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Science, Technology, Engineering, and Mathematics (STEM) Education Issues and Legislative Options

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Science, Technology, Engineering, and Mathematics (STEM) Education Issues and Legislative Options

Summary

There is growing concern that the United States is not preparing a sufficient number of students, teachers, and practitioners in the areas of science, technology, engineering, and mathematics (STEM). A large majority of secondary school students fail to reach proficiency in math and science, and many are taught by teachers lacking adequate subject matter knowledge.

When compared to other nations, the math and science achievement of U.S. pupils and the rate of STEM degree attainment appear inconsistent with a nation considered the world leader in scientific innovation. In a recent international assessment of 15-year-old students, the U.S. ranked 28th in math literacy and 24th in science literacy. Moreover, the U.S. ranks 20th among all nations in the proportion of 24-year-olds who earn degrees in natural science or engineering.

A recent study by the Government Accountability Office found that 207 distinct federal STEM education programs were appropriated nearly $3 billion in FY2004. Nearly three-quarters of those funds and nearly half of the STEM programs were in two agencies — the National Institutes of Health and the National Science Foundation. Still, the study concluded that these programs are highly decentralized and require better coordination.

Several pieces of legislation have been introduced in the 109th Congress that address U.S. economic competitiveness in general and support STEM education in particular. These proposals are designed to improve output from the STEM educational pipeline at all levels, and are drawn from several recommendations offered by the scientific and business communities.

The objective of this report is to provide a useful context for these legislative proposals. To achieve this, the report first presents data on the state of STEM education and then examines the federal role in promoting STEM education. The report concludes with a discussion of selected legislative options currently being considered to improve STEM education. The report will be updated as significant legislative actions occur.

Science, Technology, Engineering, and Mathematics (STEM) Education Issues and Legislative Options

Introduction

There is growing concern that the United States is not preparing a sufficient number of students, teachers, and professionals in the areas of science, technology, engineering, and mathematics (STEM).[1] Although the most recent National Assessment of Educational Progress (NAEP) results show improvement in U.S. pupils' knowledge of math and science, the large majority of students still fail to reach adequate levels of proficiency. When compared to other nations, the achievement of U.S. pupils appears inconsistent with the nation's role as a world leader in scientific innovation. For example, among the 40 countries participating in the 2003 Program for International Student Assessment (PISA), the U.S. ranked 28th in math literacy and 24th in science literacy.

Some attribute poor student performance to an inadequate supply of qualified teachers. This appears to be the case with respect to subject-matter knowledge: many U.S. math and science teachers lack an undergraduate major or minor in those fields — as many as half of those teaching in middle school math. Indeed, post-secondary degrees in math and physical science have steadily decreased in recent decades as a proportion of all STEM degrees awarded. While degrees in some STEM fields (particularly biology and computer science) have increased in recent decades, the overall proportion of STEM degrees awarded in the United States has historically remained at about 17% of all postsecondary degrees awarded. Meanwhile, many other nations have seen rapid growth in postsecondary educational attainment — with particularly high growth in the number of STEM degrees awarded. According to the National Science Foundation, the United States currently

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[1] In 2005 and early 2006, at least six major reports were released by highly respected U.S. academic, scientific, and business organizations on the need to improve science and mathematics education: The Education Commission of the States, *Keeping America Competitive: Five Strategies To Improve Mathematics and Science Education*, July 2005; The Association of American Universities, *National Defense Education and Innovation Initiative, Meeting America's Economic and Security Challenges in the 21st Century*, January 2006; The National Academy of Sciences, Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, February 2006; The National Summit on Competitiveness, *Statement of the National Summit on Competitiveness: Investing in U.S. Innovation*, December 2005; The Business Roundtable, *Tapping America's Potential: The Education for Innovation Initiative*, July 2005; the Center for Strategic and International Studies, *Waiting for Sputnik*, 2005.

ranks 20th among all nations in the proportion of 24-year-olds who earn degrees in natural science or engineering. Once a leader in STEM education, the United States is now far behind many countries on several measures.

