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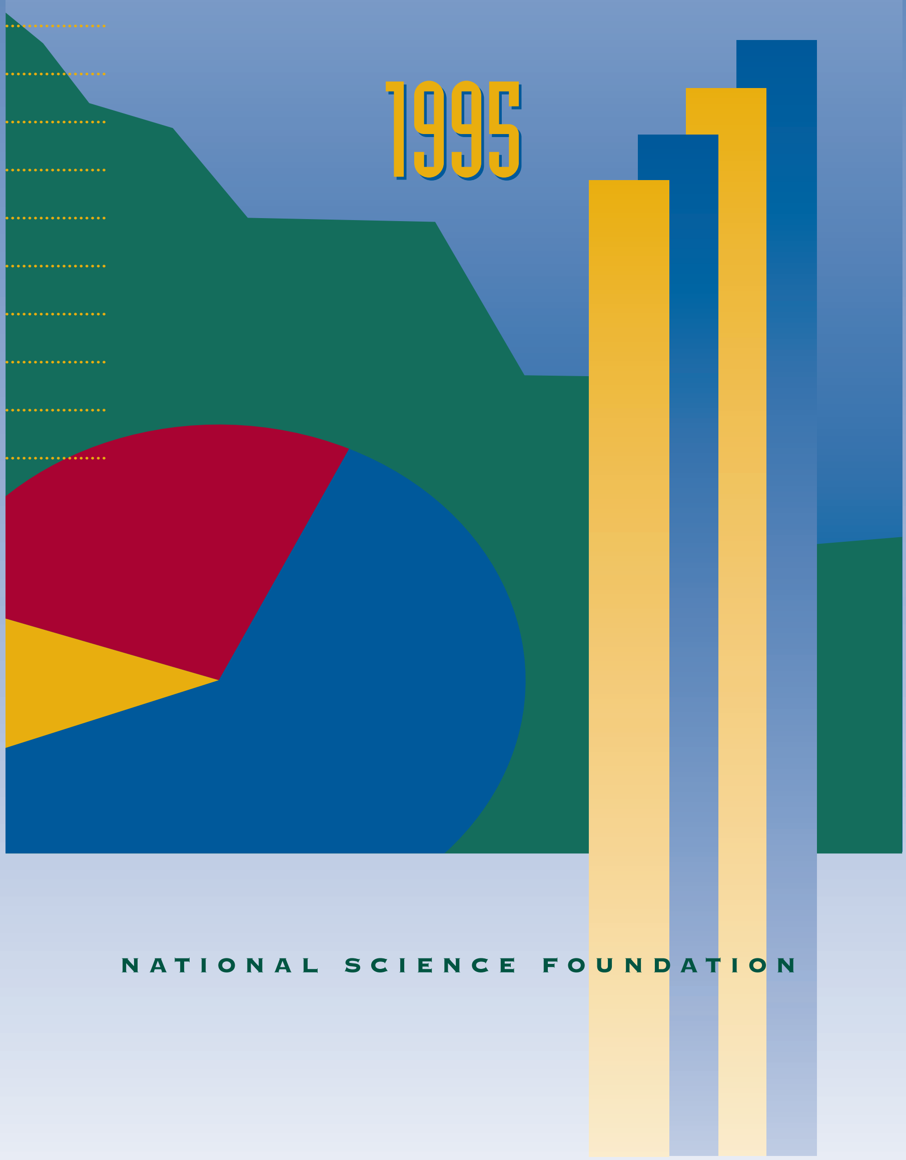
Indicators of Science & Mathematics Education

1995



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Highlights

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 education 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 a biennial science and mathematics education indicator report,[1] therefore, builds on the agency's leadership as compiler, reviewer, and interpreter of complex data.

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

A review of major reports recommending an indicator system for monitoring science and mathematics education is presented in the Postscript of this report. That section also recommends new, future directions for collection and presentation of such indicators.

Major sources of the latest data include 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 High School and Beyond. The main source for international comparisons is the International Assessment of Educational Progress. In some cases, the authors have conducted secondary analyses of the existing data, but no new data have been collected by NSF for this report.

A full understanding of the data presented here requires some familiarity with the precepts of systemic reform in science and mathematics education and the standards upon which the concept is based. It is largely within this context that the subjects of the report—student achievement, the competency of teachers, the sophistication of the learning environment, and others—have been selected.

Standards and Systemic Reform

Over the past decade, science and mathematics education standards, which provide an explicit set of expectations for teaching and learning, 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, their 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.

Meeting the standards and goals of excellence and equity requires a broadly based, coherent, systematic approach. NSF and the Department of Education have

[1]As specified in the Senate 1991 Appropriations Bill (HR 5158), this report is a congressionally mandated one:

"…In addition, the Committee expects the [National Science] Foundation to establish a biennial science and mathematics education indicator report, distinct from the science and engineering indicator report, that evaluates the progress of the United States in improving the science and mathematics capability of its students, and the effectiveness of all Federal and State education programs as part of this process."

collaborated on a number of systemic reform efforts that entail a coordinated national initiative, as opposed to piecemeal remedial efforts, to address all components of the prevailing educational system.

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; and
- Assessment reform that replaces tests based on factual knowledge with tests that measure the ability to reason, solve problems, and use scientific principles.

Observations

This report covers characteristics of elementary, secondary, and postsecondary education. The indicators were selected to show evidence of change in the Nation's science and mathematics education system. For elementary and secondary education, the selection of indicators includes curriculum coverage, teacher practices, and student achievement. This selection was influenced by national standards, which were developed by professional education associations. For postsecondary education, the selection of indicators monitors the extent of access to science and engineering postsecondary education by underrepresented minorities and females.

Overall, the trends toward higher student performance and course completion are consistent with the goals of reform. Some significant observations of changes during the past 2 decades are as follows:

Achievement Trends

- Several demographic changes have taken place during the past 2 decades that could affect student achievement. For example, the proportion of all parents who had received at least some college education increased from 25 percent in 1970 to 49 percent in 1993. (See figure 1-5.) 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. (See figure 1-6.) At the same time, students were more likely to be living below the poverty level; the proportion of students between 6 and 17 years old living in poverty rose from 14 percent in 1970 to 20 percent in 1993. (See figure 1-7.)
- Student achievement in both science and mathematics, as measured by the NAEP trends, has increased since 1977. Although increases do not occur every year, they are clearly observable for students of every race and ethnic origin and at every age. Increases occurred in the percentage of students who attained at least a basic level of knowledge in science and mathematics, especially among blacks and Hispanics and those at the lowest achievement levels. For example, the percentage of 13-year-old black students who attained a proficiency score of 250 or more increased from 29 percent in 1978 to 51 percent in 1992—a 22-percentage-point increase in students who perform at acceptable levels of mathematics in the eighth grade.
- These gains have not eliminated the gaps 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 had decreased from 14 percentage points in 1977 to 9 in 1992. (See figure 2-12.)
- Sharp differences in student mathematics performance among states in the United States match differences among countries. 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 top-performing countries (Taiwan, Korea, and the former Soviet Union), while performance in the lowest performing states was about the same as in the lowest performing countries. (See figure 2-19.)
- Overall, students in the Midwest had the highest NAEP mathematics scores, and students in the Southeast had the lowest scores. (See figure 2-19.)

