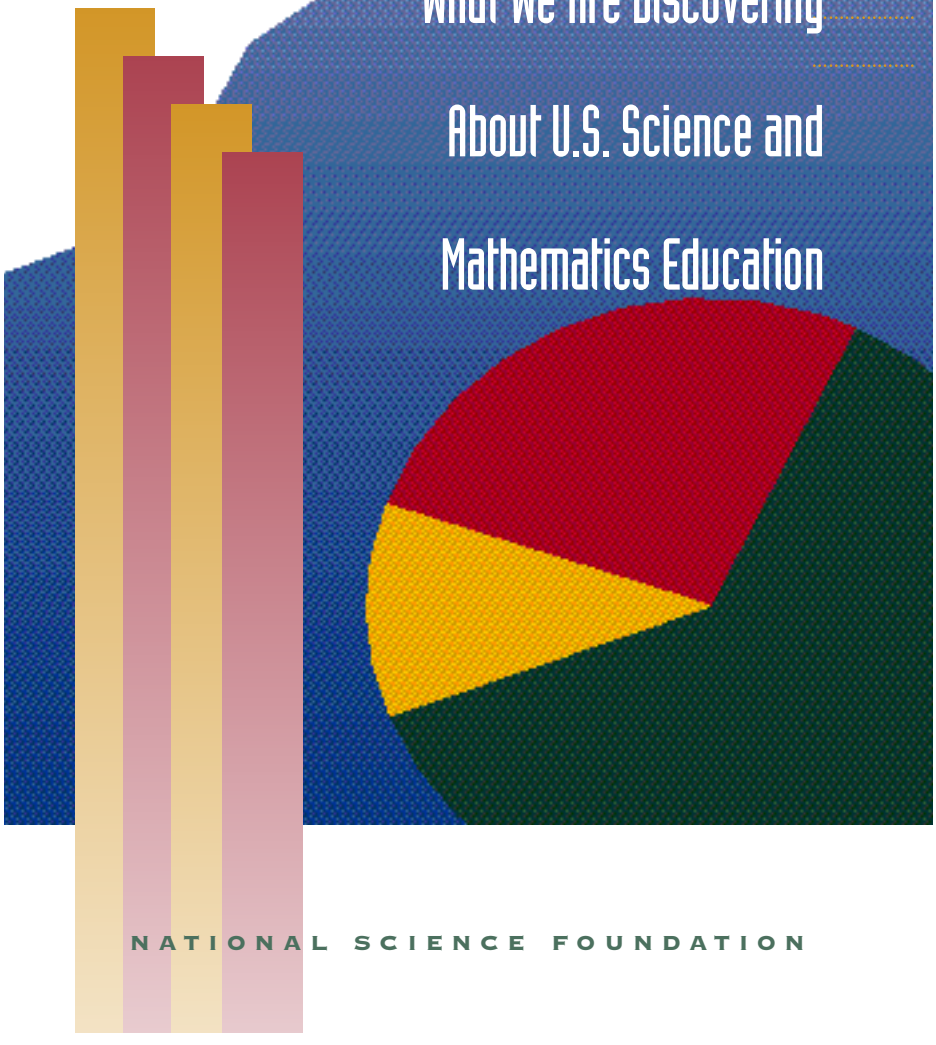
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The Learning Curve

What We Are Discovering About U.S. Science and Mathematics Education



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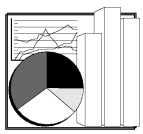
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The Learning Curve:
What We Are Discovering about U.S. Science and Mathematics Education

A Prefatory Report on the National Science Foundation's Indicators of Science and Mathematics Education 1995

January 1996



REC Indicators Series



National Science Foundation

Recommended Citation

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Presenting the Indicators

According to data recently compiled by the National Science Foundation (NSF), elementary schools in the United States today are devoting more classroom time than ever before to science and mathematics instruction. More high school students are undertaking advanced courses in these crucially important areas of study. And U.S. colleges and universities are awarding more bachelor's, master's, and doctoral degrees in the natural sciences and engineering.

Moreover, members of all racial and ethnic groups are sharing in a number of the notable gains made by the Nation's science and mathematics students; for example, a greater proportion of U.S. high school students, regardless of race or ethnic background, are now satisfactorily completing courses in science and mathematics. Achievement scores in these fields are on the rise for students of all races. And there is a discernible increase in the number of blacks, Hispanics, and Native Americans earning bachelor's degrees in science and engineering.

These and an array of other encouraging findings are offered in an NSF presentation of statistical data—or "indicators"—concerning the students, teachers, systems, curricula, learning environments, teaching methods, and other components of the Nation's science and mathematics education community. Titled *Indicators of Science and Mathematics Education 1995*, the report was created in compliance with a 1991 mandate from the U.S. Congress. Like its 1992 predecessor, for which it serves as an update, the latest volume is intended for use by anyone seeking qualitative and quantitative information on trends in elementary, secondary, and postsecondary education. NSF expects the report's readership to be broad in scope, including educators, elected officials, government policy makers, social commentators, professional scientists and mathematicians, and the general public—all citizens, that is, who support the notion that significant improvement in U.S. science and mathematics education should rank among the Nation's highest priorities.

What is an "Indicator"?

An indicator is a statistic that describes the health of a system or the status of an important policy issue.

For those who share in the hope that U.S. science and mathematics education is effectively preparing our young people to live, work, and prosper in a technology-intensive, increasingly competitive global society, the report offers grounds for cautious optimism. Indeed, based on hundreds of statistical findings gathered by NSF from a wide variety of authoritative national surveys, *Indicators of Science and*

Mathematics Education 1995 suggests that considerable progress in science and mathematics education is being made at all grade levels.

- Particularly encouraging is the growing awareness among elementary school teachers and curriculum designers that a familiarity with basic concepts in science and mathematics should be introduced to students at an early age. Measured in blocks of time ranging from approximately 20 minutes to 100 minutes, the average amount of classroom time per day dedicated to science and mathematics for grades 1 through 6 rose substantially between 1977 and 1993, according to a 1993 National Survey of Science and Mathematics Education (NSSME), one of several sources for the *Indicators of Science and Mathematics Education 1995*.

- Furthermore, students' early exposure to science and mathematics is now being parlayed beneficially through their high school years far more effectively than it has been in the past, thanks largely to an increase in the number of states that are imposing stricter graduation requirements in these areas of study. In 1974, about 15 percent of states required 2 or more years of mathematics for graduation; in 1992, the figure was approaching 90 percent. Consistent with elevated graduation requirements, the increased availability of advanced science and mathematics courses at the secondary level is evident nationwide. Currently, nearly 100 percent of all U.S. high schools offer courses not only in introductory algebra, geometry, and biology, but also in chemistry, physics, algebra II, and trigonometry.

- Along with more stringent high school graduation requirements and the availability of advanced science and mathematics courses, the level of preparation of postsecondary science and engineering students and the number of college degrees being awarded in these areas are rising. Much of this progress has been made within the very recent past. High school students who in 1993 planned an undergraduate major in the natural sciences or engineering were, for the most part, better prepared than were their counterparts just 3 years earlier. Between 1990 and 1993, for example, the proportion of intended natural science or engineering majors who took calculus in high school rose from about one-quarter to one-third, while the proportion of those taking physics increased from about one-half to almost two-thirds.

- Among the most encouraging trends noted in the report is the increase in the number of women with degrees in science fields. Between 1971 and 1991, the percent of bachelor's degrees in science and engineering fields awarded to women increased from 29 to 44 percent and the percent of doctoral degrees awarded to women increased from 10 to 28 percent. Steady increases occurred over the past 20 years in the number of women receiving bachelor's and doctoral degrees in science fields while the number of men receiving degrees did not increase. While the number of women receiving doctorates in science fields has increased by more than threefold since 1971, the number of men receiving doctoral degrees is about the same in 1991 as in 1971.

