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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 28^{th} in math literacy and 24^{th} in science literacy. Moreover, the U.S. ranks 20^{th} 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 109^{th} 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.

Contents

Introduction 1

STEM Education in the United States 3
Elementary and Secondary Education 3
Assessments of Math and Science Knowledge 3
U.S. Students Compared to Students in Other Nations 5
Math and Science Teacher Quality 9
Postsecondary Education 10
STEM Degrees Awarded in the United States 10
U.S. Degrees Awarded to Foreign Students 14
International Postsecondary Educational Attainment 14
International Comparisons in STEM Education 18

Federal Programs that Promote STEM Education 19
Government Accountability Office Study 19
Description of Selected Federal STEM Programs 20
NIH National Research Service Awards 20
NSF Graduate Research Fellowships 21
NSF Mathematics and Science Partnerships 22
NSF Research Experiences for Undergraduates 23
NASA Minority University Research Education Program 24
ED Mathematics and Science Partnerships 24

Proposals to Improve STEM Education 25
Recommendations by the Scientific Community 26
Legislation in the 109th Congress 27
Secondary School Math and Science Preparation 28
Recruiting and Retaining New STEM Teachers 28
Upgrading the STEM Skills of Current Teachers 29
Increase STEM Baccalaureate Degree Attainment 30
Graduate Research and Early-Career Scholarship 31
Federal Program Coordination 33

List of Figures

Figure 1. Percentages of Students Scoring Basic and Proficient in Math, Selected Years: 1990-2005 4
Figure 2. STEM Degrees Awarded, 1970-2003 13
Figure 3. Population 15 Years Old or Older With Tertiary Education by Country, 1980 and 2000 16

List of Tables

Table 1. TIMSS Scores by Grade and Country/Jurisdiction, 2003 6
Table 2. PISA Math and Science Scores, 2003 8
Table 3. Percentage of Middle and High School Teachers
Lacking a Major or Minor in Subject Taught, 1999-2000 10
Table 4. Degrees Conferred by Degree-Granting Institutions
by Academic Level and Field of Study, 2002-2003 12
Table 5. Field of First University Degree, by Selected Region
and Country, 2002 or the Most Recent Year Available 18

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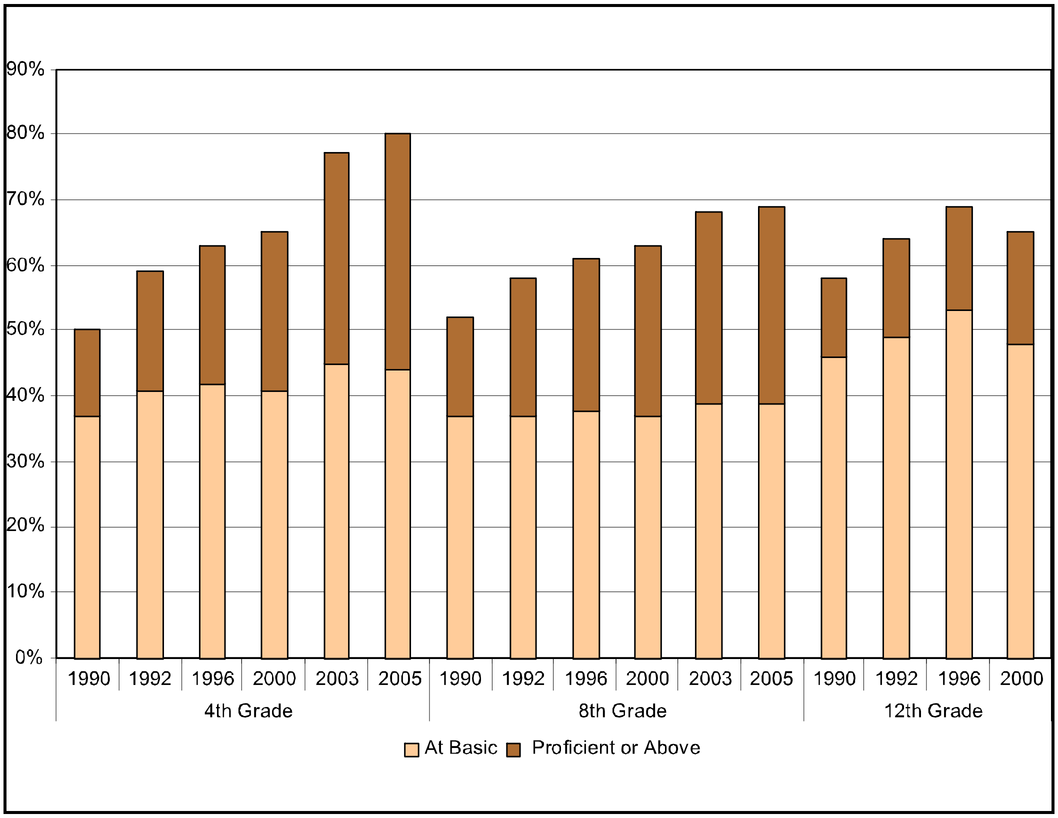
[5] For more information on NAEP and other assessments, see CRS Report RL31407, *Educational Testing: Implementation of ESEA Title I-A Requirements Under the No Child Left Behind Act*, by Wayne C. Riddle.

[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/].

— 36% and 30%, respectively.[7] 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.[8] Only 17% of 12th grade students performed at the proficient or higher level on the math assessment that year.[9] 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 math skills considered adequate. More than half of all 12th grade students performed below even the basic level in each assessment year except 1996.

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

[8] 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.

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

Similarly low levels of achievement have been found with regard to knowledge of science. Less than one-third of 4th and 8th grade students and less than one-fifth of 12th grade students score at or above proficient in science. In 2005, the percentage of 4th, 8th, and 12th grade students scoring proficient or above was 29%, 29%, and 18%, respectively; compared to 27%, 30%, and 18% in 2000 and 28%, 29%, and 21% in 1996.[10]

U.S. Students Compared to Students in Other Nations. Another relatively recent development in the area of academic assessment has been the effort by a number of nations to produce reliable cross-national comparison data.[11] The Trends in International Mathematics and Science Study (TIMSS) assesses achievement in these subjects at grades 4 and 8 among students in several countries around the world. TIMSS has been administered to 4th grade students on two occasions (1995 and 2003) and to 8th grade students on three occasions (1995, 1999, and 2003). In the latest administration, 25 countries participated in assessments of their 4th grade students, and 45 countries participated in assessments of their 8th grade students. Unlike NAEP, TIMSS results are reported only in terms of numerical scores, not achievement levels.

U.S. 4th grade pupils outscored the international average on the most recent TIMSS assessment.[12] The international average score for all countries participating in the 2003 4th grade TIMSS was 495 in math and 489 in science.[13] The average score for U.S. students was 518 in math and 536 in science. U.S. 4th grade students outscored students in 13 of the 24 countries participating in the math assessment in 2003. In science, U.S. students outperformed students in 16 of the 24 countries. Among the 10 Organization for Economic Co-operation and Development (OECD) member states participating in the 2003 TIMSS, U.S. 4th grade students ranked fourth in math and tied for second in science.

U.S. 8th grade pupils also outscored the international average. Among 8th grade students, the international average on the 2003 TIMSS was 466 in math and 473 in science. The average score for U.S. students was 504 in math and 527 in science. Among the 44 countries participating in the 8th grade assessments in 2003, U.S.

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[10] U.S. Department of Education, National Center for Education Statistics, The Nation's Report Card: Science 2005 (NCES 2006-466) May 2006, Figures 4, 14, and 24.

[11] More information on the development of this assessment can be found in archived CRS Report 86-683, *Comparison of the Achievement of American Elementary and Secondary Pupils with Those Abroad — The Examinations Sponsored by the International Association for the Evaluation of Educational Achievement (IEA)*, by Wayne C. Riddle (available on request).

[12] Performance on the 1995 TIMSS assessment was normalized on a scale in which the average was set at 500 and the standard deviation at 100. Each country was weighted so that its students contributed equally to the mean and standard deviation of the scale. To provide trend estimates, subsequent TIMSS assessments are pegged to the 1995 average.