Curriculum Trends

- High schools 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, almost

90 percent of states had that requirement in 1992. (See figure 3-1.) However, requirements in all states remain below the 4 years of science and mathematics recommended by the national standards.

- Increasing proportions of high school students received instruction in science and mathematics in the past 10 years. (See figures 3-4, 3-5, and 3-6.) Also, elementary students spent more time in class studying science and mathematics. (See figure 3-2.)
- Between 1982 and 1992, female and male high school graduates had earned credit in all science and mathematics courses at about the same rate, except in physics, where rates for males significantly exceeded those for females. (See figure 3-4.)
- Substantial differences in coursetaking existed among students in various racial and ethnic groups. (See figures 3-5 and 3-6.) 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.
- Ability grouping—assigning students to specific classes such as honors or remedial courses—in secondary science and mathematics classrooms has declined, creating a more heterogeneous environment. (See figure 3-8.) 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.

Teachers

- High school science and mathematics teachers are likely to have completed their undergraduate training with majors in their teaching fields, but few elementary school teachers majored in science or mathematics. (See figure 3-21.) 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. (See figure 3-22.)
- 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. (See figure 3-28.)
- Overall, many teachers are not yet following recommendations for reforming classroom practice; for example, teachers have not implemented early introduction of algebraic concepts or alternative assessments. However, science and mathematics teachers are using more "hands-on" activities. The number of classes using hands-on activities increased in each grade level since 1986, following a decline since 1977. Still, fewer than 40 percent of junior high or high school classes used hands-on activities in their most recent lesson. (See figure 3-20.)

Postsecondary Trends

- 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 4-2.)
- 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 States graduates significantly fewer persons with first degrees in natural science and engineering. (See figure 4-16.)
- Although interest in science and engineering careers declines among students between 10th grade and college graduation, a large portion of science and engineering graduates actually enter their discipline during the final years of college. (See figure 4-13.)
- Although 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. (See text table 4-1.)
- Between 1971 and 1991, increases in graduate degrees awarded exceeded increases at the bachelor's level. By 1991, doctorates in science and engineering constituted almost two-thirds of all doctorates granted in the United States. During this period, universities awarded 39 percent more science and engineering master's degrees and 23 percent more science and engineering doctoral degrees. (See figure 4-18.)
- The number of females receiving bachelor's degrees in science and engineering has increased substantially in the past few years; while the number of males graduating in those fields has remained flat or declined. (See appendix table 4-18.) Still, while females constituted 54 percent of all bachelor's degree recipients in 1991, they earned only 44 percent of all bachelor's degrees in science and engineering.
- The number of blacks and Hispanics graduating with science or engineering bachelor's degrees increased

between 1985 and 1991. However, blacks represented only 6 percent of science and engineering bachelor's degree recipients, whereas they represented 14 percent of the postsecondary population. Hispanics represented 4 percent of science and engineering bachelor's degree recipients and 11 percent of the population.

- Underrepresentation is evident in the number of minorities and females who serve as science and engineering faculty members. 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. (See figure 4-29.) Similarly, although the number of women teaching in U.S. postsecondary institutions increased markedly, females account for only about 15 percent of faculty in the natural sciences and only about 6 percent of engineering faculty (see figure 4-30); they make up about one-third of all higher education faculty. ■

Chapter 1

Introduction

The Senate 1991 Appropriations Bill (HR 5158) mandated that the National Science Foundation (NSF) produce this biennial report to evaluate the health of science and mathematics education.[1] This report is intended to update policy makers, educators, and the general public on the status of students and the system that serves them. It uses selected indicators of the system to provide a look at how science and mathematics education has changed in the past few years and how it is changing today. Furthermore, the report uses a number of indicators that represent important elements of the efforts of systemic reform of mathematics and science education.

The data and findings presented here about science and mathematics education are extracted from existing studies and surveys of education. In some cases, chapter authors have conducted secondary analyses of these existing data, but no new information has been collected from schools, students, or teachers specifically for purposes of writing this report. The report highlights information regarding relationships between changes in student achievement and changes in classroom conditions.

Although the picture that emerges is detailed, it is far from complete because survey data for many important topics of concern to science and mathematics educators are not available. Therefore, a secondary purpose of this volume is to evaluate the condition of current indicators as descriptors of science and mathematics education from kindergarten through the end of the collegiate experience and to identify new directions to be pursued.

Two themes are central to the indicators in this volume—excellence and equity. Excellence means the extent to which high standards of learning are attained; equity means the extent to which these standards are applied to all groups. Excellence and equity are the foremost goals of the educational system—the bottom line of the system's health.

The Context for this Report

The changes in the educational system described in this volume should be examined within the context of major events in the country that affect student performance in elementary and secondary schools and the scientific literacy of college graduates. This section provides a summary of some of the recent events in policy, funding, and demographics that the authors considered as they selected indicators for this volume. These events all affect interpretation of the selected indicators.

Policy

In response to mounting evidence from national and international studies that not all students in the U.S. educational system perform well in science and mathematics, educators and policy makers have placed a new emphasis on the promotion of excellence and equity for all U.S. students. (See Chapter 2.)

One initiative to deal with excellence and equity issues was the creation of a set of National Education Goals to be achieved by the year 2000. One of these goals stresses the importance of science and mathematics education by challenging school systems to make U.S. students' science and mathematics achievement first in the world.

Another initiative has been to implement systemic reform efforts, rather than piecemeal projects, to unify policies of reform. For example, standards have been developed for science and mathematics education to provide clear goals for students, teachers, and administrators in each subject area. (For more information on science and mathematics standards, see Chapter 3.) Also, new assessment strategies have been created to measure the outcome of new instructional methods. This volume provides an examination of the extent to which these reform efforts have been adopted by educators throughout the United States.