What has been the federal role in promoting STEM education? A recent study by the Government Accountability Office (GAO) found that 207 distinct federal STEM education programs were appropriated nearly $3 billion in FY2004.[2] Nearly three-quarters of those funds supported 99 programs in two agencies — the National Institutes of Health (NIH) and the National Science Foundation (NSF). Most of the 207 programs had multiple goals, provided multiple types of assistance, and were targeted at multiple groups. The study concluded that these programs are highly decentralized and could benefit from stronger coordination, while noting that the creation of the National Science and Technology Council in 1993 was a step in the right direction.[3]

Several pieces of legislation have been introduced in the 109th Congress that would support STEM education in the United States. Many of the proposals in these bills have been influenced by the recommendations of several reports recently issued by the scientific, business, and policy-making communities. Of particular influence has been a report issued by the National Academy of Sciences (NAS), *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* — also known as the "Augustine" report. Many of the recommendations appearing in the NAS report are also contained in the Administration's *American Competitiveness Initiative*.[4] Among the report's many recommendations, five are targeted at improving STEM education. These five recommendations seek to increase the supply of new STEM teachers, improve the skills of current STEM teachers, enlarge the pre-collegiate pipeline, increase postsecondary degree attainment, and enhance support for graduate and early-career research.

The purpose of this report is to put these legislative proposals into a useful context. The first section analyzes data from various sources to build a more thorough understanding of the status of STEM education in the United States. The second section looks at the federal role in promoting STEM education, providing a broad overview of nearly all of the programs in federal agencies and a detailed look at a few selected programs. Finally, the third section discusses legislative options currently being considered to improve STEM education. This discussion focuses primarily on the proposals that have seen congressional action to date.

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

[3] These points were reiterated by Cornelia M. Ashby, Director of GAO's Education, Workforce, and Income Security Team. Her testimony can be found at [http://edworkforce.house.gov/hearings/109th/fc/competitiveness050306/wl5306.htm], as well as on the GAO website at [http://www.gao.gov/new.items/d06702t.pdf].

[4] Office of Science and Technology Policy, Domestic Policy Council, *American Competitiveness Initiative — Leading the World In Innovation*, Feb. 2006.

STEM Education in the United States

Elementary and Secondary Education

Assessments of Math and Science Knowledge. National-level assessment of U.S. students' knowledge of math and science is a relatively recent phenomenon, and assessments in other countries that provide for international comparisons are even more recent. Yet the limited information available thus far is beginning to reveal results that concern many individuals interested in the U.S. educational system and the economy's future competitiveness. The most recent assessments show improvement in U.S. pupils' knowledge of math and science; however, the large majority still fail to reach adequate levels of proficiency. Moreover, when compared to other nations, the achievement of U.S. students is seen by many as inconsistent with the nation's role as a world leader in scientific innovation.

The National Assessment of Educational Progress (NAEP) is the only nationally representative, continuing assessment of elementary and secondary students' math and science knowledge. Since 1969, NAEP has assessed students from both public and nonpublic schools at grades 4, 8, and 12. Students' performance on the assessment is measured on a 0-500 scale, and beginning in 1990 has been reported in terms of the percentages of students attaining three achievement levels: *basic, proficient,* and *advanced*.[5]

Proficient is the level identified by the National Assessment Governing Board as the degree of academic achievement that all students should reach, and "represents solid academic performance. Students reaching this level have demonstrated competency over challenging subject matter." In contrast, the board states that "Basic denotes partial mastery of the knowledge and skills that are fundamental for proficient work at a given grade."[6]

The most recent NAEP administration occurred in 2005; results from that year have only been released for math assessments for grades 4 and 8.[7] **Figure 1** displays the available results from the NAEP math tests administered between 1990 and 2005. Although the proportion of 4th and 8th grade students achieving the proficient level or above has been increasing each year, overall math performance has been quite low. The percentage performing at the basic level has not improved in 15 years. About two in five students continue to achieve only partial mastery of math. In 2005, only about one-third of 4th and 8th grade students performed at the proficient level in math