[13] All the TIMSS results in this report were taken from, Patrick Gonzales, Juan Carlos Guzmán, Lisette Partelow, Erin Pahlke, Leslie Jocelyn, David Kastberg, and Trevor Williams, *Highlights From the Trends in International Mathematics and Science Study (TIMSS) 2003* (NCES 2005 — 005), Dec. 2004.

students outscored students in 25 countries in math and 32 countries in science. Twelve OECD countries participated in the 8th grade TIMSS in 2003 — five outscored the United States in math and three outscored the United States in science.

TIMSS previously assessed students at grade 4 in 1995 and grade 8 in 1995 and 1999. Although there was no measurable difference between U.S. 4th graders' average scores in 1995 and 2003, the standing of the United States declined relative to that of the 14 other countries participating in both math and science assessments. In math, U.S. 4th graders outperformed students in nine of these countries in 1995, on average, compared to six countries in 2003. In science, U.S. 4th graders outperformed students in 13 of these countries in 1995, on average, compared to eight countries in 2003.

Among 8th graders, U.S. scores increased on both the math and science assessments between 1995 and 2003. The increase in scores translated into a higher ranking of the United States relative to other countries. In math, 12 of the 21 participating countries outscored U.S. 8th graders in 1995, while seven did so in 2003. In science, 15 of the 21 participating countries outscored U.S. 8th graders in 1995, while 10 did so in 2003. **Table 1** displays the 2003 TIMSS math and science scores of 4th and 8th grade students by country (scores in **bold** are higher than the U.S. score).

Table 1. TIMSS Scores by Grade and Country/Jurisdiction, 2003

	4th Grade		8th Grade	
	Math	Science	Math	Science
International average	495	489	466	473
United States	518	536	504	527
United Kingdom	**531**	**540**	—	—
Tunisia	339	314	410	404
Sweden	—	—	499	524
South Africa	—	—	264	244
Slovenia	479	490	493	520
Slovak Republic	—	—	**508**	517
Singapore	**594**	**565**	**605**	**578**
Serbia	—	—	477	468
Scotland	490	502	498	512
Saudi Arabia	—	—	332	398
Russian Federation	**532**	526	**508**	514
Romania	—	—	475	470
Philippines	358	332	378	377
Palestinian National Authority	—	—	390	435
Norway	451	466	461	494
New Zealand	493	520	494	520
Netherlands	**540**	525	**536**	**536**
Morocco	347	304	387	396
Moldova, Republic of	504	496	460	472
Malaysia	—	—	**508**	510

	4th Grade		8th Grade	
	Math	**Science**	**Math**	**Science**
Macedonia, Republic of	—	—	435	449
Lithuania	**534**	512	502	519
Lebanon	—	—	433	393
Latvia	**536**	532	**508**	512
Korea, Republic of	—	—	**589**	**558**
Jordan	—	—	424	475
Japan	**565**	**543**	**570**	**552**
Italy	503	516	484	491
Israel	—	—	496	488
Iran, Islamic Republic of	389	414	411	453
Indonesia	—	—	411	420
Hungary	**529**	530	**529**	**543**
Hong Kong SAR	**575**	**542**	**586**	**556**
Ghana	—	—	276	255
Estonia	—	—	**531**	**552**
Egypt	—	—	406	421
Cyprus	510	480	459	441
Chinese Taipei	**564**	**551**	**585**	**571**
Chile	—	—	387	413
Bulgaria	—	—	476	479
Botswana	—	—	366	365
Belgium-Flemish	**551**	518	**537**	516
Bahrain	—	—	401	438
Australia	499	521	505	527
Armenia	456	437	478	461

Source: U.S. Department of Education, National Center for Education Statistics, *Highlights From the Trends in International Mathematics and Science Study (TIMSS) 2003*, NCES 2005-005, Dec. 2004.

The Program for International Student Assessment (PISA) is an OECD-developed effort to measure, among other things, mathematical and scientific literacy among students 15 years of age — i.e., roughly at the end of their compulsory education.[14] In 2003, U.S. students scored an average of 483 on math literacy — behind 23 of the 29 OECD member states that participated and behind four of the 11 non-OECD countries. The average U.S. student scored 491 on science literacy — behind 19 of the 29 OECD countries and behind three of the 11 non-OECD countries. **Table 2** displays the 2003 PISA scores on math and science literacy by country (scores in **bold** are higher than the U.S. score).

[14] Like the TIMSS, PISA results are normalized on a scale with 500 as the average score, and results are not reported in terms of achievement levels. In 2003, PISA assessments were administered in just over 40 countries.

Table 2. PISA Math and Science Scores, 2003

	2003	
	Math	**Science**
OECD average	**500**	**500**
United States	483	491
Turkey	423	434
Switzerland	**527**	**513**
Sweden	**509**	**506**
Spain	**485**	487
Slovak Republic	**498**	**495**
Portugal	466	468
Poland	**490**	**498**
Norway	**495**	484
New Zealand	**524**	**521**
Netherlands	**538**	**524**
Mexico	385	405
Luxembourg	**493**	483
Korea, Republic of	**542**	**538**
Japan	**534**	**548**
Italy	466	487
Ireland	**503**	**505**
Iceland	**515**	**495**
Hungary	**490**	**503**
Greece	445	481
Germany	**503**	**502**
France	**511**	**511**
Finland	**544**	**548**
Denmark	**514**	475
Czech Republic	**517**	**523**
Canada	**533**	**519**
Belgium	**529**	**509**
Austria	**506**	491
Australia	**524**	**525**
Non-OECD Countries		
Uruguay	422	438
United Kingdom	**508**	**518**
Tunisia	359	385
Thailand	417	429
Serbia and Montenegro	437	436
Russian Federation	468	489
Macao SAR	**527**	**525**
Liechtenstein	**536**	**525**
Latvia	483	489
Indonesia	360	395
Hong Kong SAR	**550**	**540**

Source: U.S. Department of Education, National Center for Education Statistics, *International Outcomes of Learning in Mathematics Literacy and Problem Solving*, NCES 2005-003, Dec. 2004.

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

[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.