Systemic Reform

Systemic reform is an approach to educational change based on the premise that achieving excellence and equity will require more than piecemeal attacks on the educational system. Three elements are central to systemic reform (O'Day & Smith, 1993):

- high standards for learning expected from all students;
- alignment among the parts of the educational system; and
- a change in the governance of education, which includes greater school site flexibility and control over resources and strategies of curriculum implementation.

Systemic reform efforts include more, however, than just a vision of change in classroom instruction. They

- involve the community and the public in promoting change by encouraging partnerships among the sectors of education institutions and among parents, businesses, and the community to develop goals for students;

- offer an enhanced role for what has been called "informal science" learning experiences—museums, parks, and radio and television, etc.—in improving the educational system;
- give professional development enhanced prominence, with the idea that such development is important for all actors in the educational enterprise; and
- view the elementary and secondary system as integrally related to the postsecondary system; both community colleges and 4-year institutions are involved.

Systemic reform efforts emphasize an alignment among parts, with consistent and coherent policies, instructional practices, and assessments. For instance, instruction in elementary grades should be articulated with that of secondary grades, and instruction in elementary and secondary schools should prepare students to succeed both in the postsecondary education environment and as new entrants to the workforce.

The vision that forms the foundation for systemic change forces educators to expand the definition of excellence. It considers new components, as well as the extent of alignment of the components toward a common goal. Many of the necessary measurements of alignment are not currently available. Those that could be identified are shown in this volume, especially in Chapter 3. Further development of appropriate indicators must be continued to improve measurements of the conditions that affect the health of the entire school system.

Standards

Standards for teachers and students that were developed by national professional societies play a pivotal role in systemic reform efforts. Indeed, the description of instruction and learning portrayed in both the science and mathematics standards is one that is at the heart of systemic change efforts.

The National Research Council, representing the science community, is developing science standards, building on the American Association for the Advancement of Science's *Project 2061* and the National Science Teachers Association's *The Content Core*. The National Council for Teachers of Mathematics developed standards that were published in 1989, 1991, and 1995. Both sets of standards call for changes in teaching methods, teacher preparation, the learning environment, and the system's expectations of all students.

These standards are not merely a restatement of the status quo. They stress high levels of science and mathematics competency. They call for a different kind of instruction, emphasizing depth of understanding over breadth of coverage and instruction to promote problem solving. In addition, the role of the teacher becomes one of coach or model—with students expected to engage in hands-on, inquiry-based learning—rather than purveyor of knowledge. The principles within the standards are widely accepted by leaders of the education associations to provide a path to excellence.

Assessment

Assessment is a tool that not only measures, but also drives, instruction. As such, educators consider it a critical part of the teaching and learning cycle. The types of assessment used in schools throughout the country have begun to change in recent years. Experiments and research are underway to develop new testing strategies that require more problem solving and active engagement on the part of the students. This new generation of tests is expected to contribute to a more demanding educational system in which all students are expected to be competent in solving problems as well as knowing facts.

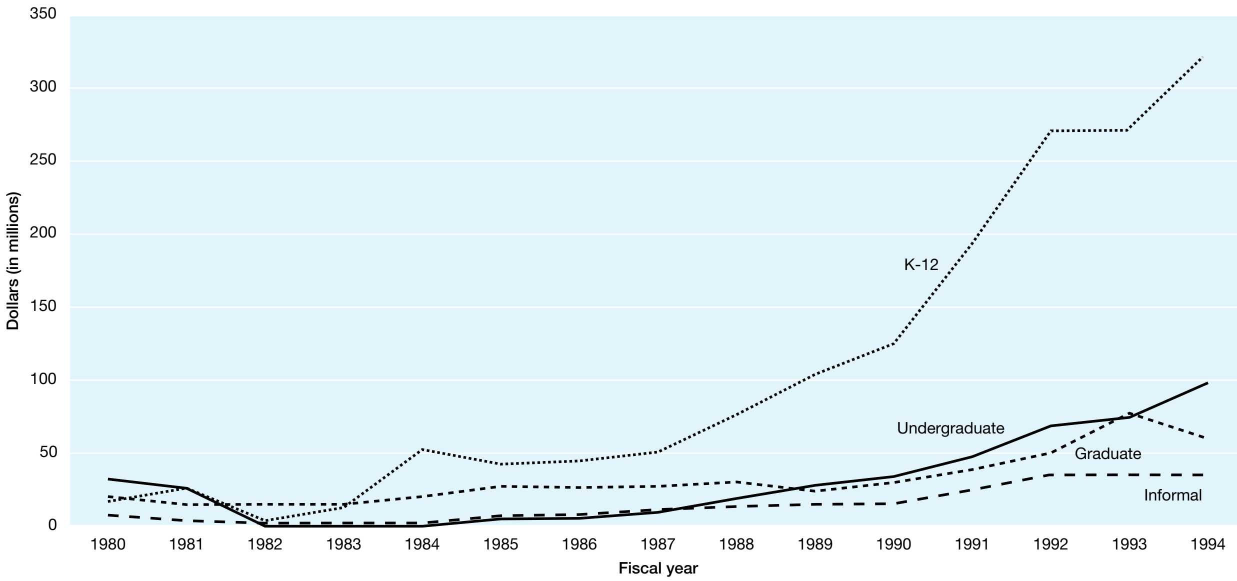
Federal Funding

One of NSF's missions is to provide research, guidance, and support for science and mathematics education in the United States. NSF provides funds to support graduate and undergraduate students in specific science and engineering fields, and primary responsibility for educational programs at NSF is vested in the Directorate for Education and Human Resources (EHR). Since the 1980s, EHR has grown rapidly, largely propelled by increases in programs for elementary and secondary education. Although EHR spent only 22 percent of its budget on elementary and secondary education programs in 1980, it expended about 57 percent of its budget on these programs in 1994. (See figure 1-1 and appendix table 1-1.) A

The science and mathematics standards are not merely a restatement of the status quo. They call for a different kind of instruction, emphasizing depth of understanding over breadth of coverage and instruction to promote problem solving.

FIGURE 1–1

Funding for sectors of education by the NSF Directorate for Education and Human Resources (EHR): 1980 to 1994



SOURCES: National Science Foundation. (1992). *EHR Directory of awards: Fiscal year 1990* (NSF 92-75). Washington, DC: NSF; National Science Foundation. (1994). [Budget figures]. Unpublished tabulations. See appendix table 1–1.

large proportion of these funds financed systemic approaches to increase the alignment of projects within a state or city to achieve a more unified policy and structure for elementary and secondary education.