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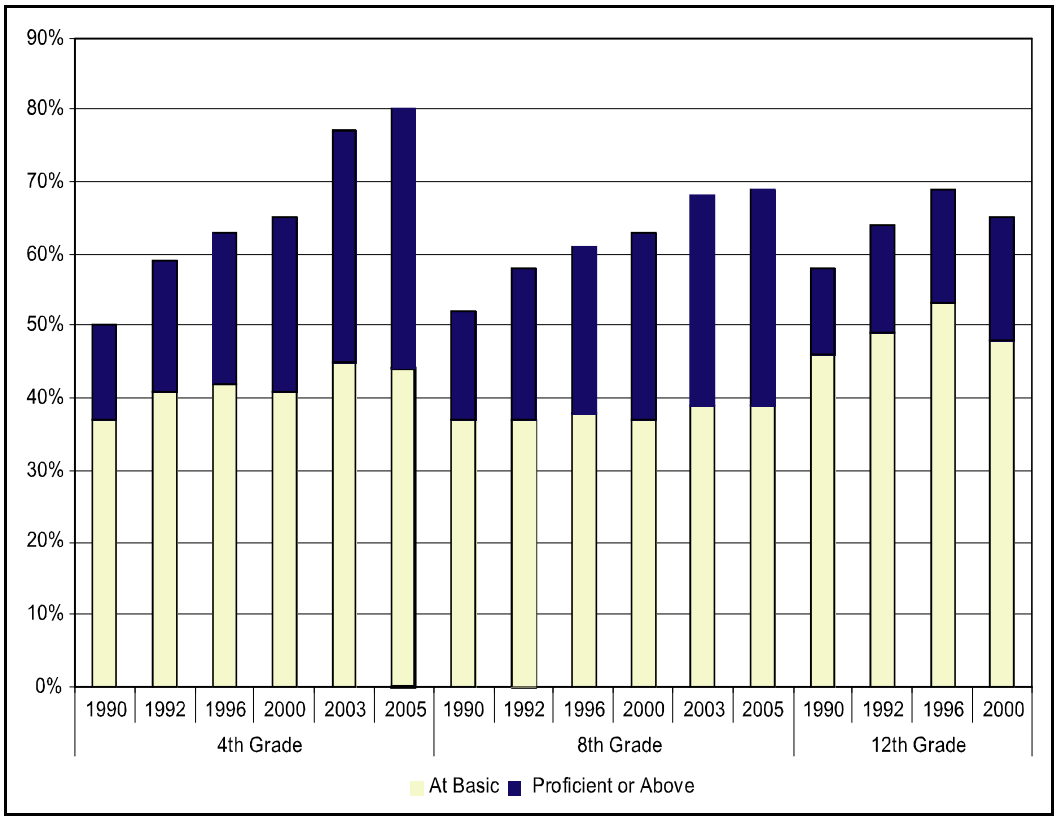
[5] For more information on NAEP and other assessments, see CRS Report RL31407, *Educational Testing: Implementation of ESEA Title I-A Requirements Under the No Child Left Behind Act*, by Wayne C. Riddle.

[6] The National Assessment Governing Board is an independent, bipartisan group created by Congress in 1988 to set policy for the NAEP. More information on the board and NAEP achievement levels can be found at [http://www.nagb.org/].

[7] The results for science assessments for all grades and math assessments for grade 12 are expected to be released later this year.

— 36% and 30%, respectively.[8] The remainder of students — approximately 20% of 4th graders and just over 30% of 8th graders — scored below the basic level.

Figure 1. Percentages of Students Scoring Basic and Proficient in Math, Selected Years: 1990-2005



Source: U.S. Department of Education, National Center for Education Statistics, *The Nation's Report Card*, various years.

For 12th grade students, the most recently published NAEP results are from the 2000 assessments.[9] Only 17% of 12th grade students performed at the proficient or higher level on the math assessment that year.[10] This figure was only slightly higher than the previous two assessments in 1996 (16%) and 1992 (15%), but was significantly higher, in statistical terms, than the 12% reported proficient in 1990. Progress aside, it appears that very few students graduate from U.S. high schools with

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[8] U.S. Department of Education, National Center for Education Statistics, *The Nation's Report Card: Mathematics 2005*, (NCES 2006-453), Oct. 2005, p. 3.

[9] The reporting delay for the 2005 grade 12 math assessments is due, in part, to substantial changes made in the assessment framework, and will not include comparisons to results from previous years.