The *Indicators of Science and Mathematics Education 1995* presents some less-encouraging indicators as well:

- While more high school students of all races are enrolling in and successfully completing science and mathematics courses, and although test scores of all students have improved during the past decade, scores for white students remain significantly higher than those for black and Hispanic students. And although more blacks, Hispanics, and Native Americans are earning bachelor's degrees in science and engineering today than ever before, all three minority groups remain underrepresented in relation to their presence in the overall U.S. college-age population.
- Despite some modest gains since 1988, women and minorities continue to be underrepresented on U.S. higher education science and engineering faculties.
- While today's students have parents with higher levels of education—a factor that many experts consider a positive influence on academic proficiency—these students are more likely to be members of one-parent families and to be living in poverty—factors that many experts consider a negative influence on performance.
- Eighth-grade mathematics achievement in some states (Iowa, North Dakota, and Minnesota) was the same as in top-performing countries (Taiwan, Korea, and former Soviet Union), while achievement in the lowest performing states (Arkansas, Alabama, Louisiana, and Mississippi) was about the same as in the lowest performing country (Jordan).
- Despite increases in the time and attention being devoted to science and mathematics, the high school graduation requirements for these subjects in many states still fall short of the 4 years of each that has been recommended by education reform advocates.

These and a wealth of other significant revelations emerge from the array of indicators presented in the report, a sampling of which appears in Highlights (page 8 of this summary report). In creating *Indicators of Science and Mathematics Education 1995*, NSF has focused on collecting, synthesizing, analyzing, evaluating, and presenting relevant data.

Standards and the Quest for Reform

Over the past decade, science and mathematics education standards have been articulated by a number of prestigious organizations, such as the National Council for Teachers of Mathematics, the National Research Council, the National Science Teachers Association, and the American Association for the Advancement of Science. While differing in details, the standards are consistent in providing guidelines for instruction, calling for improvement in teacher qualifications and the learning environment, and setting levels of expectation for student achievement. The standards reinforce the notion that the pursuit of excellence must be open to all students, regardless of their sex, race, or the community in which they live.

The standards have, in turn, yielded a widely endorsed set of specific goals, such as the following:

- All students should be expected to attain a high level of scientific and mathematical competency.
- Students should learn science and mathematics as active processes focused on a limited number of concepts.
- Curricula should stress understanding, reasoning, and problem solving rather than memorization of facts, terminology, and algorithms.
- Teachers should engage students in meaningful activities that regularly and effectively employ calculators, computers, and other tools in the course of instruction.
- Teachers need both a deep understanding of subject matter and the opportunity to learn to teach in a manner that reflects research on how students learn.

What are the "Standards"?

National standards provide an explicit set of expectations for teaching and learning. Stressing the importance of mathematics and science for all students, they provide a vision that is based on our best understanding of teaching and learning. Standards provide the basis for guiding educational programs and for measuring the accomplishments of our educational institutions.

One way the standards and goals of excellence and equity in science and mathematics education have been implemented is through efforts to reform many aspects of the school system at once—an approach entailing a coordinated national initiative, as opposed to piecemeal remedial efforts, to address all critical components of the prevailing educational system. Dr. Luther S. Williams, Assistant Director of NSF's Directorate for Education and Human Resources, says that systemic reform "…is a revolutionary vehicle to ameliorate the performance gap—which demographics dictate we must do in order to achieve Goals 2000 for all of our students."

Systemic science and mathematics education reform is built on the following elements:

- Curricular reform for all students at all grade levels, including the establishment of achievement standards based on the ability to master scientific processes rather than memorization of facts or formulas.
- Changes in the learning environment, including pedagogic reform, with teachers emphasizing active student involvement through discussion, problem solving, hands-on activities, and small-group work.
- More opportunities for all students to use calculators and computers in the classroom and for homework.
- More exposure of low-achieving students to the full range of educational opportunities and demands.
- Assessment reform that replaces tests based on factual knowledge with tests that measure the ability to reason, solve problems, and use scientific principles.

What is "Systemic Reform?"

"Systemic reform" is a process of educational reform based on the premise that achieving excellence and equity requires alignment of critical activities and components. It is as much a change in infrastructure as in outcomes. Central elements include—

- **High standards for learning expected from all students;**
- **Alignment among all the parts of the system—policies, practices, and accountability mechanisms;**
- **A change in governance that includes greater school site flexibility;**
- **Greater involvement of the public and the community;**
- **A closer link between formal and informal learning experiences;**
- **Enhanced attention to professional development; and**
- **Increased articulation between the precollege and postsecondary education institutions.**

In light of prevailing concerns about U.S. students' comparatively low academic achievement in science and math, and considering the commitment of the Federal Government and state governments to reverse the situation by the year 2000, it follows that policy makers, congressional leaders, parents, and others are looking for answers to a number of questions, including the following:

- Are current reform efforts succeeding in improving science and mathematics education?
- Has overall achievement improved?
- Do students in each state and region of the country perform equally?
- Are achievement levels among ethnic groups converging?
- Have differences in the achievement levels of the United States and other countries narrowed?
- Is a reduction occurring in the practice of grouping students by ability level?
- Is there an increase in the number of teacher-development programs that emphasize new methods of science and mathematics instruction?
- Is there an increase in the number of teachers with undergraduate-level coursework in science and mathematics?
- Is there an increase in the number of teachers who belong to racial and ethnic minorities, especially in schools with large minority student populations?

Data Sources

Since its establishment in 1950, one of NSF's missions has been to provide research, guidance, and support for U.S. science and mathematics education. NSF's role extends into the compilation of statistical data about science and mathematics programs gathered by Federal agencies, such as the National Center for Education Statistics. NSF analyzes statistical information from outside sources as well and develops appropriate methods for evaluating the effectiveness of programs and initiatives. Creation of the biennial indicators report, therefore, builds on the agency's leadership as compiler, reviewer, and interpreter of complex data.

While the 1992 *Indicators of Science and Mathematics Education* report primarily described science- and mathematics-related trends from 1970 to 1990, the latest document focuses wherever possible on information regarding student proficiency, curricula, learning environments, demographics, and so forth, that has been gathered through 1993. Therefore, the 1995 report serves as an update on the ways in which the important issues in science and mathematics education that were analyzed in the 1992 edition continue to change.

Major sources of the latest data included such existing national surveys as the National Assessment of Educational Progress (NAEP), the National Education Longitudinal Study of 1988, the National Survey of Science and Mathematics Education, and the High School and Beyond study. The main source for international comparisons was the International Assessment of Educational Progress. In some cases, the authors have conducted secondary analyses of the existing data, but no new data were collected by NSF.

The 1995 report is presented in three main chapters, covering student achievement, characteristics of elementary and secondary education, and progress in postsecondary education. The indicators were chosen by the authors of each chapter, who were guided by members of an advisory committee and by publications on the status of relevant indicators. In the selection of the indicators, a special effort was made to address salient issues and trends of specific concern to school administrators and decision makers in the congressional and executive branches of government. The data cover, for example, the policy environment of educational reform, the demographic context of education, student achievement in science and math, reforms in science and mathematics education on the elementary and secondary levels, and trends in postsecondary science and engineering education. The report also discusses the overall state of educational reform and highlights the types of indicators required to assess future progress.

Highlights

To reflect the content of the full *Indicators of Science and Mathematics Education 1995*, the following sampling of the report highlights significant findings regarding student achievement, curriculum, teachers and the learning environment, equity, demographic changes, and postsecondary education.

Student Achievement

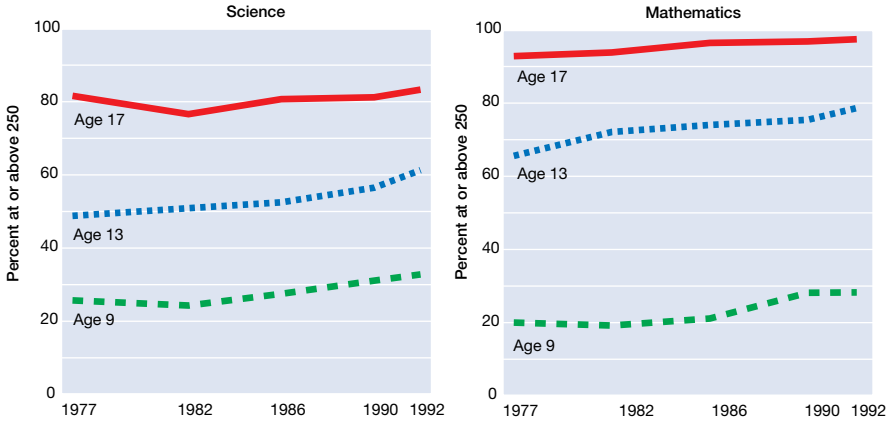
Science and mathematics proficiency among high school students, regardless of race, gained between 1977 and 1992 (see figure 1)—a change that may be attributed in part to the fact that many more students are taking advanced science and mathematics courses in high school as a result of changes in requirement policies within each state.