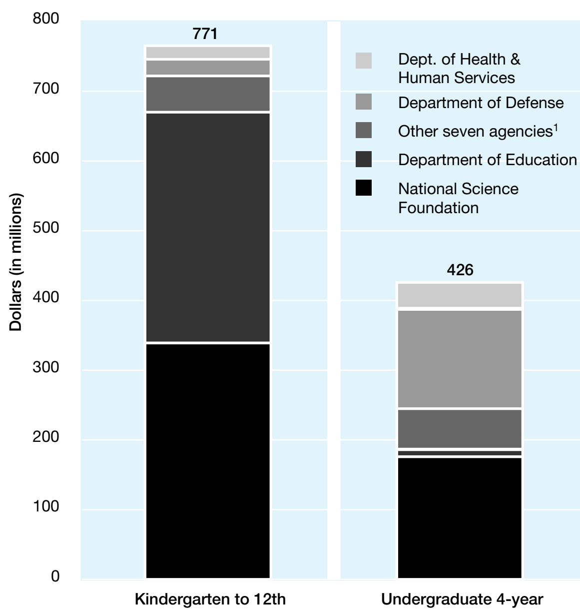
Although Federal funding is a small portion of the state and local government expenditures for science and mathematics education, changes in Federal funding may provide useful indicators of changes in national priorities. NSF's financial contribution to education represents about one-fourth of the total Federal investment in science and mathematics education. Other funding sources are the departments of Education, Health and Human Services, Defense, Agriculture, Commerce, Energy, and Interior; the National Aeronautics and Space Administration; the Smithsonian Institution; and the Environmental Protection Agency. (See figure 1-2 and appendix table 1-2.)

Demographics

Even as educators have continued to search for new ways to enhance excellence and equity during the past 2 decades, the demographic context of the educational system has changed. Several of the changes that occurred in the past 2 decades are ones that directly influence performance of U.S. students. Since most of the indicators in this volume are averages of a diverse population distributed over 50 states, they reflect important trends, such as changes in immigration patterns; however, because some

FIGURE 1–2

Budget obligations of 11 Federal agencies for science and mathematics education: 1994



[1]Other Federal agencies include the departments of Agriculture, Commerce, Energy, Interior; Smithsonian Institution; National Aeronautics and Space Administration; and Environmental Protection Agency.
NOTES: Because of definitional changes, these figures may not be compatible with previous analyses of this topic. Agency figures may be different as a result of evolving priorities for uses of funding. The figures reflect appropriated amounts.
SOURCE: NSTC-CET Budget Working Group. (1995). [Budget figures from departmental budget offices]. Unpublished tabulations.
See appendix table 1-2.

demographic changes occur slowly, they have limited influence on education indicators.

Elementary and Secondary

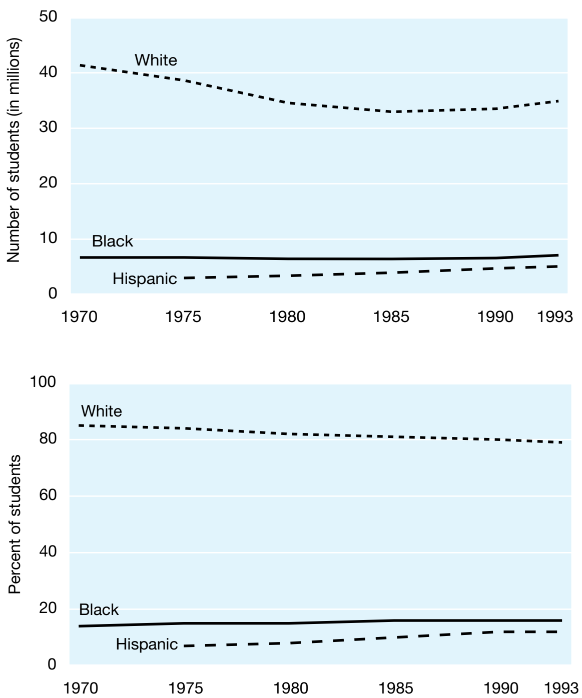
Between 1970 and 1985, the size of the elementary and secondary population declined. In 1985, it began increasing again. During this period, racial and ethnic diversity increased slightly within the elementary and secondary school population. By 1993, the white population was 16 percent smaller than it had been in 1970. The black population was about the same size as in 1970, and the population of other races, mostly Asian, grew. The Hispanic population increased by 2 million students, or about two-thirds, between 1975—when it was first measured—and 1993, to about 12 percent of the elementary and secondary population. (See figure 1-3 and appendix table 1-3.)

Corresponding to the increase in the Hispanic population was an increase in the number of children who did not speak English in the home. (See figure 1-4 and appendix table 1-4.) Between 1980 and 1990, the number of children who spoke a language other than English at home increased from 4.5 million to 6.3 million, or from 10 percent to 14 percent of all children. In 1990, just under 1 million children, about 2 percent of all children, reported that they did not speak English well or at all. A higher percentage of children who spoke a language other than English at home reported to the Census Bureau that they speak English very well. However, this change in the number of children who normally speak a language other than English at home was not large enough to have any dramatic effect on the indicators of student performance presented in this volume.

Overall, elementary and secondary students of all races and ethnic origins were more likely in 1993 than in previous years to have parents with higher education levels. (See figure 1-5 and appendix table 1-5.) Between 1970 and 1993, the proportion of parents who had received at least some college education increased from 25 percent to 49 percent. However, in 1993, only 37 percent of black and

FIGURE 1–3

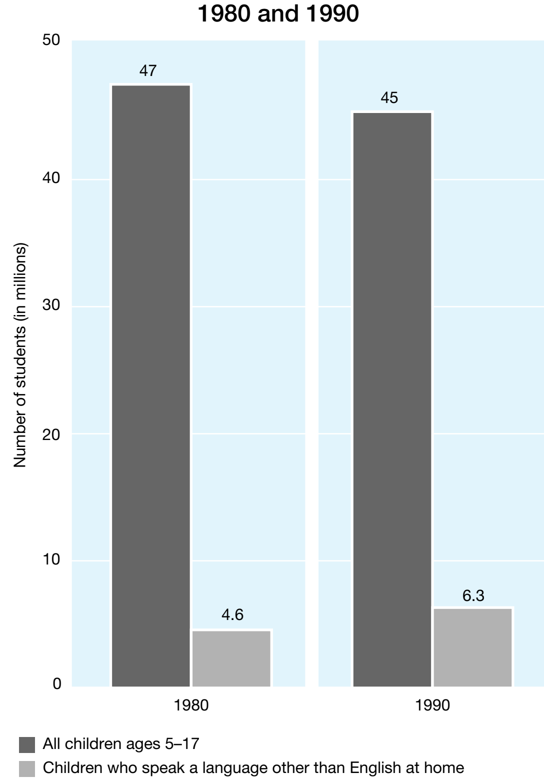
Number and percent of students enrolled in grades 1–12, by race or ethnic origin: 1970 to 1993



