEA authorized the first federal student loan program; provided funds to states for science, mathematics, and modern foreign language instruction; and authorized grants to states for programs to identify and encourage gifted students. Some NDEA scholars assert that this act paved the way for the Elementary and Secondary Education Act of 1965 by establishing a legislative precedent for federal education aid to states.[149]

Elementary and Secondary Education Act of 1965 (P.L. 89-10)[150]

The primary source of federal aid to K-12 education is the Elementary and Secondary Education Act (ESEA).[151] ESEA was initially enacted in 1965 and was most recently amended and reauthorized by the No Child Left Behind Act of 2001 (NCLB, P.L. 107-110). STEM education was not central to the ESEA as originally constructed in 1965, but STEM-specific provisions have been added in subsequent reauthorizations. For example, as amended by No Child Left Behind, the act authorizes the Mathematics and Science Partnerships (MSP) program at ED[152] and requires states to have mathematics assessments and standards.

(...continued)

[145] National Science Foundation Act of 1950 (P.L. 81-507), http://www.nsf.gov/about/history/legislation.pdf.

[146] Controversy over the founding of the NSF focused mostly on organizational questions, concerns about patents, and on other issues not related to STEM education.

[147] Dorothy Schaffter, *The National Science Foundation* (New York, NY: Frederick A. Praeger, Publishers, 1969), p. 96.

[148] National Defense Education Act (P.L. 85-864).

[149] For example, see Barbara Barksdale Clowse, *Brainpower for the Cold War: The Sputnik Crisis and National Defense Education Act of 1958* (Westport, CT: Greenwood Press, 1981), p. 147; and Wayne J. Urban, *More Than Science and Sputnik: The National Defense Education Act of 1958* (Tuscaloosa, AL: University of Alabama Press, 2010), p. 202.

[150] For more information on ESEA, see CRS Report RL33960, *The Elementary and Secondary Education Act, as Amended by the No Child Left Behind Act: A Primer*, by Rebecca R. Skinner.

[151] Particularly Title I, Part A, Program of Education for the Disadvantaged.

[152] NSF hosts a companion program that is also called Mathematics and Science Partnerships (MSP). As currently authorized, the two programs were designed to complement each other.

Higher Education Act of 1965 (P.L. 89-329)

The Higher Education Act (HEA) authorizes a series of programs that provide federal aid and support to institutions of higher education as well as a broad array of federal student aid programs that assist students and their families with paying for or financing the costs of obtaining a postsecondary education. The HEA was most recently amended in 2008 by the Higher Education Opportunity Act (P.L. 110-315); however, the only major STEM-related postsecondary program administered by ED was enacted by the Higher Education Reconciliation Act of 2005 (HERA; P.L. 109-171). The HERA amendments included authorization and appropriations for the SMART Grant program, which provided $4,000 grants to students majoring in STEM fields. Congress provided that the program sunset at the end of the 2010-2011 academic year. Approximately $1.4 billion in grants were awarded between FY2006 and FY2010.

Department of Education Organization Act of 1979 (P.L. 96-88)

The Department of Education Organization Act established ED as an independent federal agency. Section 304 of the act transferred science education programs established at NSF to ED.[153] Excluded from this directive were programs that related to scientific career development, continuing education of scientific personnel, career-focused broadening participation programs, research and development in science learning, and programs to inform the general public about the nature of science and technology and related policy issues. The conference report on the final bill included two specific examples of NSF programs to be transferred to ED: Elementary and Pre-school Science Teacher Training and Minority Institutions Science Improvement.[154] The act provided only for the transfer of programs in existence at the time of enactment and included a provision affirming NSF's authority to initiate and conduct programs under its originating act (P.L. 81-507).

Education for Economic Security Act of 1984 (P.L. 98-377)

The Education for Economic Security Act of 1984 (EESA) authorized teacher institutes and mathematics and science education development programs (including partnerships) at the National Science Foundation; directed the Department of Education to provide grants to states and local educational agencies for STEM teacher training and development; and authorized presidential awards for teaching in mathematics and science, among other things. EESA was enacted following publication of several reports—most notably *A Nation at Risk*—that were highly critical of the U.S. education system and amid growing concerns about international competitiveness in the wake of the 1970s recession and apparent ascendancy of the Japanese and German economies.

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[153] Department of Education Organization Act (P.L. 96-88), http://www.eric.ed.gov/PDFS/ED180121.pdf.

[154] U.S. Congress, Senate Committee on Governmental Affairs, *Legislative History of P.L. 96-88, Department of Education Organization Act* (Part 2), committee print, 96th Cong., 2nd sess. (Washington, DC: GPO 1980), p. 1758.

America COMPETES Act of 2007 (P.L. 110-69) and America COMPETES Reauthorization Act of 2010 (P.L. 111-358)[155]

The America COMPETES Act (and its 2010 reauthorization) authorized a variety of STEM education programs at several federal science agencies and ED. Most of the specified STEM education appropriations authorizations in these acts are at the NSF, but the acts also contain STEM education provisions for the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and the National Oceanic and Atmospheric Administration (NOAA). Among other things, the 2010 reauthorization established a federal government-wide STEM education coordinating committee under the National Science and Technology Council.

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[155] For more information about the America COMPETES Act see CRS Report R41819, *Reauthorization of the America COMPETES Act: Selected Policy Provisions, Funding, and Implementation Issues*, by Heather B. Gonzalez.

The acronym refers to science, technology, engineering, and mathematics and includes careers in physical and life sciences, computer science, mathematics, and engineering. Many employment experts include health professions, health technology, and social sciences under this umbrella as well. Should You Pursue a STEM Career? There are some incredibly compelling reasons to pursue a STEM careerÂ In fact, combining arts education with STEM education can provide you with some vital skills such as critical reasoning, problem solving, time management, communication, and presentation skills. In addition, design is an essential ingredient in innovation. Not only must things be functional, but they must also be aesthetically pleasing.