However, while a higher percentage of 13-year-old students scored 250 or higher on the NAEP science and mathematics proficiency test in 1992 than in 1977, recent comparisons of achievement show 13-year-old U.S. students scoring below students of other countries. (See figure 2.) These latter data, based on a 1991 study, substantiated results from earlier studies that provided the impetus for efforts to improve science and mathematics education in the United States.

Notwithstanding, a recent reanalysis of data shows that there are sharp differences in student mathematics performance among states in the United States that match differences among countries. (See figures 2 and 3.) A comparison of international and state proficiencies shows, for example, that eighth-grade performance in the highest ranking states (Iowa, North Dakota, and Minnesota) was the same as in the

FIGURE 1

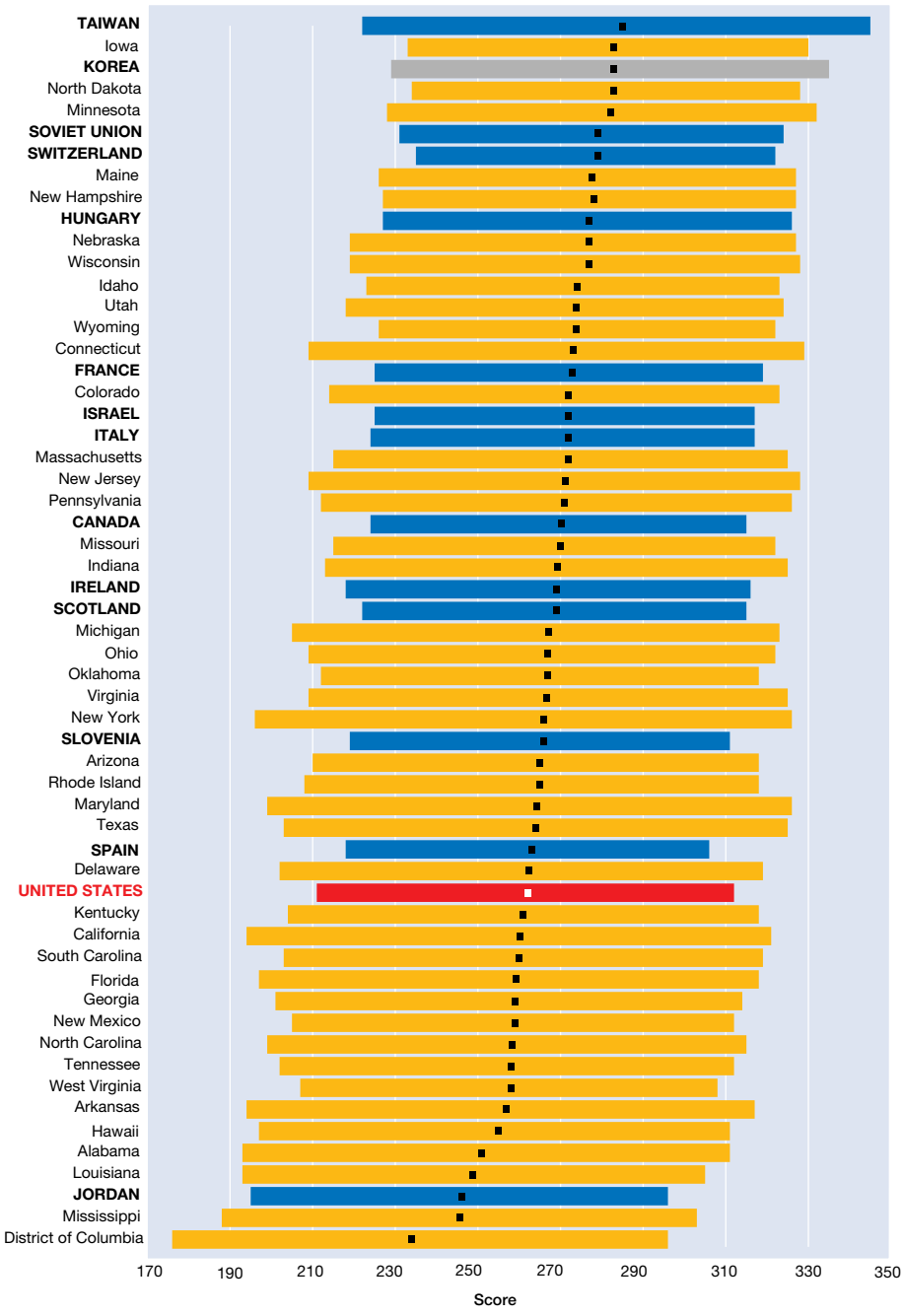
Science and mathematics proficiency—percent of students at or above anchor point 250, by age: 1977 to 1992



SOURCE: Mullis, I.V.S., et al. (1994). *NAEP [National Assessment of Educational Progress] 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

FIGURE 2

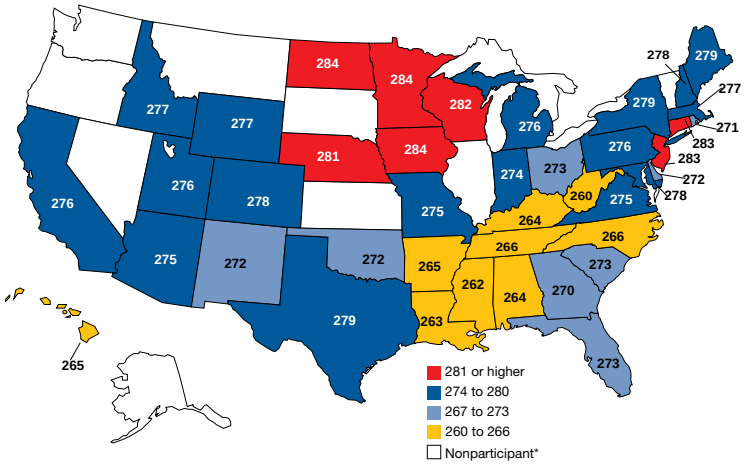
Mathematics proficiency scores for 13-year-olds in countries and public school eighth-grade students in selected U.S. states: 1991 or 1992



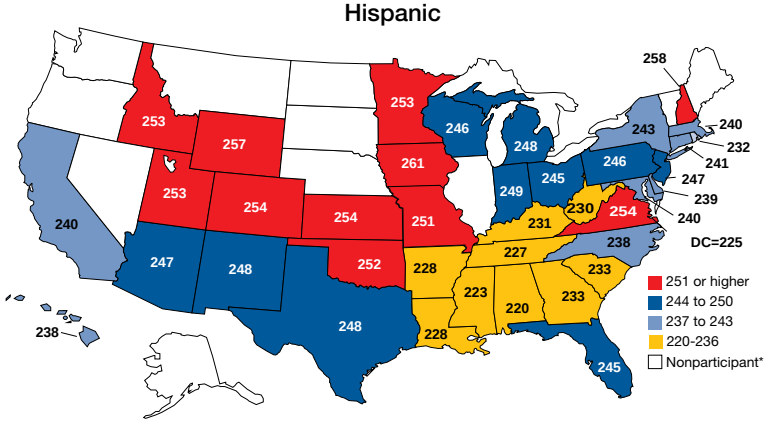
NOTES: International data are 1991. All U.S. data are 1992. Only 41 states and the District of Columbia volunteered to participate in the study.
SOURCE: National Center for Education Statistics (NCES). (1993). *Education in states and nations: Indicators comparing U.S. states with the OECD countries in 1988* (NCES 93-237). Washington, DC: NCES.