NOTES: Data not available for Hispanics before 1975. Persons of Hispanic origin may be of any race.
SOURCES: U.S. Bureau of the Census. (1990). *School enrollment–social and economic characteristics of students: 1989* (Current Population Reports, Population Characteristics Series P-20, No. 443). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1991). *School enrollment–social and economic characteristics of students: October 1990* (Current Population Reports, Population Characteristics Series P-20, No. 460). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1994). *School enrollment–social and economic characteristics of students: October 1993* (Current Population series, P-20, No. 479). Washington, DC: U.S. Government Printing Office.
See appendix table 1–3.

FIGURE 1–4

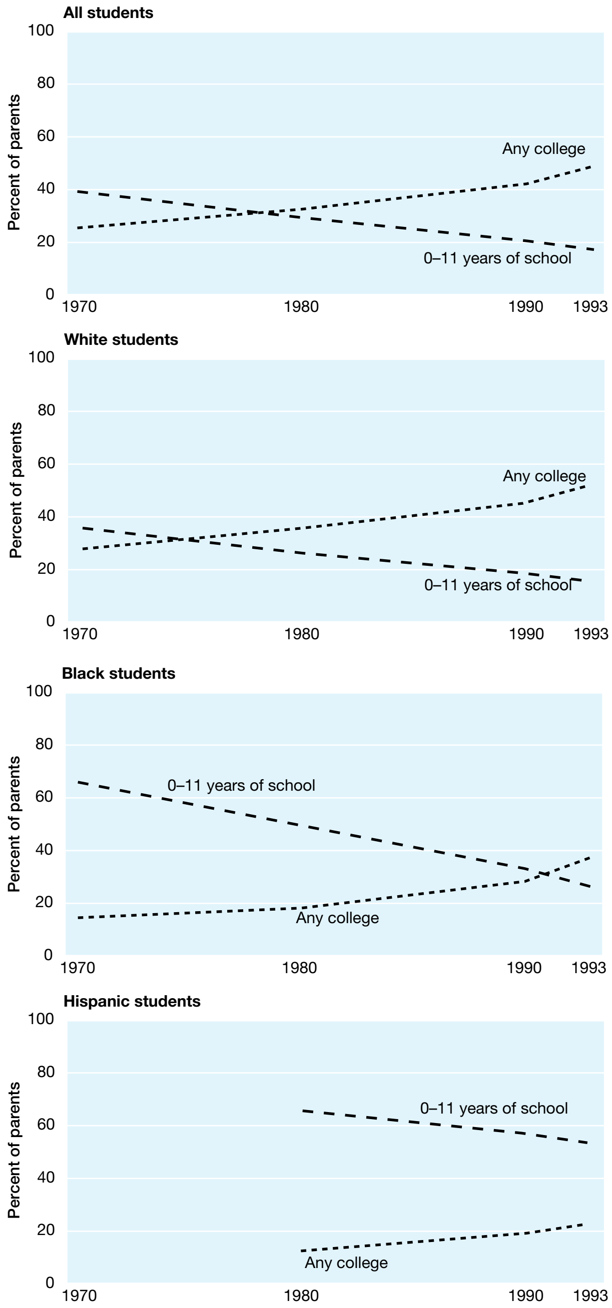
Number of children ages 5–17 speaking a language other than English at home: 1980 and 1990



NOTES: Includes only children in households and excludes children in group quarters.
SOURCES: U.S. Department of Commerce. (1980). *1980 Census of population, detailed population characteristics: United States summary* (PC-80-1-D1-A). Washington, DC: U.S. Bureau of the Census; U.S. Department of Commerce. (1990). *1990 Census of population* (CPH-L-96). Washington, DC: U.S. Bureau of the Census.
See appendix table 1–4.

FIGURE 1–5

Education level of parents of elementary or secondary school students, by student race or ethnic origin: 1970 to 1993



NOTES: Data not available for Hispanics before 1980. Persons of Hispanic origin may be of any race.
SOURCES: U.S. Bureau of the Census. (1990). *School enrollment—social and economic characteristics of students: U.S. Bureau of the Census. (1971). School enrollment: October 1970 (Current Population Reports, Population Characteristics Series P-20, No. 222). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1981). School enrollment—social and economic characteristics of students: October 1981 and 1980 (Current Population Reports, Population Characteristics Series P-20, No. 400). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1991). School enrollment—social and economic characteristics of students: October 1990 (Current Population Reports, Population Characteristics Series P-20, No. 460). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1993). School enrollment—social and economic characteristics of students: October 1992 (Current Population Reports, Population Characteristics Series P-20, No. 474). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1994). School enrollment—social and economic characteristics of students: October 1993 (Current Population Reports, Current Population Series P-20, No. 479). Washington, DC: U.S. Government Printing Office.*
See appendix table 1–5.

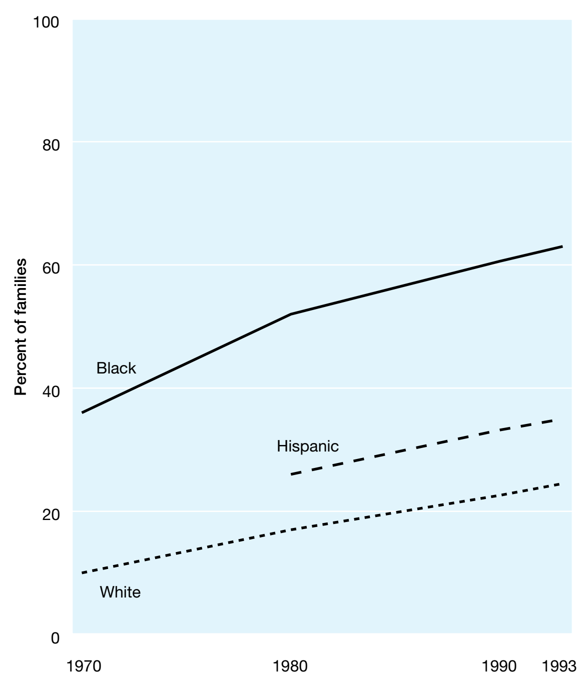
22 percent of Hispanic parents had received at least some college education. About one-half of the increases in the proportion of students who performed at a basic level on the National Assessment of Education Progress between 1982 and 1992 can be attributed to the overall increase in parental education levels.[2] (See Chapter 2.)