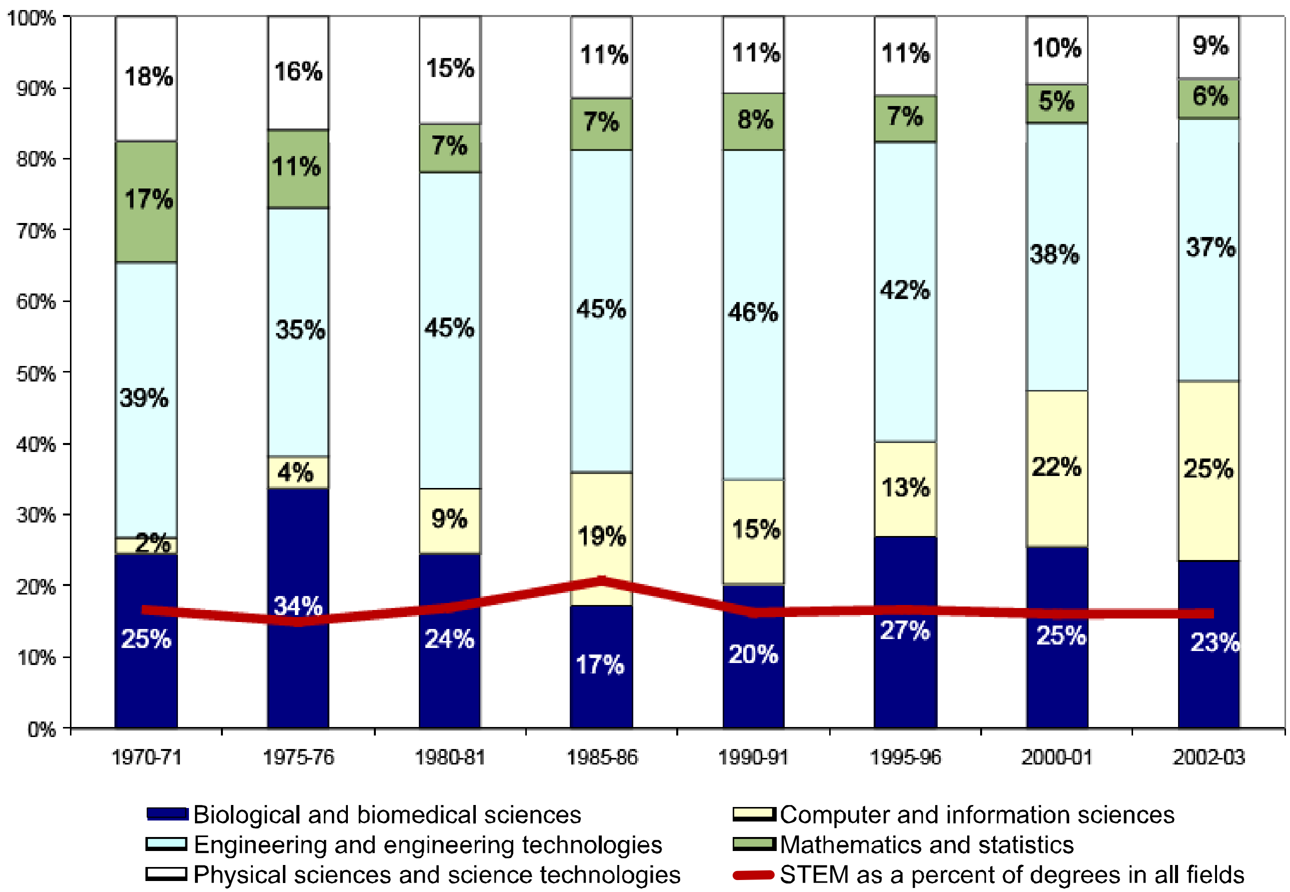
Figure 2 displays the trends in STEM degrees awarded over the last three decades (excluding associate degrees). The solid line represents the number of STEM degrees awarded as a proportion of the total number of degrees awarded in all fields of study. The flat line indicates that the ratio of STEM degrees 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



U.S. Degrees Awarded to Foreign Students. The increased presence of foreign students in graduate science and engineering programs and in the scientific workforce has been and continues to be of concern to some in the scientific community. Enrollment of U.S. citizens in graduate science and engineering programs has not kept pace with that of foreign students in these programs. According to the National Science Foundation (NSF) Survey of Earned Doctorates, foreign students earned one-third of all doctoral degrees awarded in 2003.

Doctoral degrees awarded to foreign students were concentrated in STEM fields. The NSF reports that foreign students earned "more than half of those [awarded] in engineering, 44% of those in mathematics and computer science, and 35% of those in the physical sciences."[23] Many of these degree recipients remain in the United States to work. The same NSF report indicates that 53% of those who earned a doctorate in 1993 remained in the U.S. as of 1997, and 61% of the 1998 cohort were still working in the United States in 2003. In addition to the number of foreign students in graduate science and engineering programs, a significant number of university faculty in the scientific disciplines are foreign, and foreign doctorates are employed in large numbers by industry.[24]

International Postsecondary Educational Attainment. The United States has one of the highest rates of postsecondary educational attainment in the world. In 2003, the most recent academic year for which international data are available, 38% of the U.S. population aged 25-64 held a postsecondary degree — 9% at the *tertiary-type B* (vocational level) and 29% at the *tertiary-type A* (university level) or above. The OECD compiled comparison data from 30 OECD member states and 13 other nations. Three countries (Canada, Israel, and the Russian Federation) had larger shares at the two tertiary levels combined; however, all three had lower rates at the tertiary-type A level. At the tertiary-type A level, only one country (Norway) had a rate as high as the United States. The average for OECD member states was 16% at tertiary-type A and 8% at tertiary-type B.[25]

China and India were not included in the OECD data. Reliable information on postsecondary educational attainment is very difficult to obtain for these countries.

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[23] National Science Board, *Science and Engineering Indicators, 2006*, (NSB 06-1). Arlington, VA: National Science Foundation, Jan. 2006, p. O-15.

[24] For more information on issues related to foreign students and foreign technical workers, see the following: CRS Report 97-746, *Foreign Science and Engineering Presence in U.S. Institutions and the Labor Force*, by Christine M. Matthews; CRS Report RL31973, *Programs Funded by the H-1B Visa Education and Training Fee and Labor Market Conditions for Information Technology (IT) Workers*, by Linda Levine; and CRS Report RL30498, *Immigration: Legislative Issues on Nonimmigrant Professional Specialty (H-1B) Workers*, by Ruth Ellen Wasem.

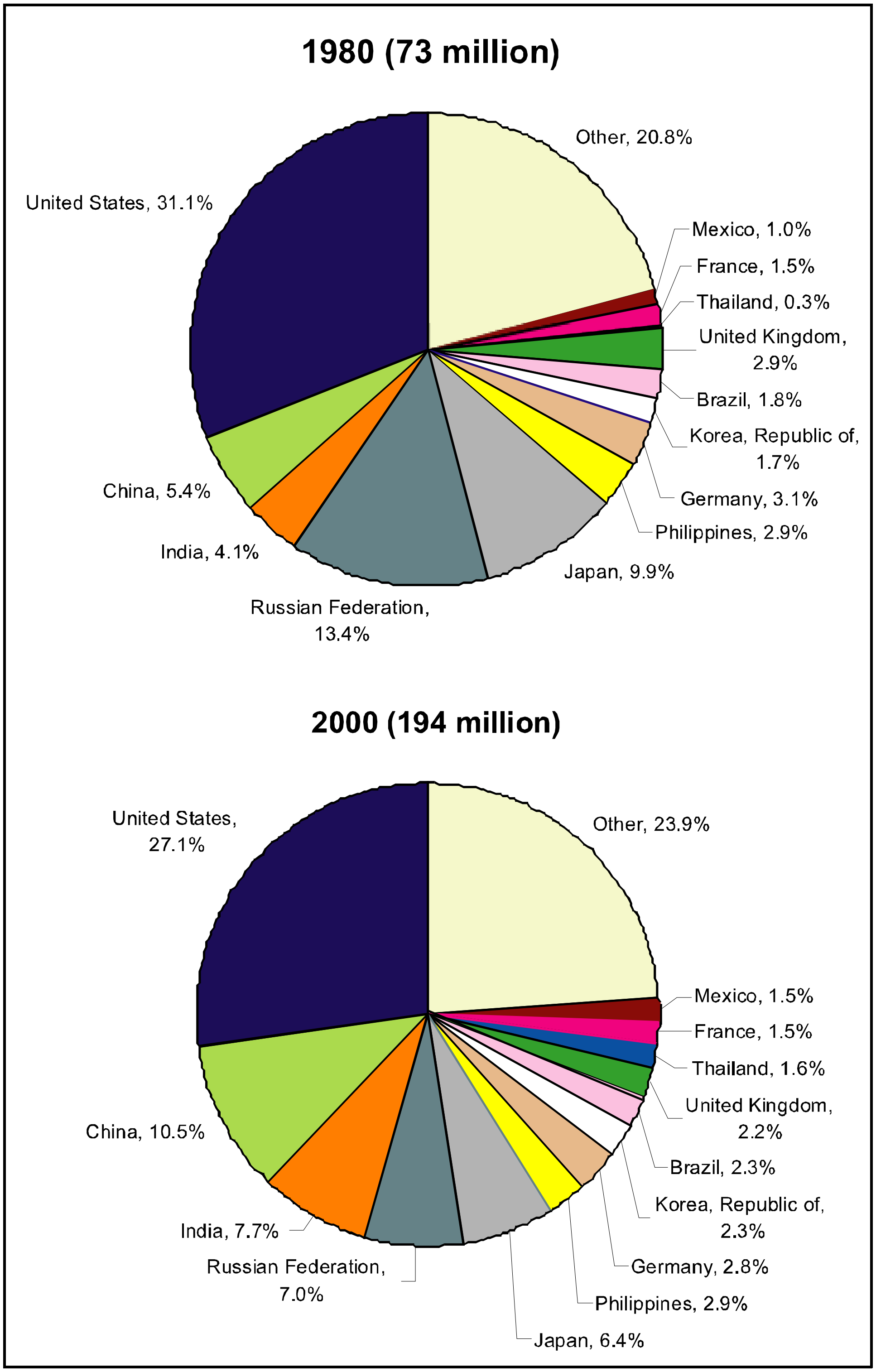
[25] Organization for Economic Co-operation and Development, Education at a Glance, OECD Indicators 2005, Paris, France, Sept. 2005. The OECD compiles annual data from national labor force surveys on educational attainment for the 30 OECD member countries, as well as 13 non-OECD countries that participate in the World Education Indicators (WEI) program. More information on sources and methods can be found at [http://www.oecd.org/dataoecd/36/39/35324864.pdf].