FIGURE 3

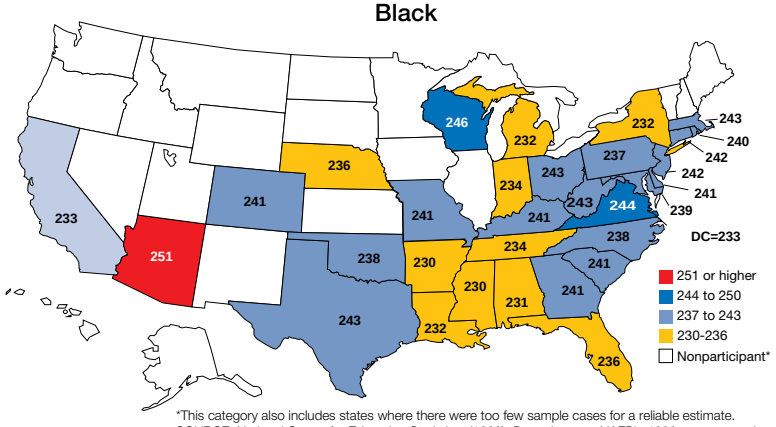
Mean scores of 13-year-old public school students on NAEP mathematics test, by race: 1992



Hispanic



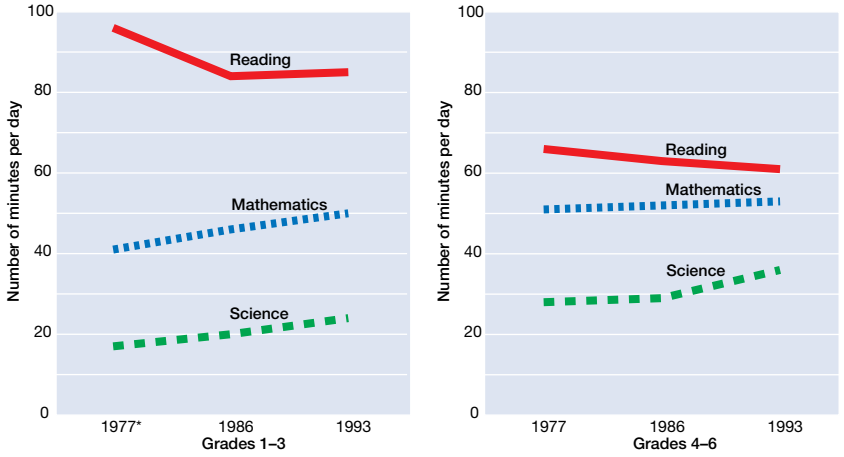
Black



*This category also includes states where there were too few sample cases for a reliable estimate.
SOURCE: National Center for Education Statistics. (1993). *Data almanac: NAEP's 1992 assessment in mathematics* [CD-ROM]. Princeton, NJ: Education Testing Service [Producer]. Washington, DC: U.S. Department of Education [Distributor].

FIGURE 4

Average number of minutes per day spent teaching each subject to self-contained classes, by grade range: 1977 to 1993



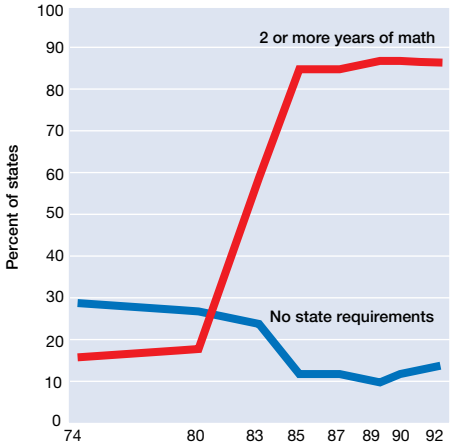
* 1977 data include kindergarten.
SOURCES: Weiss, I.R. (1987). *Report of the 1985–86 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute; Weiss, I.R., Matti, M.C., & Smith, P.S. (1994). *Report of the 1993 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research, Inc.

top-performing countries (Taiwan, Korea, and the former Soviet Union), and achievement in the lowest performing states (Arkansas, Alabama, Louisiana, and Mississippi) was about the same as in the lowest performing country (Jordan).

Within the United States, differences in student mathematics achievement are not simply a reflection of the concentration of racial or ethnic groups in some regions. For example, large differences in state mathematics scores exist for white and Hispanic students across regions and small differences exist for black students across regions. Overall, students in the Midwest had the highest NAEP mathematics scores, and students in the Southeast had the lowest scores. (See figure 3.)

FIGURE 5

Percent of states imposing graduation requirements in mathematics: 1974 to 1992



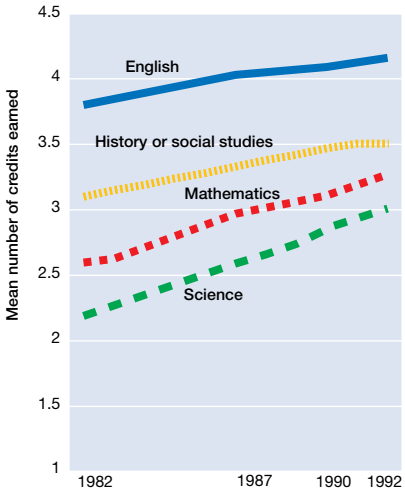
SOURCES: Stecher, B. (1991). *Describing secondary curriculum in mathematics and science: Current conditions and future indicators (N-3406-NSF).* A RAND note presented to the National Science Foundation, Arlington, VA; Blank, R.K. & Gruebel, D. (1993). *State Indicators of Science and Mathematics Education 1993.* Washington, DC: Council of Chief State School Officers.

CURRICULUM

Elementary schools are placing more emphasis on science and mathematics education by devoting more classroom time to it. (See figure 4.) Since 1977, the time devoted to science and mathematics has been more in line with recommendations incorporated in the standards delineated by various organizations.

FIGURE 6

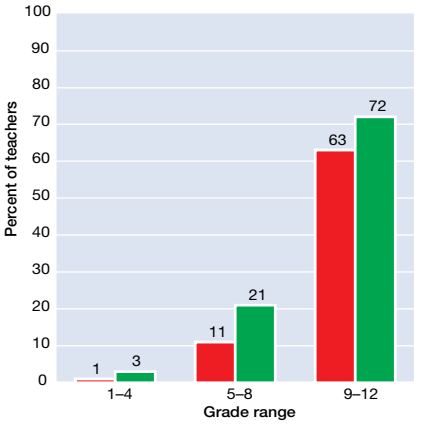
Mean number of credits earned by high school graduates in each subject field: 1982 to 1992



NOTE: Credits are measured as Carnegie Units.
SOURCES: Legum, S., et al. (1993). *The 1990 high school transcript study tabulations: Comparative data on credits earned and demographics for 1990, 1987, and 1982 high school graduates* (NCES 93-423). Washington, DC: National Center for Education Statistics; National Center for Education Statistics. (1992). *National education longitudinal study of 1988: Second teacher follow-up study.* Unpublished tabulations.

FIGURE 7

Percent of science and mathematics teachers with undergraduate or graduate majors in science or mathematics fields, by grade range: 1993



NOTE: "Field" includes any science or science education major for science teachers and any mathematics or mathematics education major for mathematics teachers.
SOURCE: Weiss, I.R., Matti, M.C., & Smith, P.S. (1994). *Report of the 1993 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research, Inc.

High schools also appear to be placing more emphasis on science and mathematics education. Whereas 20 percent of states required high school students to complete 2 or more years of mathematics in 1974, 86 percent of states had that requirement in 1992. (See figure 5.) The indicators are similar for science.

Despite elevated graduation requirements by states, the requirements still fall short of the standards recommended by reform advocates—4 years each of science and math. By 1992, high school graduates earned about 3 years each in science and mathematics. (See figure 6.)

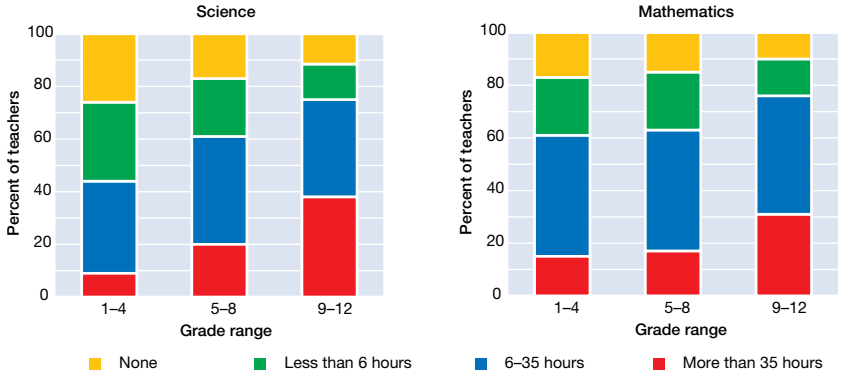
Teachers and the Learning Environment

Overall, high school teachers are likely to be academically well prepared to teach science and mathematics, but elementary teachers are likely to be unprepared. (See figure 7.) This is an important matter, since teachers' ability to implement science and mathematics reform, such as early introduction of challenging concepts and ideas, often depends on their own levels of competence and professionalism.