In 1993, students of any race or ethnic origin were more likely to be members of one-parent families. (See figure 1-6.) The proportion of one-parent families increased from 13 percent in 1970 to 30 percent in 1993; in 1993, 63 percent of black families had only one parent. (See appendix table 1-6.) Clearly, schools can no longer assume that children have parents at home to monitor school activities.

The proportion of children living in families with incomes below the poverty level increased steadily between 1970 and 1993—from 14 percent to 20 percent of children 6 to 17 years old. (See figure 1-7 and appendix table 1-7.) Although the proportion of black children

FIGURE 1–6

Percent of white, black, and Hispanic families with only one parent present, by race or ethnic origin: 1970 to 1993



NOTES: Universe: Families with children under age 18. Data not available for Hispanics before 1980. Persons of Hispanic origin may be of any race.
SOURCES: U.S. Bureau of the Census. (1992). *Household and family characteristics: March 1991* (Current Population Reports, Population Characteristics Series P-20, No. 458). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1993). *Household and family characteristics: March 1992* (Current Population Reports, Population Characteristics Series P-20, No. 467). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1994). *Household and family characteristics: March 1993* (Current Population Reports, Population Characteristics Series P-20, No. 477). Washington, DC: U.S. Government Printing Office.
See appendix table 1–6.

living in families with incomes below the poverty level did not increase substantially during this period, it remained high—at about 43 percent. High or increasing levels of poverty for various populations could have a negative influence on educational excellence and equity.

Postsecondary

Somewhat less racial and ethnic diversity exists among the college population than the elementary and secondary population, and diversity among postsecondary students has not changed greatly in the past decade. Between 1970 and 1993, the proportion of students enrolled in college who were white decreased. (See figure 1-8 and appendix table 1-3.) The proportion of black students has increased little since 1975, when it reached 10 percent. The proportion of students of other races and of Hispanic origin each increased to about 7 percent of students enrolled in college by 1993.

The Organization of the Report

This report considers changes in science and mathematics education in the United States with regard to excellence and equity within the educational system. The data are presented in three chapters, followed by a concluding chapter:

Chapter 2 provides an update on the achievement of students, looking at overall changes in achievement and differences by sex, race and ethnic origin, and region. The chapter reports some "good news," in terms of excellence and equity; however, many questions remain.

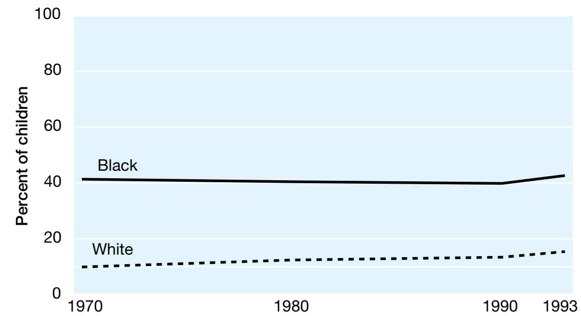
Chapter 3 considers the characteristics of the elementary and secondary educational system, examining the adequacy of teachers, curricula, and resources in light of what the science and mathematics standards have presented as a guiding vision for science and mathematics instruction. These data provide the basis for both celebration and concern. These analyses also highlight areas where information is slim.

Chapter 4 looks at postsecondary education. It considers how well the system is producing students who are adequately prepared for the science, engineering, and technology workforce. This chapter examines equity in terms of scientific literacy. It also considers how U.S. students fare compared with students from other nations.

Chapter 5, the concluding chapter, contains additional reflections, not as much on what the indicators say, but on what the present system of indicators does not say. The chapter returns to policy issues and suggests critical themes that researchers should pursue in the future. ■

FIGURE 1–7

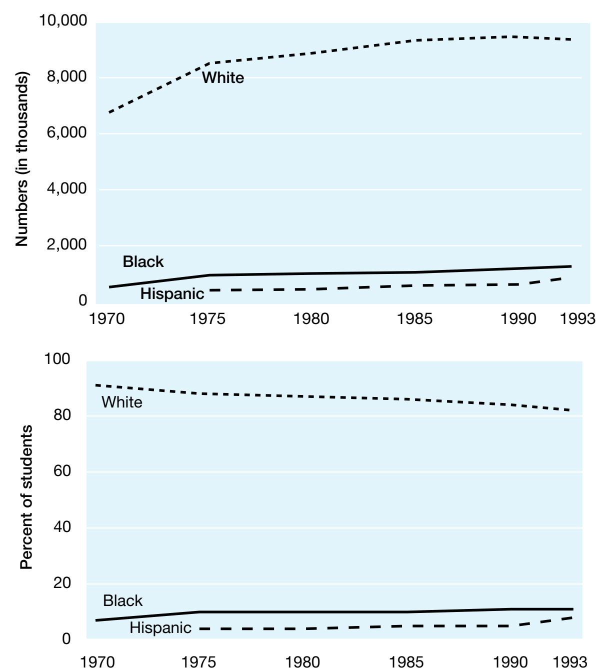
Percent of white and black children ages 6–17 below the poverty level: 1970 to 1993



NOTE: Poverty status of 1970, 1980, 1990, and 1993 as surveyed on a sample in March of 1971, 1981, 1991, and 1994, respectively.
SOURCES: U.S. Bureau of the Census. (1971). *Characteristics of the low-income population: 1970* (Current Population Reports, Population Characteristics Series P-60, No. 18). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1981). *Characteristics of the population below the poverty level: 1980* (Current Population Reports, Population Characteristics Series P-60, No. 133). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1991). *Poverty in the United States: 1990* (Current Population Reports, Population Characteristics Series P-60, No. 175). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1994). *Official poverty statistics: 1993* (Current Population Reports, Population Characteristics Series P-60, No. 188). Washington, DC: U.S. Government Printing Office.
See appendix table 1–7.

FIGURE 1–8

Race or ethnic origin of students enrolled in college: 1970 to 1993



NOTES: Data not available for Hispanics before 1975. Persons of Hispanic origin may be of any race.
SOURCES: U.S. Bureau of the Census. (1990). *School enrollment–social and economic characteristics of students: 1989* (Current Population Reports, Population Characteristics Series P-20, No. 443). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1991). *School enrollment–social and economic characteristics of students: October 1990* (Current Population Reports, Population Characteristics Series P-20, No. 460). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1994). *School enrollment–social and economic characteristics of students: October 1993* (Current Population Reports, Current Population Series, P-20, No. 479). Washington, DC: U.S. Government Printing Office.
See appendix table 1–3.