The World Bank estimates that, in 1998, tertiary enrollment of the population between 18 and 24 years old was 6% in China and 8% in India, up from 1.7% and 5.2%, respectively, in 1980.[26] Based on measures constructed by faculty at the Center for International Development (CID), the National Science Foundation (NSF) has generated an estimate of the distribution of the world's population that possesses a tertiary education.[27] The NSF estimates that the number of people in the world who had a tertiary education more than doubled from 73 million in 1980 to 194 million in 2000. Moreover, the two fastest-growing countries were China and India. China housed 5.4% of the world's tertiary degree holders in 1980, and India had 4.1%; by 2000, the share in these countries was 10.5% and 7.7%, respectively. Indeed, as **Figure 3** indicates, China and India were the only countries to substantially increase their share of the world's tertiary degree-holders during that period.

[26] The World Bank, *Constructing Knowledge Societies: new challenges for tertiary education*, Washington, D.C., October 2002. Available at [http://siteresources.worldbank.org/EDUCATION/Resources/278200-1099079877269/547664-1099079956815/ConstructingKnowledgeSocieties.pdf].

[27] Unlike the OECD data, which are based on labor-force surveys of households and individuals, the CID data are based on the United Nations Educational, Scientific and Cultural Organization (UNESCO) census and survey data of the entire population. Documentation describing methodology as well as data files for the CID data is available at [http://www.cid.harvard.edu/ciddata/ciddata.html].

Figure 3. Population 15 Years Old or Older With Tertiary Education by Country, 1980 and 2000



Source: National Science Foundation, *Science and Engineering Indicators, 2006, Volume 1*, Arlington, VA, NSB 06-01, Jan. 2006.

International Comparisons in STEM Education. The NSF has compiled data for many countries on the share of *first university* degrees awarded in STEM fields.[28] According to these data, the United States has one of the lowest rates of STEM to non-STEM degree production in the world. In 2002, STEM degrees accounted for 16.8% of all first university degrees awarded in the United States (the same NCES figure reported at the outset of this section). The international average for the ratio of STEM to non-STEM degrees was 26.4% in 2002. **Table 5** displays the field of first university degrees for regions and countries that award more than 200,000 university degrees annually. Among these nations, only Brazil awards a smaller share (15.5%) of STEM degrees than the United States. By contrast, the world leaders in the proportion of STEM degrees awarded are Japan (64.0%) and China (52.1%). Although the U.S. ranks near the bottom in the proportion of STEM degrees, it ranks third (behind Japan and China) in the absolute number of STEM degrees awarded.

Table 5. Field of First University Degree, by Selected Region and Country, 2002 or the Most Recent Year Available

Region/Country	All fields	STEM Fields	Percent STEM
All regions	9,057,193	2,395,238	26.4%
Asia	3,224,593	1,073,369	33.3%
China	929,598	484,704	52.1%
India	750,000	176,036	23.5%
Japan	548,897	351,299	64.0%
South Korea	239,793	97,307	40.6%
Middle East	445,488	104,974	23.6%
Europe	2,682,448	713,274	26.6%
France	309,009	83,984	27.2%
Spain	211,979	55,418	26.1%
United Kingdom	282,380	72,810	25.8%
Central/Eastern Europe	1,176,898	319,188	27.1%
Russia	554,814	183,729	33.1%
North/Central America	1,827,226	341,526	18.7%
Mexico	321,799	80,315	25.0%
United States	1,305,730	219,175	16.8%
South America	543,805	96,724	17.8%
Brazil	395,988	61,281	15.5%

Source: National Science Foundation, *Science and Engineering Indicators, 2006, Volume 1*, Arlington, VA, NSB 06-01, January 2006, Table 2-37.

[28] *First university* degrees are those designated Level 5A by the International Standard Classification of Education (ISCED 97), and usually require less than five years to complete. More information on this classification and the ISCED is available at [http://www.unesco.org/education/information/nfsunesco/doc/isced_1997.htm].

Federal Programs that Promote STEM Education

Government Accountability Office Study

According to a 2005 Government Accountability Office (GAO) survey of 13 federal civilian agencies, in FY2004 there were 207 federal education programs designed to increase the number of students studying in STEM fields and/or improve the quality of STEM education.[29] About $2.8 billion was appropriated for these programs that year, and about 71% ($2 billion) of those funds supported 99 programs in two agencies. In 2004, the National Institutes of Health (NIH) received $998 million that funded 51 programs, and the National Science Foundation (NSF) received $997 million that funded 48 programs. Seven of the 13 agencies had more than five STEM-related education programs. In addition to the NIH and NSF, only three other agencies received more than $100 million for STEM-related education programs. In FY2004, the National Aeronautics and Space Administration (NASA) received $231 million that funded five programs, the U.S. Department of Education (ED) received $221 million that funded four programs, and the Environmental Protection Agency (EPA) received $121 million that funded 21 programs.

The GAO study found that most of the 207 programs had multiple goals, provided multiple types of assistance, and were targeted at multiple groups. The analysis identified six major program goals, four main types of assistance, and 11 target groups. The findings revealed that federal STEM education programs are heavily geared toward attracting college graduates into pursuing careers in STEM fields by providing financial assistance at the graduate and postdoctoral levels. Moreover, improving K-12 teacher education in STEM areas was the least frequent of the major goals, improving infrastructure was the least frequent of the main types of assistance, and elementary and secondary students were the least frequent group targeted by federal STEM education programs.[30]

The major goals of these programs were found by GAO to be the following (the number of programs with this goal is shown in parentheses):

- attract and prepare students at all educational levels to pursue coursework in STEM areas (114),
- attract students to pursue STEM postsecondary degrees (two-year through Ph.D.) and postdoctoral appointments (137),
- provide growth and research opportunities for college and graduate students in STEM fields (103),

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[29] U.S. Government Accountability Office, *Federal Science, Technology, Engineering, and Mathematics Programs and Related Trends,* GAO-06-114, Oct. 2005. The GAO study does not include programs in the Department of Defense because the department decided not to participate. Other programs were omitted from the report for various reasons; typically because they did not meet the GAO criteria for a STEM-related educational program (according to an Apr. 26, 2006 conversation with the report's lead author, Tim Hall).

[30] Attrition rates among college students majoring in STEM fields combined with the growth of foreign students in U.S. graduate STEM programs suggest that pre-college STEM education may be a major source of the nation's difficulty in this area.

- attract graduates to pursue careers in STEM fields (131),
- improve teacher education in STEM areas (73), and
- improve or expand the capacity of institutions to promote STEM fields (90).

The four main types of assistance provided by these programs were as follows (the number of programs providing this service is shown in parentheses):

- financial support for students or scholars (131),
- institutional support to improve educational quality (76),
- support for teacher and faculty development (84), and
- institutional physical infrastructure support (27).

The 11 target groups served by these programs were the following (the number of programs targeting them is shown in parentheses):

- elementary school students (28),
- middle school students (34),
- high school students (53),
- two-year college students (58),
- four-year college students (96),
- graduate students (100),
- postdoctoral scholars (70),
- elementary school teachers (39),
- secondary school teachers (50),
- college faculty or instructional staff (79), and
- institutions (82).