Only about two-thirds of teachers of grades 1 through 8 have completed at least one college course in the biological, physical, or earth sciences. Indeed, less than 30 percent of elementary school teachers say they feel well qualified to teach life science, while 60 percent feel well qualified to teach mathematics and close to 80 percent feel well qualified to teach reading.

FIGURE 8

Percent of science and mathematics teachers with various amounts of in-service education in these fields during the past 3 years: 1993



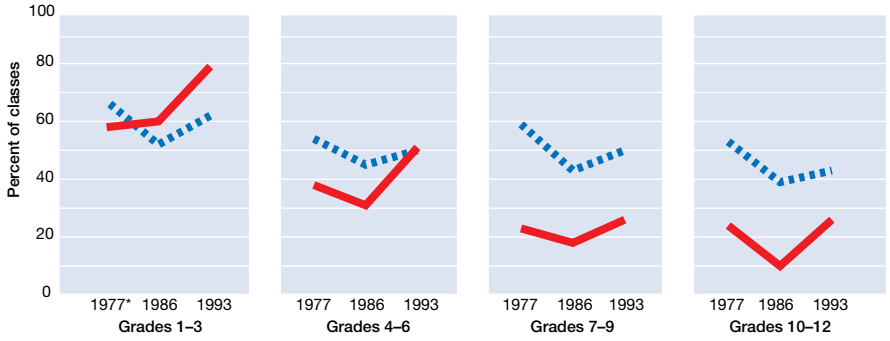
SOURCE: Weiss, I.R., Matti, M.C., & Smith, P.S. (1994). *Report of the 1993 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research, Inc.

Academic preparation is only one element of teacher competence. Other elements include continuing professional education, in-service training, and formal and informal contacts with colleagues and experts. In 1993, about one-third of all science and mathematics teachers had taken college courses within the past 3 years, and most had had at least some in-service education in their field. (See figure 8.) Elementary science and mathematics teachers had the least amount of in-service training.

Overall, teachers are not yet following recommendations for reforming classroom practice; for example, teachers have not implemented early introduction of algebraic concepts or alternative assessments. Additionally, despite strong recommendations for hands-on approaches in science and mathematics education, teachers still rely heavily on lectures. Fewer than 40 percent of junior high or high school classes used hands-on activities in their most recent lesson. (See figure 9.) Teachers may not be following recommendations for reforming classroom practice because science and mathematics classrooms tend to lack adequate facilities or supplies, such as up-to-date textbooks or modern computers.

FIGURE 9

Percent of classes using hands-on activities in most recent lesson, by subject and grade range: 1977 to 1993



* 1977 data include kindergarten.

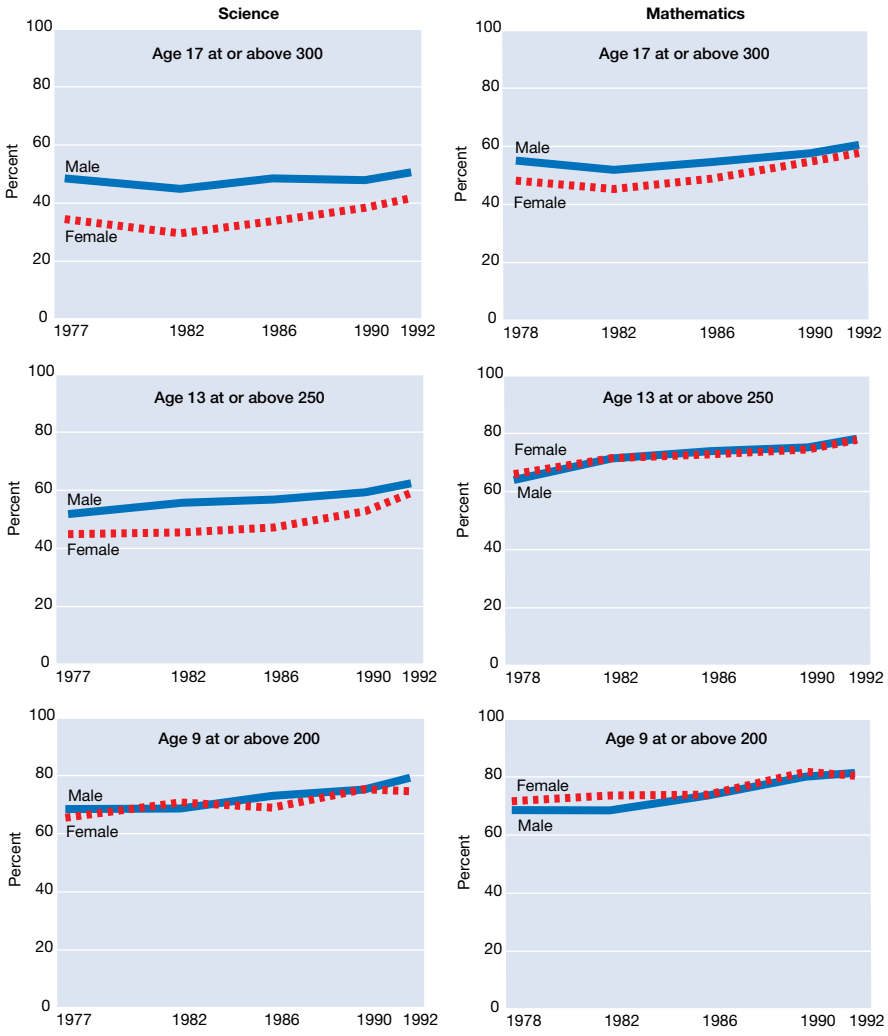
SOURCES: Weiss, I.R. (1987). *Report of the 1985–86 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute; Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.

Equity

Although proficiency gains are evident across both sexes and all racial and ethnic groups, these gains have not eliminated the gaps among different population groups or between males and females. For example, in 1977, the largest gap between the percentage of males and the percentage of females scoring at selected NAEP anchor points was in science at age 17. The gap between the achievement of males and females remained in 1992, although it had decreased from 14 percentage points in 1977 to 9 percentage points in 1992. (See figure 10.)

FIGURE 10

Science and mathematics proficiency—percent of students at or above selected anchor points, by age and sex: 1977 to 1992

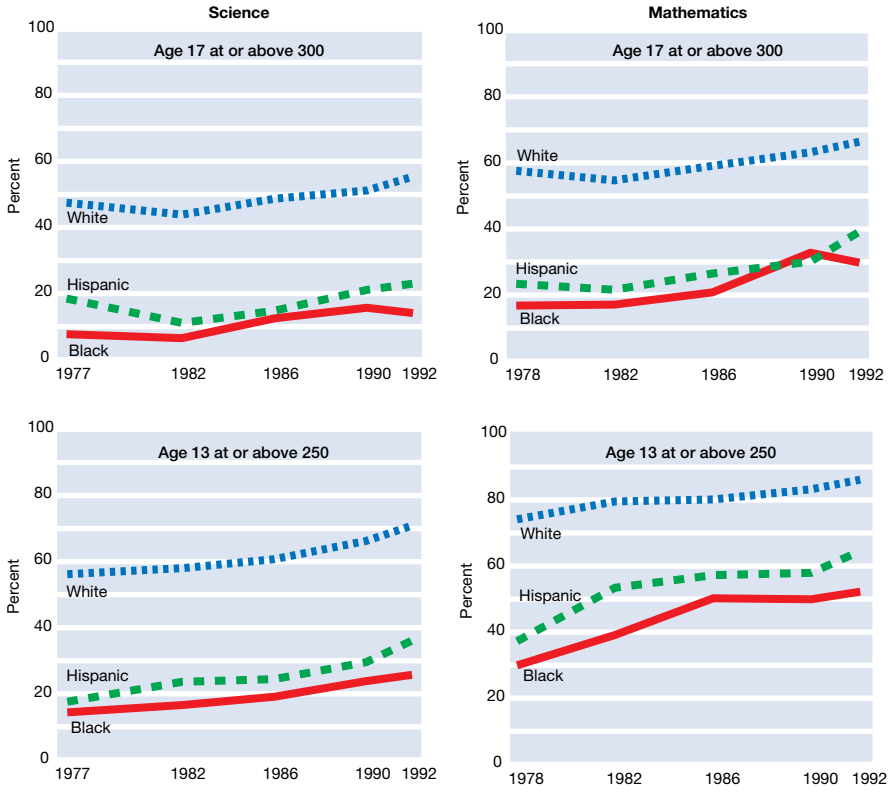


SOURCE: Mullis, I.V.S., et al. (1994). *NAEP [National Assessment of Educational Progress] 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