[10] U.S. Department of Education, National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000* (NCES 2001-517) Aug. 2001, Figure B.

math skills considered adequate. More than half of all 12th grade students performed below even the basic level in each assessment year except 1996.

Similarly low levels of achievement have been found with regard to knowledge of science. In 2000, the most recent assessment year available, the percentage of 4th, 8th, and 12th grade students scoring proficient or above was 29%, 32%, and 18%, respectively; compared to 29%, 29%, and 21%, respectively, on the only previous NAEP science assessment (in 1996).

Math and Science Teacher Quality

Many observers look to the nation's teaching force as a source of national shortcomings in student math and science achievement. A recent review of the research on teacher quality conducted over the last 20 years revealed that, among those who teach math and science, having a major in the subject taught has a significant positive impact on student achievement.[15] Unfortunately, many U.S. math and science teachers lack this credential. The Schools and Staffing Survey (SASS) is the only nationally representative survey that collects detailed data on teachers' preparation and subject assignments.[16] The most recent administration of the survey for which public data are available took place during the 1999-2000 school year. That year, there were just under 3 million teachers in U.S. schools, about evenly split between the elementary and secondary levels. Among the nation's 1.4 million public secondary school teachers, 13.7% reported math as their main teaching assignment and 11.4% reported science as their main teaching assignment.[17]

Nearly all public secondary school math and science teachers held at least a baccalaureate degree (99.7%), and most had some form of state teaching certification (86.2%) at the time of the survey.[18] However, many of those who taught middle school (classified as grades 5-8) math and science lacked an undergraduate or graduate major or minor in the subject they taught. Among middle-school teachers, 51.5% of those who taught math and 40.0% of those who taught science did not have a major or minor in these subjects. By contrast, few of those who taught high school (classified as grades 9-12) math or science lacked an undergraduate or graduate major or minor in that subject. Among high school teachers, 14.5% of those who taught math and 11.2% of those who taught science did not have a major or minor in these subjects.[19] **Table 3** displays these statistics for teachers in eight subject areas.

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

[16] The sample is drawn from the Department of Education Common Core of Data, which contains virtually every school in the country.

[17] U.S. Department of Education, *Digest of Education Statistics, 2004*, NCES 2005-025, Oct. 2005, Table 67.

[18] CRS analysis of Schools and Staffing Survey data, Mar. 29, 2006.

[19] U.S. Department of Education, *Qualifications of the Public School Teacher Workforce*, May 2002, Tables B-11 and B-12.

Table 3. Percentage of Middle and High School Teachers Lacking a Major or Minor in Subject Taught, 1999-2000

	Middle School	High School
English	44.8%	13.3%
Foreign language	27.2%	28.3%
Mathematics	51.5%	14.5%
Science	40.0%	11.2%
Social science	29.6%	10.5%
ESL/bilingual education	57.6%	59.4%
Arts and music	6.8%	6.1%
Physical/health education	12.6%	9.5%

Source: U.S. Department of Education, National Center for Education Statistics, *Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-Field Teaching 1987-88 to 1999-2000*, NCES 2002-603, May 2002.

Given the link between teachers' undergraduate majors and student achievement in math and science, these data appear to comport with some of the NAEP findings discussed earlier. Recall that those assessments revealed that only about one-third of 4th and 8th grade students performed at the proficient or higher level in math and science. On the other hand, at the high school level, the data seem to diverge. While four-fifths of math and science teachers at this level have a major in the subject, only two-fifths of high school students scored proficient or above on the NAEP in those subjects.

Postsecondary Education

STEM Degrees Awarded in the United States. The number of students attaining STEM postsecondary degrees in the U.S. more than doubled between 1960 and 2000; however, as a proportion of degrees in all fields, STEM degree awards have stagnated during this period.[20] In the 2002-2003 academic year, more than 2.5 million degrees were awarded by postsecondary institutions in the United States.[21] That year, just under 16% (399,465) of all degrees were conferred in STEM fields; all STEM degrees comprised 14.6% of associate degrees, 16.7% of baccalaureate degrees, 12.9% of master's degrees, and 34.8% of doctoral degrees.[22] **Table 4** displays the distribution of degrees granted by academic level and field of study.