Description of Selected Federal STEM Programs

The 2005 GAO report did not discuss federal STEM programs in detail (a very brief description of programs funded at $10 million or more is contained in Appendix III of the report). This section describes the kinds of activities the largest of these programs support, and how they operate at the federal, state, and/or local levels.[31]

NIH National Research Service Awards. The NIH was appropriated $998 million in FY2004 in support of its 51 STEM educational programs. Nearly two-thirds ($653 million) of those funds went to three programs under the National Research Service Awards (NRSA), first funded in 1975.[32] Most of these funds ($547 million) went to one program, the NRSA Institutional Research Training Grants, which provides pre- and postdoctoral fellowships in health-related fields. An additional $73 million went to NRSA Individual Postdoctoral Fellowship Grants and $34 million went to NRSA Predoctoral Fellowship Grants. The Training Grants are

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[31] Additional program descriptions are available in the CRS congressional distribution memorandum, *Federally Sponsored Programs for K-12 Science, Mathematics, and Technology Education*, by Bonnie F. Mangan, available upon request.

[32] More information on the NRSA program is available at [http://grants.nih.gov/training/nrsa.htm].

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. The Fellowship Grants are awarded directly to individuals from various organizations within the NIH (e.g., the National Institute on Aging) to support the particular research interests of the individual receiving the award.

NRSA grant applicants must be U.S. citizens or nationals, or permanent resident aliens of the United States — individuals on temporary or student visas are not eligible. Predoctoral trainees must have received a baccalaureate degree by the starting date of their appointment, and must be training at the postbaccalaureate level and be enrolled in a program leading to a Ph.D. in science or in an equivalent research doctoral degree program. Health-profession students who wish to interrupt their studies for a year or more to engage in full-time research training before completing their professional degrees are also eligible. Postdoctoral trainees must have received, as of the beginning date of their appointment, a Ph.D., M.D., or comparable doctoral degree from an accredited domestic or foreign institution. Institutional grants are made for a five-year period. Trainee appointments are normally made in 12-month increments, although short-term (two- to three-month) awards are available. No individual trainee may receive more than five years of aggregate NRSA support at the predoctoral level or three years of support at the postdoctoral level, including any combination of support from institutional training grants and individual fellowship awards. The annual stipend for predoctoral trainees in 2005 was about $12,000, and the postdoctoral stipend was between $20,000 and $32,000 (depending on years of experience).

In FY2004, Training Grants were awarded to 293 institutions in all but six states. A total of 2,356 grants were awarded, which funded nearly 9,000 predoctoral fellowships and nearly 5,500 postdoctoral fellowships. The Fellowship Grant programs supported around 2,500 pre- and postdoctoral students in 2004. The large majority of the Training Grants were awarded through the National Institute of General Medical Sciences.

NSF Graduate Research Fellowships. The largest of the NSF STEM education programs — the Graduate Research Fellowships ($97 million in FY2005) — is also one of the longest-running federal STEM programs (enacted in 1952). The purpose of this program is to increase the size and diversity of the U.S. workforce in science and engineering. The program provides three years of support to approximately 1,000 graduate students annually in STEM disciplines who are pursuing research-based master's and doctoral degrees, with additional focus on women in engineering and computer and information sciences. In 2006, 907 awards were given to graduate students studying in nine major fields at 150 instituions.

Applicants must be U.S. citizens or nationals, or permanent resident aliens of the United States; must have completed no more than twelve months of full-time graduate study at the time of their application; and must be pursuing an advanced degree in a STEM field supported by the National Science Foundation.[33] The fellows' affiliated institution receives a $40,500 award — $30,000 for a 12-month stipend and $10,500 for an annual cost-of-education allowance. These awards are for a maximum of three years and usable over a five-year period, and provide a one-time $1,000 International Research Travel Allowance. All discipline-based review panels, made up of professors, researchers, and others respected in their fields, convene for three days each year to read and evaluate applications in their areas of expertise. In 2005, there were 29 such panels made up of more than 500 experts.

NSF Mathematics and Science Partnerships. The Mathematics and Science Partnerships program was the NSF's second-largest program in FY2005 ($79 million in FY2005) and was the agency's largest program in FY2004 ($139 million). Since its inception in 2002, this program has awarded grants that support four types of projects (the number of awards is shown in parentheses):

- Comprehensive Partnership projects (12) to implement change in mathematics and science education across the K-12 continuum;
- Targeted Partnership projects (28) to improve K-12 student achievement in a narrower grade range or disciplinary focus in mathematics and/or science;
- Institute Partnership projects (8) to focus on improving middle and high school mathematics and science through the development of school-based intellectual leaders and master teachers; and
- Research, Evaluation & Technical Assistance projects (22) to build research, evaluation, and infrastructure capacity for the MSP.

One of the Comprehensive Partnership projects is between the Baltimore County Public Schools (BCPS) and the University of Maryland, Baltimore County (UMBC). The two main goals of the UMBC-BCPS STEM Partnership are to (1) facilitate the implementation, testing, refinement, and dissemination of promising practices for improving STEM student achievement, and (2) improve teacher quality and retention in selected high-need elementary, middle, and high schools in Baltimore County Public Schools. Centered on creating and evaluating performance-based pre-service (internship) teacher education programs and sustainable professional development programs for teachers and administrators, the project is designed to increase K-12 student achievement in STEM areas by increasing teacher and administrator knowledge. Ongoing assessments of student work and the differentiation of instruction based upon these assessments serve to evaluate and refine instruction, curricula and assessments, professional development programs, administrative leadership strategies, and directions for overall school improvement in STEM areas. UMBC and BCPS collaboration is facilitated by the creation of the Center for Excellence in STEM Education, where UMBC faculty and BCPS teachers and administrators develop projects to serve the needs of the BCPS district and the university. At the center, faculty and teachers work together to

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[33] A list of NSF-supported fields of study can be found at [http://www.nsf.gov/pubs/2005/nsf05601/nsf05601.htm#study].

simultaneously improve the university's STEM and teacher education departments and the teaching and learning culture in the BCPS.

One of the Targeted Partnership grants supports the Promoting Reflective Inquiry in Mathematics Education Partnership, which includes Black Hills State University, Technology and Innovations in Education (TIE) of the Black Hills Special Services Cooperative, and the Rapid City School District in South Dakota. The overall goal of the partnership is aimed at improving achievement in mathematics for all students in Rapid City schools, with a particular goal of reducing the achievement gap between Native American and non-Native American students. The project seeks to improve the professional capacity and sustain the quality of K-12 in-service teachers of mathematics in the Rapid City School District, and student teachers of mathematics from Black Hills State University in order to provide effective, inquiry-based mathematics instruction. Objectives include reducing the number of high school students taking non-college preparatory mathematics, increasing the number of students taking upper level mathematics, and increasing student performance on college entrance exams. To accomplish these goals, the project provides 100 hours of professional development in combination with content-based workshops at the district level, and building-based activities involving modeling of effective lessons, peer mentoring and coaching, and lesson study. Mathematics education and discipline faculty from Black Hills State University are involved in district-wide professional development activities. A cadre of building-based Mathematics Lead Teachers convenes learning teams composed of mathematics teachers, mathematics student teachers, school counselors, and building administrators to identify key issues in mathematics curriculum and instruction.

NSF Research Experiences for Undergraduates. The Research Experiences for Undergraduates (REU) program is the largest of the NSF STEM education programs that supports active research participation by undergraduate students ($51 million in FY2005). REU projects involve students in research through two avenues. REU Sites are based on independent proposals to initiate and conduct projects that engage a number of students in research. *REU Supplements* are requested for ongoing NSF-funded research projects or are included as a component of proposals for new or renewal NSF grants or cooperative agreements. REU projects may be based in a single discipline or academic department, or on interdisciplinary or multi-department research opportunities with a coherent intellectual theme. Undergraduate student participants in either Sites or Supplements must be citizens or permanent residents of the United States or its possessions. Students apply directly to REU Sites (rather that to the NSF) to participate in the program.