Furthermore, the amount of change in achievement for students in all racial and ethnic groups has been somewhat mixed, depending on test subject matter and age of students. NAEP science and mathematics tests, which were first administered in 1977, suggest that the gap between the percentage of white, black, and Hispanic students scoring at selected anchor points decreased for mathematics and, to a lesser degree, for science until 1990. Since 1990, however, science score differences have increased. (See figure 11.)

FIGURE 11

Science and mathematics proficiency—percent of students at or above selected anchor points, by age, and race or ethnic origin: 1977 to 1992

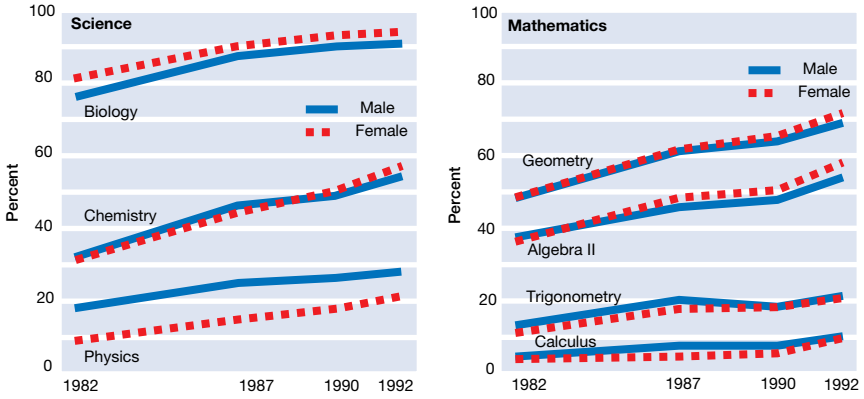


SOURCE: Mullis, I.V.S., et al. (1994). *NAEP [National Assessment of Educational Progress] 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

Between 1982 and 1992, female and male high school graduates earned credit in all science and mathematics courses at about the same rate, except in physics, where males significantly exceeded females. (See figure 12.) However, substantial differences in course taking existed among students in various racial and ethnic groups. (See figure 13.) For example, while about the same proportion of white, black, and Hispanic high school graduates had earned credits in biology and introductory algebra in 1992, a significantly higher proportion of white graduates had completed courses in chemistry, physics, geometry, advanced algebra, and trigonometry.

FIGURE 12

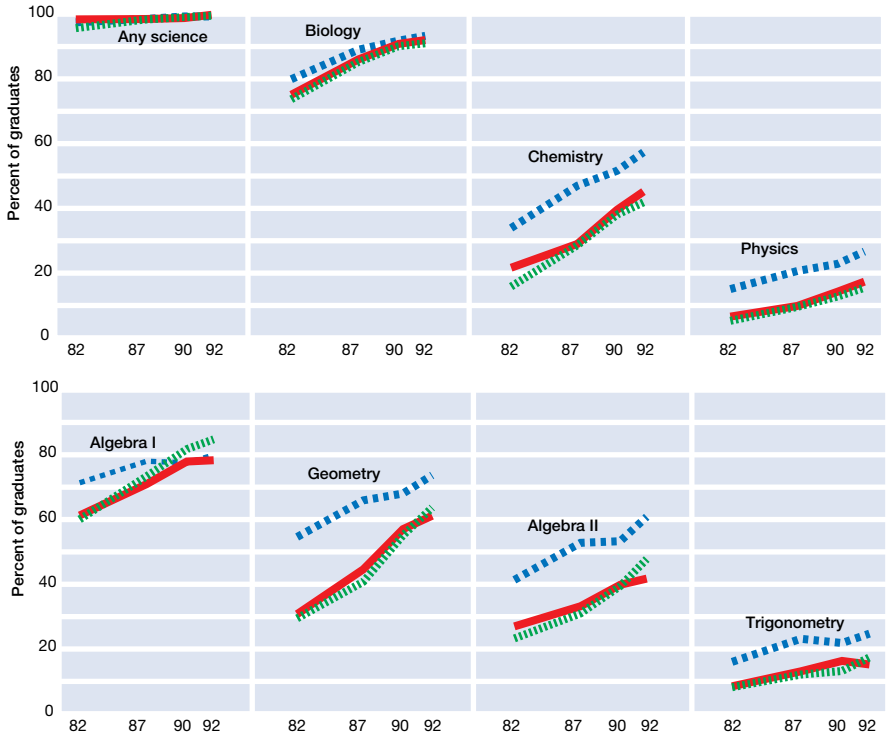
Percent of high school graduates earning credits in science and mathematics courses, by subject and sex: 1982 to 1992



NOTE: Credits are measured in Carnegie Units
SOURCES: Legum, S., et al. (1993). *The 1990 high school transcript study tabulations: Comparative data on credits earned and demographics for 1990, 1987, and 1982 high school graduates* (NCES 93-423). Washington, DC: National Center for Education Statistics; National Center for Education Statistics. (1992). *National education longitudinal study transcripts.* Washington, DC: Author.

FIGURE 13

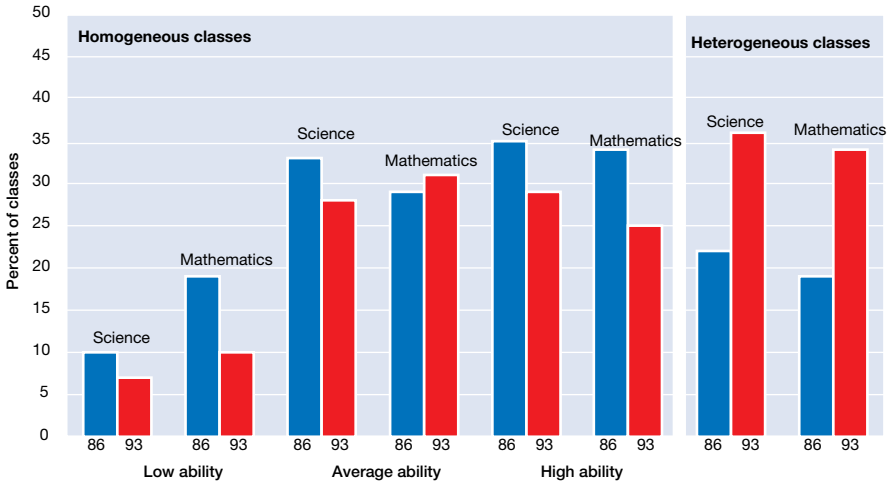
Percent of high school graduates earning credits in science and mathematics courses, by race or ethnic origin: 1982 to 1992



NOTE: Credits are measured in Carnegie Units.
SOURCES: Legum, S., et al. (1993). *The 1990 high school transcript study tabulations: Comparative data on credits earned and demographics for 1990, 1987, and 1982 high school graduates* (NCES 93-423). Washington, DC: National Center for Education Statistics; Smith, T.M., et al. (1994). *The condition of education, 1994* (NCES 94-149). Washington, DC: National Center for Education Statistics.

FIGURE 14

Ability composition of high school science and mathematics classes: 1986 and 1993



NOTE: High school includes grades 10–12.
SOURCES: Weiss, I.R. (1987). *Report of the 1985–1986 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute; Weiss, I.R. (1994). *1993 National survey of science and mathematics education*. Unpublished tabulations.