At the associate and baccalaureate levels, the number of STEM degrees awarded was roughly equivalent to the number awarded in business. In 2002-2003, 92,640

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[20] Through various "completions" surveys of postsecondary institutions administered annually since 1960, ED enumerates the number of degrees earned in each field during the previous academic year.

[21] U.S. Department of Education, National Center for Education Statistics, *Digest of Education Statistics, 2004*, NCES 2005-025, Oct. 2005, Table 169.

[22] Includes Ph.D., Ed.D., and comparable degrees at the doctoral level, but excludes first-professional degrees, such as M.D., D.D.S., and law degrees.

associate degrees and 224,911 baccalaureate degrees were awarded in STEM fields, compared to 102,157 and 293,545, respectively, in business. However, nearly twice as many master's degrees were granted in business (127,545) as in STEM (65,897), and an even larger number of master's degrees were awarded in education (147,448). At the doctoral level, STEM plays a larger role. Doctoral degrees awarded in STEM fields account for more than one-third of all degrees awarded at this level. Education is the only field in which more doctoral degrees (6,835) were awarded than in the largest three STEM fields — biology, engineering, and the physical sciences (5,003, 5,333, and 3,858, respectively).

Specialization within STEM fields also varies by academic level. Engineering was among the most common STEM specialties at all levels of study in 2002-2003. Biology was a common specialization at the baccalaureate and doctoral levels, but not at the master's level. Computer science was common at all but the doctoral level. Physical sciences was a common specialization *only* at the doctoral level.

Figure 2 displays the trends in STEM degrees awarded over the last three decades (excluding associate degrees). The solid line represents the number of STEM degrees awarded as a proportion of the total number of degrees awarded in all fields of study. The flat line indicates that the ratio of STEM degrees to all degrees awarded has historically hovered at around 17%. The bars represent the number of degrees awarded in each STEM sub-field as a proportion of all STEM degrees awarded. The top two segments of each bar reveal a consistent decline, since 1970, in the number of degrees awarded in math and the physical sciences. The bottom segment of each bar shows a history of fluctuation in the number of degrees awarded in biology over the last 30 years. The middle two segments in the figure represent the proportion of degrees awarded in engineering and computer science. The figure reveals a steady decline in the proportion of STEM degrees awarded in engineering since 1980, and a steady increase in computer science degrees (except for a contraction that occurred in the late 1980s following a rapid expansion in the early 1980s).

Table 4. Degrees Conferred by Degree-Granting Institutions by Academic Level and Field of Study, 2002-2003

	Associate	Baccalaureate	Master's	Doctoral	Total
All fields	**632,912**	**1,348,503**	**512,645**	**46,024**	**2,540,084**
STEM fields, total	**92,640**	**224,911**	**65,897**	**16,017**	**399,465**
STEM, percentage of all fields	**14.6%**	**16.7%**	**12.9%**	**34.8%**	**15.7%**
Biological and biomedical sciences	1,496	60,072	6,990	5,003	73,561
Computer and information sciences	46,089	57,439	19,503	816	123,847
Engineering and engineering technologies	42,133	76,967	30,669	5,333	155,102
Mathematics and statistics	732	12,493	3,626	1,007	17,858
Physical sciences and science technologies	2,190	17,940	5,109	3,858	29,097
Non-STEM fields, total	**540,272**	**1,123,592**	**446,748**	**30,007**	**2,140,619**
Business	102,157	293,545	127,545	1,251	524,498
Education	11,199	105,790	147,448	6,835	271,272
English language and literature/letters	896	53,670	7,413	1,246	63,225
Foreign languages and area studies	1,176	23,530	4,558	1,228	30,492
Liberal arts and sciences, general studies, and humanities	216,814	40,221	3,312	78	260,425
Philosophy, theology, and religious studies/vocations	804	18,270	6,677	1,983	27,734
Psychology	1,784	78,613	17,123	4,831	102,351
Social sciences	5,422	115,488	12,109	2,989	136,008
History	316	27,730	2,525	861	31,432
Other	199,704	366,735	118,038	8,705	693,182

Source: U.S. Department of Education, National Center for Education Statistics, *Digest of Education Statistics, 2004*, NCES 2005-025, Oct. 2005, Table 249-252..

Figure 2. STEM Degrees Awarded, 1970-2003