One of the grantees under this program is the REU Site in Microbiology at the University of Iowa. The goals of this project are to (1) recruit and select bright students, including women, individuals with diverse backgrounds with respect to geographic origin and ethnicity, and students from non-Ph.D.-granting institutions where research possibilities are limited; (2) involve students in basic, experimental research in microbiology; (3) expose students to a broad range of bioscience research; (4) develop each student's critical-thinking skills; and (5) develop each student's ability to record, analyze, and present scientific information. The student participants are integrated into faculty research programs and expected to perform like beginning graduate students. Informal faculty-student discussions and weekly seminars supplement laboratory research. Weekly informal lunches, two picnics, and a banquet facilitate social and scientific interactions. At the end of each summer's program, the students prepare oral presentations to be given at a Summer Program Symposium. Each student also prepares a written research report under the guidance of a mentor.

NASA Minority University Research Education Program. Nearly half of the funds ($106 million of $231 million) appropriated for NASA's STEM education programs in FY2004 went to the Minority University Research Education Program (MUREP). MUREP supports grants to expand and advance NASA's scientific and technological base through collaborative efforts with Historically Black Colleges and Universities (HBCUs) and other minority universities, including Hispanic-serving institutions and tribal colleges and universities. The program provides (1) K-12 awards to build and support successful pathways for students to progress to the next level of mathematics and science through a college preparatory curriculum and enrollment in college; (2) higher-education awards to improve the rate at which underrepresented minorities are awarded degrees in STEM disciplines; and (3) partnership awards to higher-education institutions and school districts that improve K-12 STEM teaching.

One of the partnership programs, the Minority University Mathematics, Science and Technology Awards for Teacher and Curriculum Enhancement Program, supports collaborative efforts between universities and school districts to increase the number and percentage of state-certified STEM teachers in schools with high percentages of disadvantaged students. Grant awards range from $50,000 to $200,000 annually for each of three years of support, for a total of up to $600,000. A longstanding grant funded under this program involves a partnership between Florida International University and Miami-Dade County Public Schools. Students from three middle schools and one high school attend mathematics, science, and technology classes for half of each day at the university and spend the other half of the day in their home school. University faculty, graduate students, and preservice secondary mathematics teachers work with district teachers in providing the at-risk students with standards-based curriculum and instruction.

ED Mathematics and Science Partnerships. Three-quarters of the STEM program funds in the Department of Education ($149 million of $221 million) in FY2004 went to the Mathematics and Science Partnership (MSP) program. The MSP is intended to increase the academic achievement of students in mathematics and science by enhancing the content knowledge and teaching skills of classroom teachers. These partnerships — between state education agencies, high-need school districts, and STEM faculty in institutions of higher education — are supported by state-administered formula grants and carried out in collaboration with the NSF-MSP program. Partnerships must use their grants for one or more of several specific activities. Among them are the following:

- professional development to improve math and science teachers' subject knowledge;
- activities to promote strong teaching skills among these teachers and teacher educators;

- math and science summer workshops or institutes with academic-year followup;
- recruitment of math, science, and engineering majors to teaching jobs through signing and performance incentives, stipends for alternative certification, and scholarships for advanced course work;
- development and redesign of more rigorous, standards-aligned math and science curricula;
- distance-learning programs for math and science teachers;
- and opportunities for math and science teachers to have contact with working mathematicians, scientists, and engineers.

A review of projects funded in 2004 revealed that most grantees focus on math (as opposed to science) instruction in middle schools, and provide professional development to roughly 46 teachers over a period of about 21 months.[34] The survey found that most projects link content to state standards, and that algebra, geometry, and problem-solving are the top three math topics addressed by professional development activities. Most projects administer content knowledge tests to teachers, conduct observations, and make pre-and post-test comparisons. About half of the projects develop their own tests for teachers, and most rely on state tests of academic achievement to measure student knowledge.

Proposals to Improve STEM Education

Several pieces of legislation have been introduced in the 109th Congress with the purpose of improving 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 leading academic, scientific, and business organizations (mentioned in the introduction of this report).[35] These recommendations, particularly those from the business community, are not limited to the educational system. This report does not discuss these non-educational policy recommendations (e.g., immigration policies that affect the supply of foreign workers to fill U.S. demand in STEM occupations). The concluding section of this report discusses STEM education policy recommendations in detail, as well as selected pieces of legislation that have been introduced in this area.

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[34] Analysts at the Brookings Institution conducted a survey of 266 winning MSP projects from 41 states. Results of the survey are available at [http://www.ed.gov/programs/mathsci/proposalreview.doc].

[35] 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*, Jan. 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*, Feb. 2006; The National Summit on Competitiveness, *Statement of the National Summit on Competitiveness: Investing in U.S. Innovation*, Dec. 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.

Recommendations by the Scientific Community

The recommendations to improve federal STEM policy concern every aspect of the educational pipeline. All of the recent reports issuing STEM education policy recommendations focus on five areas: improving elementary and secondary preparation in math and science, recruiting new elementary and secondary math and science teachers, retooling current math and science teachers, increasing the number of undergraduate STEM degrees awarded, and supporting graduate and early-career research. As mentioned at the outset of this report, one report that has been of particular influence in the STEM debate is from the National Academy of Sciences (NAS) — *Rising Above the Gathering Storm*. This influence is perhaps due to the clear targets and concrete programs laid out in the report. The NAS report's five recommendations to improve STEM education follow.

- quadruple middle- and high-school math and science course-taking by 2010,
- recruit 10,000 new math and science teachers per year,
- strengthen the skills of 250,000 current math and science teachers,
- increase the number of STEM baccalaureate degrees awarded, and
- support graduate and early-career research in STEM fields.

To *enlarge the pipeline* of future STEM degree recipients, NAS sets a goal of quadrupling the number of middle and high school students taking Advanced Placement (AP) or International Baccalaureate (IB) math or science courses, from the current 1.1 million to 4.5 million by 2010. NAS further sets a goal of increasing the number of students who pass either the AP or IB tests to 700,000 by 2010. To enlarge the pipeline, NAS also supports the expansion of programs such as *statewide specialty high schools* for STEM immersion and *inquiry-based learning* through laboratory experience, summer internships, and other research opportunities.

To *recruit 10,000 new STEM teachers*, NAS advocates the creation of a competitive grant program to award merit-based scholarships to obtain a four-year STEM degree in conjunction with certification as a K-12 mathematics or science teacher. These $10,000 to $20,000 awards could be used only for educational expenses and would require a five-year service commitment. An additional $10,000 annual bonus would be awarded to participating teachers in underserved schools in inner cities and rural areas. In further support of this scholarship program, NAS recommends that five-year, $1 million matching grants be awarded to postsecondary institutions to encourage the creation of programs that integrate the obtainment of a STEM bachelor's degree with teacher certification.

NAS proposes four approaches to achieving the goal of *strengthening the skills of 250,000 current STEM teachers*. First, NAS proposes that matching grants be awarded to support the establishment of state and regional summer institutes for STEM teachers modeled after the Merck Institute for Science Education. Second, NAS proposes that additional grants go to postsecondary institutions that support STEM master's degree programs for current STEM teachers (with or without STEM bachelor's degrees) modeled after the University of Pennsylvania Science Teachers Institute. Third, NAS proposes that programs be created to train current teachers to provide AP, IB, and pre-AP or pre-IB instruction modeled after the Advanced

Placement Initiative and the Laying the Foundation programs. Fourth, NAS proposes the creation of a national panel to collect, evaluate, and develop rigorous K-12 STEM curricula modeled after Project Lead the Way.

To *increase STEM bachelor's degree attainment*, NAS proposes providing 25,000 new scholarships each year. These Undergraduate Scholar Awards in Science, Technology, Engineering, and Mathematics (USA-STEM) would be distributed to each state in proportion with its population, and awarded to students based on competitive national exams. The $20,000 scholarships could only go to U.S. citizens, and could only be used for the payment of tuition and fees in pursuit of a STEM degree at a U.S. postsecondary institution.