During this same period, ability grouping—assigning students to specific classes such as honors or remedial courses—in secondary science and mathematics classrooms declined, creating a more heterogeneous environment. (See figure 14.) Whatever may have stimulated this change, it is a move toward greater classroom equity, since homogeneous classrooms may deprive low-achieving students of exposure to demanding coursework and the stimulation and encouragement to achieve.

Demographic Changes

During the past two decades, the demographic context of the U.S. educational system has evolved in ways that directly influence averages of student performance. For example, students were more likely to be living below the poverty level in 1993 than in 1970; the proportion of students between 6 and 17 years old living in poverty rose from 14 percent to 20 percent during that period.

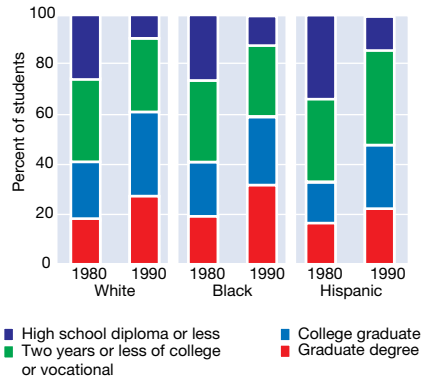
At the same time, the proportion of all parents who had received at least some college education increased from 25 percent in 1970 to 49 percent in 1993. The trend held for white, black, and Hispanic parents, although in 1993, parents of Hispanic students still had less education than parents of white or black students. Additionally, the proportion of families with children younger than age 18 living with only one parent increased from only 13 percent in 1970 to 30 percent by 1993.

Postsecondary Education

In the past, the primary purpose of secondary science and engineering education was seen as to provide credentials to students seeking to enter the workforce in science and engineering. Recently, this task has been augmented by the need to prepare users—

FIGURE 15

Percent of high school sophomores aspiring to various levels of postsecondary education, by race or ethnic origin: 1980 and 1990



SOURCES: National Center for Education Statistics. (1992). *High school and beyond, 1980 to 1992.*Washington, DC: Author; National Center for Education Statistics. (1992). *National educational longitudinal study of 1988: Second teacher follow-up study.* Washington, DC: Author.

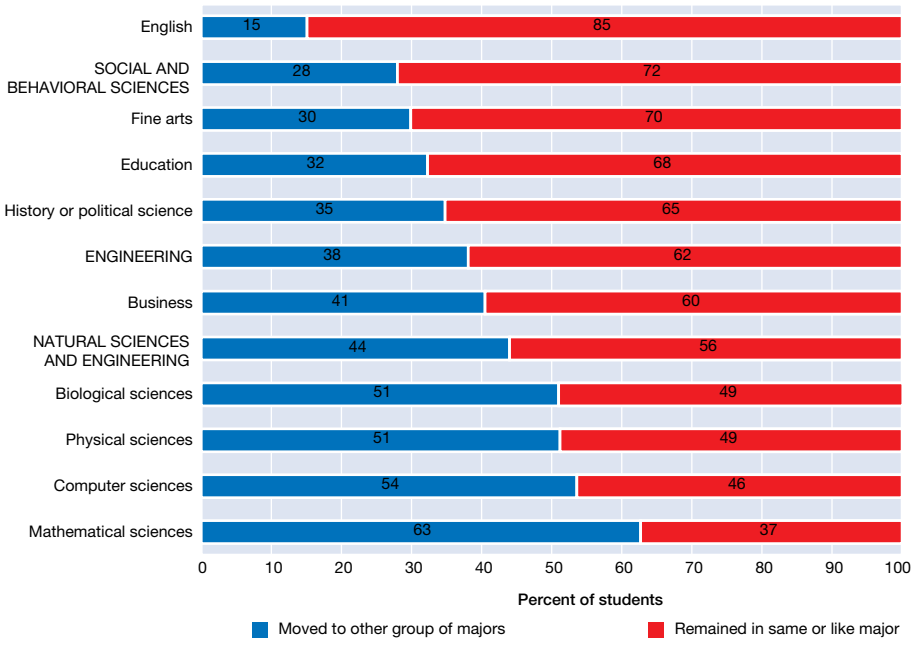
future professionals and managers—for a workplace transformed by scientific and technological innovations.

As the value of postsecondary education has increased across all sectors of the economy, the percentage of high school students aspiring to obtain a bachelor's, or higher, degree has increased dramatically, regardless of sex, race, or ethnic origin. (See figure 15.)

During the 1980s, despite decreases in the population of college-age youth, the number of bachelor's degree recipients increased markedly. The number of science and engineering bachelor's degree recipients also increased, although not as notably. However, compared with nations such as Japan, South Korea, and Germany, the United

FIGURE 16

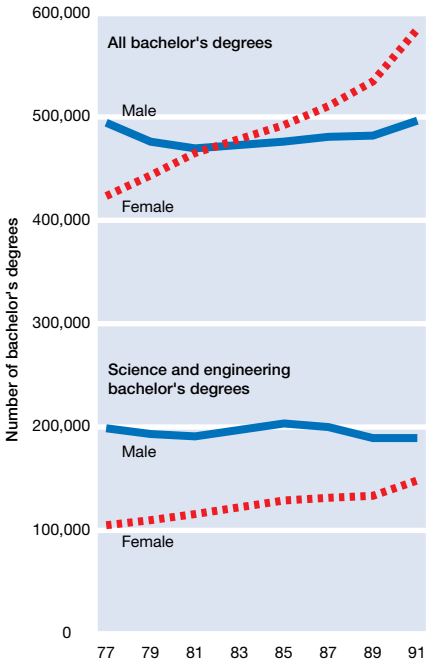
Percent of 1987 first-year undergraduate students in 4-year institutions who stayed in or switched to other (declared or intended) majors by 1991, by field of major: 1991



NOTE: Totals may not add to 100 percent as a result of rounding.
SOURCE: Seymour, E., & Hewitt, N.M. (1994). Talking about leaving: Factors contributing to high attrition rates among science, mathematics & engineering undergraduate majors. *Final report to the Alfred P. Sloan Foundation on an ethnographic inquiry at seven institutions.* Boulder, CO: University of Colorado.

FIGURE 17

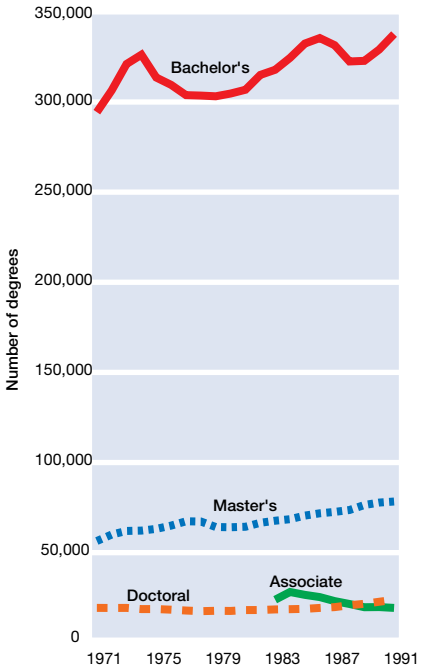
Number of bachelor's degrees awarded, by sex and major field group: 1977 to 1991



SOURCE: National Science Foundation. (1994). Science and engineering degrees: 1966-91 (NSF 94-305). Arlington, VA: Author.

FIGURE 18

Science and engineering degrees awarded, by degree level: 1971 to 1991



NOTE: Associate degree data available beginning in 1983.
SOURCE: National Science Foundation. (1994). *Science and engineering degrees: 1966-91* (NSF 94-305). Arlington, VA: Author.

States graduates significantly fewer persons with first degrees in natural sciences and engineering.

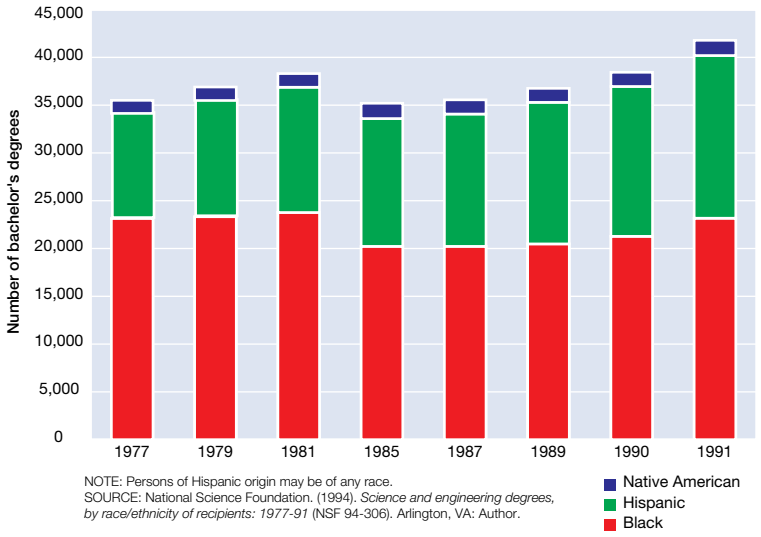
The slow growth in science and engineering degrees conferred in the United States may be partially attributed to "major switching," which is more prevalent for science and engineering majors than for any other major. (See figure 16.) While 28 percent of male and 10 percent of female high school seniors planned to major in one of the science or engineering fields, by the time they were college seniors, only 11 percent of males and 4 percent of females actually completed the major.

Another explanation for the slow rate of growth in science and engineering fields may be the lack of female and minority participation. Females constituted 54 percent of all bachelor's degree recipients in 1991, yet they earned only 44 percent of all bachelor's degrees in science and engineering. (See figure 17.)

Between 1971 and 1991, graduate degrees in science and engineering increased at a faster rate than at the bachelor's level. By 1991, doctorates in science and engineering constituted almost two-thirds of all doctorates granted in the United States. Universities awarded about 22,000, or 39 percent, more science and engineering master's degrees in 1991 than in 1971 and about 4,500, or 23 percent, more science and engineering doctoral degrees. (See figure 18.)

FIGURE 19

Science and engineering bachelor's degrees awarded, by selected racial and ethnic groups: 1977 to 1991

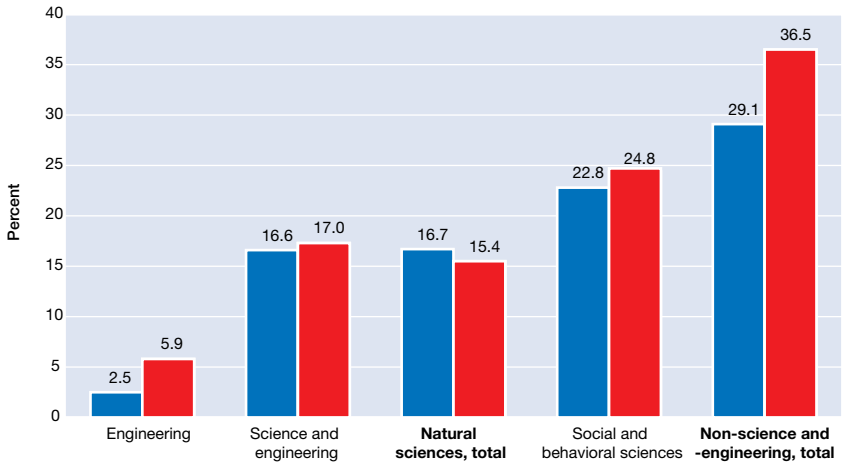


NOTE: Persons of Hispanic origin may be of any race.
SOURCE: National Science Foundation. (1994). *Science and engineering degrees, by race/ethnicity of recipients: 1977-91* (NSF 94-306). Arlington, VA: Author.

Recent data reveal that equity problems prevail in the postsecondary environment as they do in elementary and secondary education. While there has been an increase in the number of blacks, Hispanics, and Native Americans earning bachelor's degrees in science and engineering, all three ethnic groups remained significantly underrepresented when compared with their presence in the total U.S. college-age population. (See figure 19.)

FIGURE 20

Percent of full-time instructional faculty who are female, by field: Fall 1987 and Fall 1992



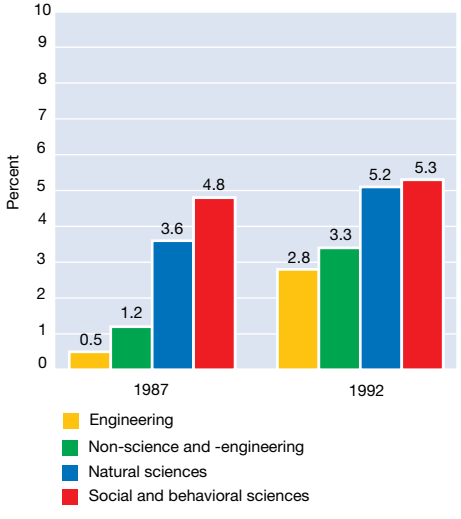
SOURCE: National Center for Education Statistics. (1994b). [Special tabulations from the 1993 national study of postsecondary faculty]. Unpublished data.

Between 1977 and 1991, Hispanics earned 55 percent more science and engineering bachelor's degrees and Native Americans earned 17 percent more science and engineering bachelor's degrees. Still, in 1991, Hispanics, who made up 11 percent of the college-age population, earned less than 5 percent of all science and engineering bachelor's degrees awarded to U.S. citizens, and Native Americans, who made up 1 percent of the population, earned less than 1 percent of these degrees. Blacks, who made up 14 percent of the college-age population, earned about 6 percent of the science and engineering bachelor's degrees awarded to U.S. citizens.

Underrepresentation is also evident in the number of females and minorities who serve as science and engineering faculty members. Between 1987 and 1992, the number of females teaching in U.S. postsecondary institutions increased markedly. Still, females account for only about 15 percent of faculty in the natural sciences and only about 6 percent of engineering faculty (see figure 20); they make up about one-third of all higher education faculty. Black faculty members within science and engineering fields are similarly underrepresented. (See figure 21.) In 1992, blacks made up about 5 percent of all higher education faculty, but they made up only 3 percent of natural sciences faculty and less than 3 percent in engineering.

FIGURE 21

Percent of full-time faculty who are black, by field: Fall 1987 and Fall 1992



SOURCE: National Center for Education Statistics (1994). [Special tabulations from the 1993 national study of postsecondary faculty]. Unpublished data.

Toward The Future

Although the syntheses of available statistics presented above, along with the abundance of additional data published in the full report, provide significant insights into the evolution of U.S. science and mathematics education over the past two decades, many elusive questions remain. It is becoming increasingly clear that both additional data and new types of data are needed to describe reform and its impact. For example:

- While available indicators reveal encouraging trends toward greater participation in science and mathematics by elementary school students and increased course completion and achievement by high school students, many states have yet to match their requirements to recommended standards. What are the obstacles, and what incentives might be needed?

- Since 1978, advances in performance have been observable for students of all ages and races; yet the pace is slow and uneven. Why is this so? What practices toward achieving full equity are proving most effective? Where are they being implemented? Why do they succeed or fail?

- Why do science and mathematics students in some regions of the United States consistently perform better than students in other areas? Is there solid empirical support for the notion that demographic factors such as family income and level of parental education have a profound impact on student motivation and performance?

Review of available data also shows that critical gaps in information exist with regard to

- state-level indicators measuring trends in student achievement, course taking, and teaching methods;

- data on science and mathematics course taking and content in higher education institutions; and

- the relationship between the planned and implemented classroom curricula.

Finally, comprehensive reports from bodies such as the National Academy of Sciences and the RAND Corporation suggest additional areas that indicator systems need to address, including adult literacy, resources committed by governmental and nongovernmental bodies, and teachers' knowledge.

NSF is taking steps to address these concerns and fill these gaps by supporting the development of measures of adult literacy and by considering studies to collect information on resources committed to science and mathematics education. However, few measures of teachers' knowledge exist in surveys of teachers.

Long term, the Foundation must take a broader look at ways to characterize the state of U.S. science and mathematics education. Challenges will include specifying the indicators for modification and future investigation; reviewing the frameworks that have, thus far, provided the basis for selecting indicators; and reevaluating the sources of data that will be available for the next biennial indicators report.

Measuring systemic reform and the progress of this evolving practice will require new efforts with survey techniques—techniques that measure the relationship among more parts of the educational system, the sharing of resources, and the public's understanding of science and mathematics education in the United States. ■

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