To *increase graduate study in areas of national need, including STEM*, NAS proposes the creation of 5,000 new fellowships each year to U.S. citizens pursuing doctoral degrees. The fellowships would be administered by the National Science Foundation, which would also draw on the advice of several federal agencies in determining the areas of need. An annual stipend of $30,000 would be accompanied by an additional $20,000 annually to cover the cost of tuition and fees. These fellowships would also be portable, so that students could choose to study at a particular institution without the influence of faculty research grants.

Legislation in the 109th Congress

Several bills containing STEM education-related proposals have been introduced in the 109th Congress, and have also seen additional legislative action. Some of these bills have already been passed by Congress and signed into law by the President. The National Aeronautics and Space Administration Authorization Act of 2005 (P.L. 109-155) directed the Administrator to develop, expand, and evaluate educational outreach programs in science and space that serve elementary and secondary schools. The National Defense Authorization Act of 2006 (P.L. 109-163) made permanent the Science, Mathematics and Research for Transformation pilot program initiated by the Defense Act of 2005 (P.L. 108-375) to address deficiencies of scientists and engineers in the national security workforce. The Deficit Reduction Act of 2005 (P.L. 109-171) established the Academic Competitiveness Grants and the National Science and Mathematics Access to Retain Talent Grants programs, which supplement Pell Grants for students studying mathematics, technology, engineering, critical foreign languages, and physical, life, and computer sciences. The act also established the Academic Competitiveness Council, chaired by the Secretary of Education and charged with identifying and evaluating all federal STEM programs, and recommending reforms to improve program integration and coordination.

Additional bills that have been introduced in the 109th Congress that would make substantial changes or additions to current federal STEM education policy include two intended to reauthorize the Higher Education Act (HEA), as well as several pieces of so-called "competitiveness" legislation. On February 28, 2006, the Senate Committee on Health, Education, Labor, and Pensions reported S. 1614, the Higher Education Amendments of 2005 (S.Rept. 109-218). On March 30, 2006, the House passed H.R. 609, the College Access and Opportunity Act of 2005, which was placed on the Senate legislative calendar on April 4, 2006. That same day, the Senate

Committee on Energy and Natural Resources reported S. 2197, Protecting America's Competitive Edge Through Energy Act of 2006 (S.Rept. 109-249). A companion bill, S. 2198, Protecting America's Competitive Edge Through Education and Research Act of 2006, has been the subject of two hearings (February 28, 2006 and March 1, 2006). Another bill that would make substantial additions to federal STEM education policy is S. 2109, the National Innovation Act. On June 8, 2006, the House Committee on Science reported two bills — H.R. 5358, the Science and Mathematics Education for Competitiveness Act, and H.R. 5356, the Early Career Research Act.

Secondary School Math and Science Preparation. S. 2197 would provide experiential-based learning opportunities for students by establishing a summer internship program for middle school and secondary school students at the National Laboratories funded by the Department of Energy (DOE). Language in the bill requires that 40% of the participants be from low-income families. The bill also requires that the participants be from schools where teachers are teaching "out-of-field," hold temporary certification, or have a high turnover rate. For this purpose, S. 2197 would authorize appropriations of $50 million for each of five fiscal years — FY2007 through FY2011.

S. 2109 would increase support for science education through the NSF. The bill would authorize the following amounts for expansion of science, mathematics, engineering, and technology talent under the NSF Authorization Act of 2002 (P.L. 107-368): FY2007, $35 million; FY2008, $50 million; FY2009, $100 million; and FY2010, $150 million. S. 2109 would also promote innovation-based experiential learning. This bill would allow NSF to award grants to local education agencies (LEAs) for implementation of innovation-based experiential learning. A total of 500 elementary or middle schools and 500 secondary schools would participate. Funding would total $10 million in FY2007 and $20 million each for FY2008 and FY2009.

Recruiting and Retaining New STEM Teachers. Provisions in S. 2198 would direct the NSF to provide two types of support for future science and mathematics teachers. One such award would be four-year fellowships in the amount of $10,000 annually to individuals who complete a baccalaureate degree in science, engineering, or mathematics, with concurrent teacher certification. A requirement would be that these individuals teach as full-time mathematics, science, or elementary school teachers in high-need elementary and secondary schools. Additional support for teacher recruitment would be through scholarships for science and mathematics teachers. The NSF Director would award merit-based scholarships of up to $20,000 per year for not more than four years to students majoring in science, mathematics, and engineering education who pursue concurrent teacher certification to assist students in paying their college education expenses.

S. 2198 would also authorize institutional grants to provide an integrated course of study in mathematics, science, engineering, or teacher education that leads to a baccalaureate degree in the STEM disciplines with concurrent teacher certification. The awards would total $1 million per year for a period of five years. Matching funds in predetermined amounts would be required from non-federal sources — not less than 25% of the amount for the first year, not less than 35% for the second year, and not less than 50% of the amount of the grant award for each succeeding year of the grant.

S. 2198 would provide further institutional grants to develop part-time, three-year master's degree programs in science and mathematics education for teacher enhancement. Eligible participants must collaborate with a teacher preparation program of an institution of higher education. The competitively awarded grants are not to exceed $1 million. Priority would be given to applicants who consult with LEAs, use online technology, and develop innovative efforts directed at reducing shortages of science and mathematics teachers in low-income urban or rural areas.

H.R. 609 and S. 1614 would expand and extend the current loan forgiveness program for STEM teachers. Currently, HEA Title IV, Section 428J and 465, as amended by the Taxpayer-Teacher Protection Act of 2004 (P.L. 108-409), provides a higher maximum debt relief for qualified math and science secondary school teachers; up to $17,500 in loan forgiveness compared to $5,000 for other eligible teachers. However, only teachers who were *new borrowers* between October 1, 1998 and October 1, 2005 are eligible. Both S. 1614 and H.R. 609 would extend eligibility for loan forgiveness of up to $17,500 to qualified math and science secondary school teachers who were *new borrowers* after October 1, 1998; i.e., they would extend eligibility beyond the October 1, 2005 limit set by P.L. 108-409.[36]

H.R. 609 would establish the Mathematics and Science Incentive Program to provide eligible math and science teachers relief from interest payments on student loans in return for working in high-need schools. Participating teachers would serve at least five years and could not receive more than $5,000 in total relief. S. 1614 would allow state and partnership grantees under the HEA Title II, Teacher Enhancement Grant program to provide scholarships to students who later teach in the areas of math or science.

H.R. 609 would create an Adjunct Teacher Corps that would award grants to LEAs or other educational organizations (private or public) to recruit professionals with math and science skills to serve as adjunct teachers. Grants could be used to develop outreach programs, fund signing bonuses, and compensate outside entities for the costs associated with allowing employees to serve. Grantees would have to match the federal funds received dollar-for-dollar.

Upgrading the STEM Skills of Current Teachers. Another type of award provided in S. 2198 would be in the form of a fellowship for five years, in the amount of $10,000 annually, to teachers who have successfully completed a master's degree in science or mathematics education, and who undertake increased responsibilities such as teacher mentoring and other leadership activities. S. 2198 would also direct the Secretary of Education to award grants to nonprofit entities that partner with local school districts for the training of teachers who will lead Advanced Placement or International Baccalaureate (AP-IB) and pre-AP-IB programs in science

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[36] More information on teacher loan forgiveness can be found in CRS Report RL32516, *Student Loan Forgiveness Programs*, by Gail McCallion.

and mathematics. The grantees must demonstrate an ability to serve not fewer than 10,000 children from low-income families.

S. 2198 would also support a National Clearinghouse on Mathematics and Science Teaching Materials. The Secretary of Education would establish a national panel, after consultation with the National Academies, to collect proven effective K-12 mathematics and science teaching materials, and create a clearinghouse of such materials for dissemination to states and school districts. The bill would authorize the appropriation of $20 million for each fiscal year — FY2007 through FY2011.

S. 2197 would provide for assistance to speciality schools for science and mathematics. The bill would require that funds and staff of the National Laboratories be made available to assist in teaching courses at statewide speciality schools with comprehensive programs in science, mathematics, and engineering.

Both S. 1614 and H.R. 609 would target the HEA, Title II, Teacher Enhancement Grant program to math and science teachers. Under the current program, partnership grantees may provide professional development to improve teachers' content knowledge; however, no particular subject areas are specified. Both bills would support efforts by partnership grantees to increase the number of math and science teachers and to provide opportunities for clinical experience in the areas of math and science. Both bills would also allow state grantees to support bonus pay for math and science teachers.

H.R. 5358 would establish a new NSF program to provide grants that support teacher training partnerships between LEAs and either IHEs or eligible nonprofit organizations. Grantees would operate teacher institutes that provide intensive content instruction in science and mathematics, as well as induction programs for new teachers, professional development, and training in the use of technology and laboratory equipment. Grants would be awarded for a period of five years at between $75,000 and $2 million per year. The bill would authorize appropriations of $50 million for each of the fiscal years 2007 through 2011.

Increase STEM Baccalaureate Degree Attainment. S. 2198 would provide support for a Future American Scientist Scholarships program. This program would provide 25,000 new competitive merit-based undergraduate scholarships to students who are U.S. citizens. The scholarships would be awarded in the amount of $20,000 per year. The bill would authorize an appropriation of $375 million for FY2007; $750 million for FY2008; $1.125 billion for FY2009; and $1.5 billion annually for FY2010 through FY2013.

S. 1614 would create a new Mathematics and Science Scholars Program that would award $1,000 for each of up to two years to eligible undergraduate students majoring in mathematics, science, technology, or engineering. To be eligible, students would have to complete a "rigorous secondary school curriculum in mathematics and science" as determined by the state. In determining priority for the scholarship winners, the governor of the state may take into consideration (1) the student's regional or geographic location, (2) whether the student attended school in a high-need area, (3) attended a low-performing school, or (4) is a member of a group under-represented in STEM fields.

H.R. 609 would amend the current Robert C. Byrd Honors Scholarship Program to focus these awards on students pursuing a major in studies leading to a baccalaureate, master's, or doctoral degree in mathematics, engineering, or the physical, life, or computer sciences. These scholarships would be for a period of up to five years, and would be equal to the students' unmet financial need (i.e., the cost of attendance minus any non-loan aid). At least 50% of the cost of these scholarships would have to come from non-federal funds.

H.R. 5358 would amend the current NSF Robert Noyce Scholarship Program, which provides scholarships to undergraduates majoring in STEM fields. Students would be eligible for a $10,000 scholarship annually (up from the current $7,500), and would be required to teach math or science in a high-need school. Recipients must serve two years as a teacher for every year they received a scholarship, with a maximum of four years of service. The bill would also make special considerations for students and working professionals attending part-time. The bill authorizes $50 million for this program in FY2007, $70 million in FY2008, and $90 million for FY2009 through FY2011.

H.R. 5358 would establish a Talent Expansion Program, as well as Centers for Undergraduate Education in Science, Mathematics, and Engineering, which would award grants to IHEs intended to improve and expand course-taking in STEM fields. The former program would be authorized at $40 million for FY2007, $45 million for FY2008, and $50 million for FY2009 through FY2011. The latter program would be authorized at $4 million for FY2007, $10 million for FY2008 through FY2011.

Graduate Research and Early-Career Scholarship. S. 2198 would provide funding for graduate research fellowships in the critical fields of science, mathematics, and engineering. The bill would establish a fellowship program to provide tuition and financial support for eligible students pursuing master's and doctoral degrees in science, mathematics, and engineering, and other areas of national need. S. 2198 would authorize appropriations of $225 million for FY2007, $450 million for FY2008, and $675 million for FY2009 through FY2013.

Both S. 1614 and H.R. 609 would amend the Graduate Assistance in Areas of National Need program (HEA, Title VII, Section 711) to encourage study in STEM fields. The current program provides grants to institutions of higher education that award graduate degrees in *areas of national need*. This program also funds fellowships to graduate students pursuing doctoral degrees in areas of national need at eligible institutions. The Secretary of Education, in consultation with federal agencies and nonprofit organizations, is given the authority to determine the areas of national need. S. 1614 would require the Secretary to consult with specific federal and nonprofit agencies and organizations (including NAS) in determining the areas of national need. H.R. 609 would require that in determining the areas of national need, the Secretary shall prioritize "math and science teachers, special education teachers, and teachers who provide instruction for limited English proficient individuals."

S. 2109 proposes expanded graduate fellowship and graduate traineeship programs in the NSF. It would authorize the appropriation of $34 million each year for FY2007 through FY2011 for expansion of the Graduate Research Fellowship

Program in NSF. Such funding would allow for an additional 250 fellowships to be awarded to U.S. citizens each year during the five-year period. The total number of fellowships to be awarded is 1,250. The bill also provides $57 million each year for a period of five years for the expansion of the Integrative Graduate Education and Research Traineeship program in NSF. The support would provide an additional 250 grants per year to U.S. citizens, for a total of 1,250 awards.

S. 2109 would direct the Secretary of the Department of Defense (DOD) to utilize appropriations for expansion of the Science, Mathematics, and Research for Transformation Defense Scholarship Program (SMART). The bill would provide support for an additional 160 doctoral degrees and 60 master's degrees for FY2007 through FY2011. The Secretary of Defense would be charged with expanding by 200 the number of participants in the National Defense Science and Engineering Graduate Fellowship program each fiscal year from FY2007 through FY2011. S. 2109 calls for the establishment of a program to award traineeships to undergraduate and graduate students pursuing studies in areas important to DOD in science, mathematics, and engineering. The selected programs should expose students to multidisciplinary studies, innovation-oriented studies, and academic, private sector, or government laboratories and research. Awardees would be required to work for DOD for 10 years following the completion of the degree program. The bill would authorize appropriations in the amount of $11.1 million each year for FY2007 through FY2011.

S. 2109 would establish a clearinghouse of successful professional science master's degree programs, and make the program elements available to colleges and universities. Grants would be awarded for pilot programs at four-year institutions that foster improvement of professional science master's degree programs. The bill directs that preference be given to institutions that obtain two-thirds of their funding from non-federal support. A maximum of 200 grants would be awarded to four-year institutions for one three-year term, with renewal possible for a maximum of two additional years. Language included in the bill states that performance benchmarks be developed prior to the beginning of the program. The amount of $20 million would be made available for evaluation and reporting of the pilot program.

S. 2197 would authorize research grants for early-career scientists and engineers. The participants must have completed their degrees no more than 10 years before the awarding of the grants. Not less than 65 grants per year would be awarded to outstanding early-career researchers to support other researchers in the DOE National Laboratories, and federally funded research and development centers. The grants would be awarded for a period of five years in duration, and at a level of $100,000 for each year of the grant period. The bill would authorize the appropriation of $6.5 million in FY2007, $13 million in FY2008, $19.5 million in FY2009, $26 million in FY2010, and $32.5 million in FY2011.

H.R. 5356 would authorize two new programs (one carried out by the NSF Director and the other by the DOE Under Secretary of Science) that would award grants to scientists and engineers at the early stages of their careers at IHEs and other research institutions. Five-year, merit-based grants are to be awarded at a minimum of $80,000 per year to support innovative projects that integrate research and education.

Federal Program Coordination. Under S. 2198, the Director of the Office of Science and Technology Policy would establish a standing committee on education in mathematics, science, and engineering. The responsibility of the committee would include the development of national goals for support of the disciplines by the federal government. Language in the bill stipulates that there should be public comment on the national goals. In addition, plans should be periodically reviewed and updated by the Director.

S. 2197 calls for the creation of a position of Director of Mathematics, Science and Engineering Education, and charges that the Director administer and oversee programs at the DOE. In conjunction with the NAS, the Director would assess, after five years, the performance of science and mathematics programs at DOE. The bill would establish a Mathematics, Science, and Engineering Education fund, using 0.3% of funding made available to DOE for research, education, demonstration, and commercial application.

H.R. 609 would establish Mathematics and Science Education Coordinating Council Grants to assist states in coordinating math- and science-related activities supported by the Elementary and Secondary Education Act Title II, Part B, Mathematics and Science Partnerships Program, and the HEA Title II, Teacher Quality Enhancement Program.