Endnotes

[1] As specified in the Senate 1991 Appropriations Bill (HR 5158), this report is a congressionally mandated one:

"…In addition, the Committee expects the [National Science] Foundation to establish a biennial science and mathematics education indicator report, distinct from the science and engineering indicator report, that evaluates the progress of the United States in improving the science and mathematics capability of its students, and the effectiveness of all Federal and State education programs as part of this process."

[2] Calculated by deriving the percentage of students achieving basic levels in 1982 and 1992 for each education level of parents and adjusting the education of parents to a current population.

Chapter 1 References

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Chapter 2

Achievement in Science and Mathematics

Achievement tests provide key information about trends in science and mathematics education—such as how students are doing in mathematics and science, whether student performance is improving, whether students of all races and ethnic origins are scoring equally well, and whether any differences exist between the scores of males and females. This information provides a useful measure of educational progress, even though the tests examine only a fraction of students' knowledge and tend to reflect older notions of mathematics and science, such as recitation of fact rather than demonstration of performance.

This chapter examines academic achievement in science and mathematics of various groups of students—whites and minorities, males and females, students in various states, and students from other countries—as a basis for discussion of elementary and secondary science and mathematics education in Chapter 3.

Data Sources for this Chapter

The National Assessment of Educational Progress (NAEP) tests are the primary source of information about educational achievement in the United States. NAEP tests have tracked student achievement in science, mathematics, reading, writing, and other subjects for more than 25 years. The advantages of NAEP tests are that they are administered to a representative national sample of students and allow for comparisons over time on comparable test items. The disadvantages are that the test items, which remain consistent over time to show trends, may not adequately capture current classroom experiences and that the tests use small sample sizes, especially for black, Hispanic, and Asian students.

Longitudinal measures of student achievement complement the conclusions drawn from NAEP results. The National Education Longitudinal Study (NELS) program is a continuing long-term project designed to study the educational, vocational, and personal development of students at various grade levels. NELS and the High School and Beyond Study provide data that are not available from NAEP, including information on student background and detailed and reliable measures of family background. The drawback of these longitudinal surveys is that the measures of student performance are much shorter, hence less reliable, than those in NAEP. ■

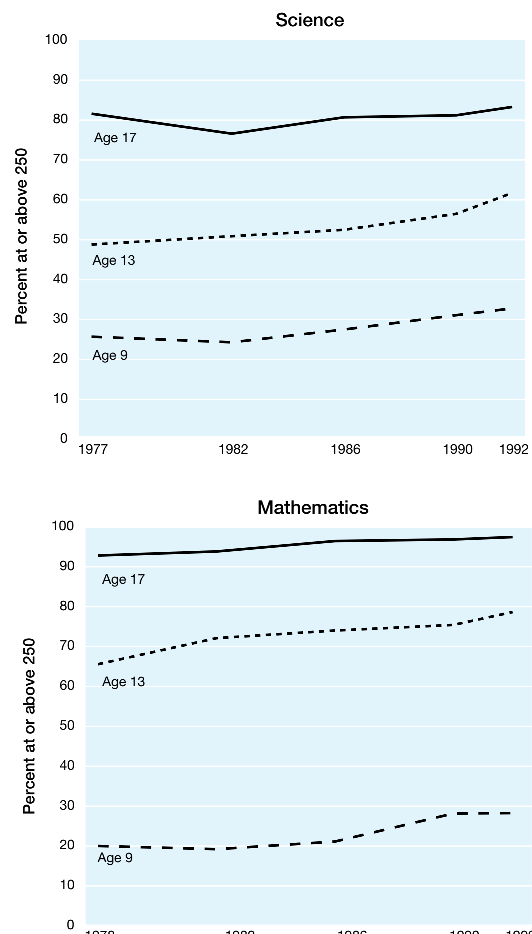
Achievement of Students by Race and Ethnic Origin

Over the past 15 years, student achievement on the National Assessment of Educational Progress (NAEP) science and mathematics tests (see sidebar on data sources) has improved slightly for all ages and racial and ethnic groups. (See figures 2-1 and 2-2 and appendix tables 2-1 and 2-2.)

The percentage of white students who scored at or above "basic performance" levels, at all ages and for both

FIGURE 2–1

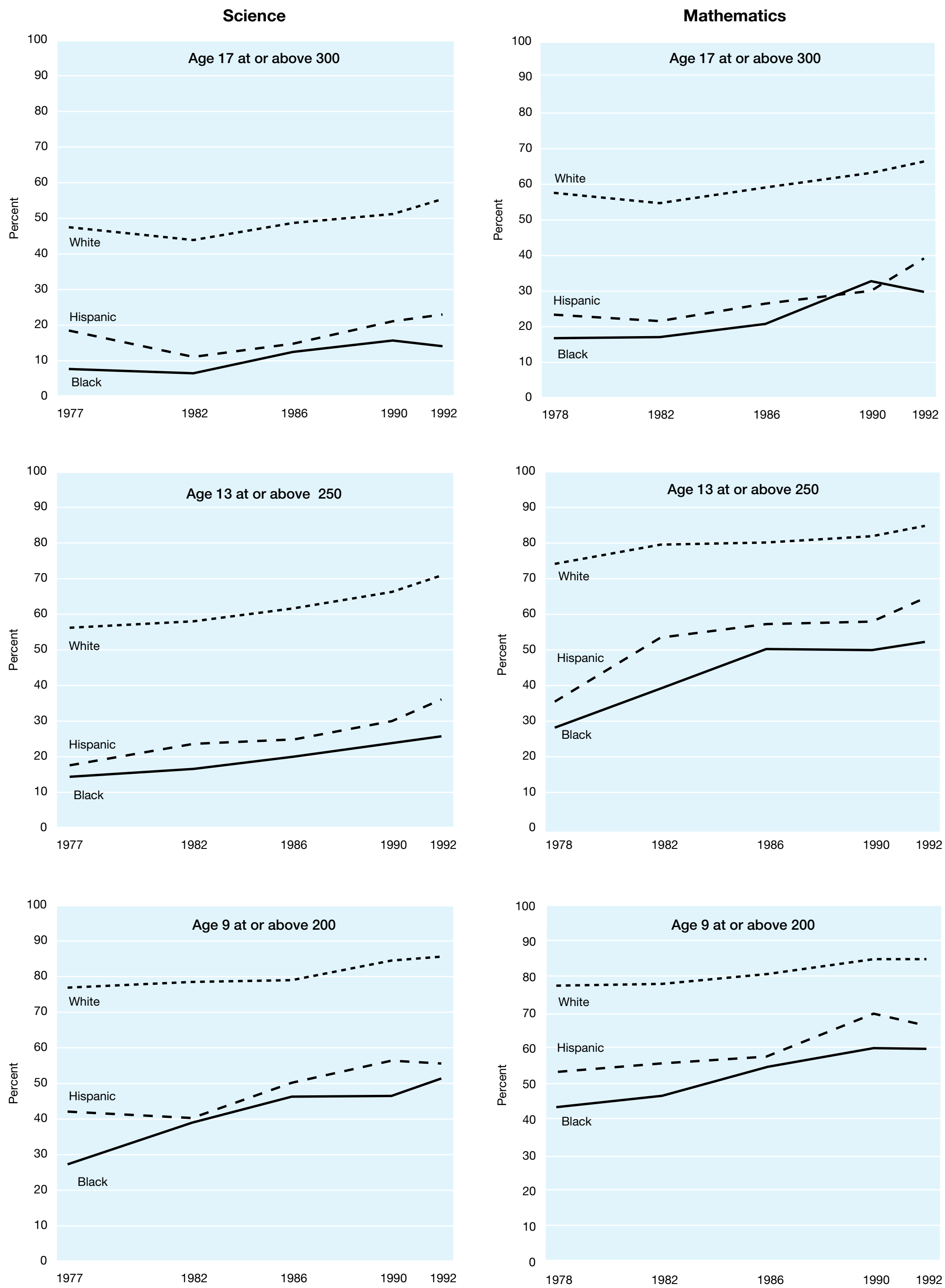
NAEP science and mathematics proficiency, by percent of students at or above anchor point 250 and age: 1977 to 1992



SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.
See appendix tables 2-1 and 2-2.

FIGURE 2–2

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



SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.
See appendix tables 2-1 and 2-2.

science and mathematics, increased somewhat less between 1977 and 1992 than the percentage of black and Hispanic students scoring that well. Results of the 1992 NAEP science test showed that

- the percent of 9-year-old students who scored at 200 or above increased by 24 percentage points for black students, 14 percentage points for Hispanic students, and 9 percentage points for white students since 1977;
- the percent of 13-year-old black students scoring at 250 or above increased more slowly between 1977 and 1992 than the percent of white or Hispanic students scoring at this level; and
- the scores of 17-year-old students of all races and ethnic groups increased more slowly since 1977 than the scores of younger students.

Results of the 1992 NAEP mathematics test showed that

- the percent of 9-year-old students who scored at 200 or above increased by 18 percentage points for black students, 11 percentage points for Hispanic students, and 11 percentage points for white students since 1978;
- the percent of 13-year-old students who scored at 250 or above increased by 22 percentage points for black students, 27 percentage points for Hispanic students, and 12 percentage points for white students since 1978; and
- the percent of 17-year-olds who scored at 300 or above increased by 13 percentage points for black students, 16 percentage points for Hispanic students, and 9 percentage points for white students since 1978.

The increases between 1977 and 1992 represent a large change for significant proportions of the student population. While considerable differences in achievement remain among white students and students of other races and ethnic groups, those differences are narrowing over time.

NELS Scores Supporting NAEP Data

Increases in mean scores of all students on the National Education Longitudinal Study (NELS) tests generally support this upward trend in the achievement of all students and the narrowing of the gap in achievement scores of students from various races and ethnic groups. Among all eighth graders, from all races and ethnic groups, NELS mathematics test scores rose significantly between 1980 and 1990—from 33 in 1980 to 36 in 1990. The mean scores of black and Hispanic students increased 4 points. The mean scores of white students increased 3 points; the mean scores of Asians increased 1 point.

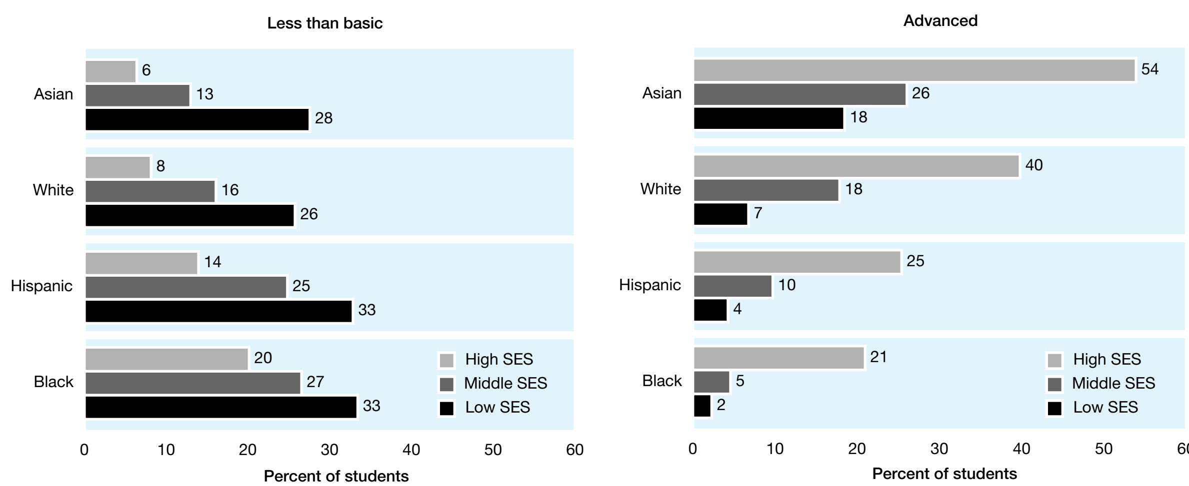
Even among students of the same socioeconomic status, large differences remain between the scores of Asian and white students and scores of students of other races and ethnic origins. (See figure 2-3 and appendix table 2-3.) Attempts to explain why these gaps persist, even among students of the same socioeconomic status, generate a great deal of controversy. Some authors cite cultural differences; others point out the difficulty and imprecision entailed in applying measures of socioeconomic status across ethnic groups or the effects of barriers erected by a majority society (Ogbu, 1994).

Locus of Improvements

Most of the progress in average achievement scores can be attributed to an increase in the scores of the lowest

FIGURE 2–3

NELS mathematics proficiency levels in eighth grade, by race or ethnic origin and socioeconomic status (SES): 1988



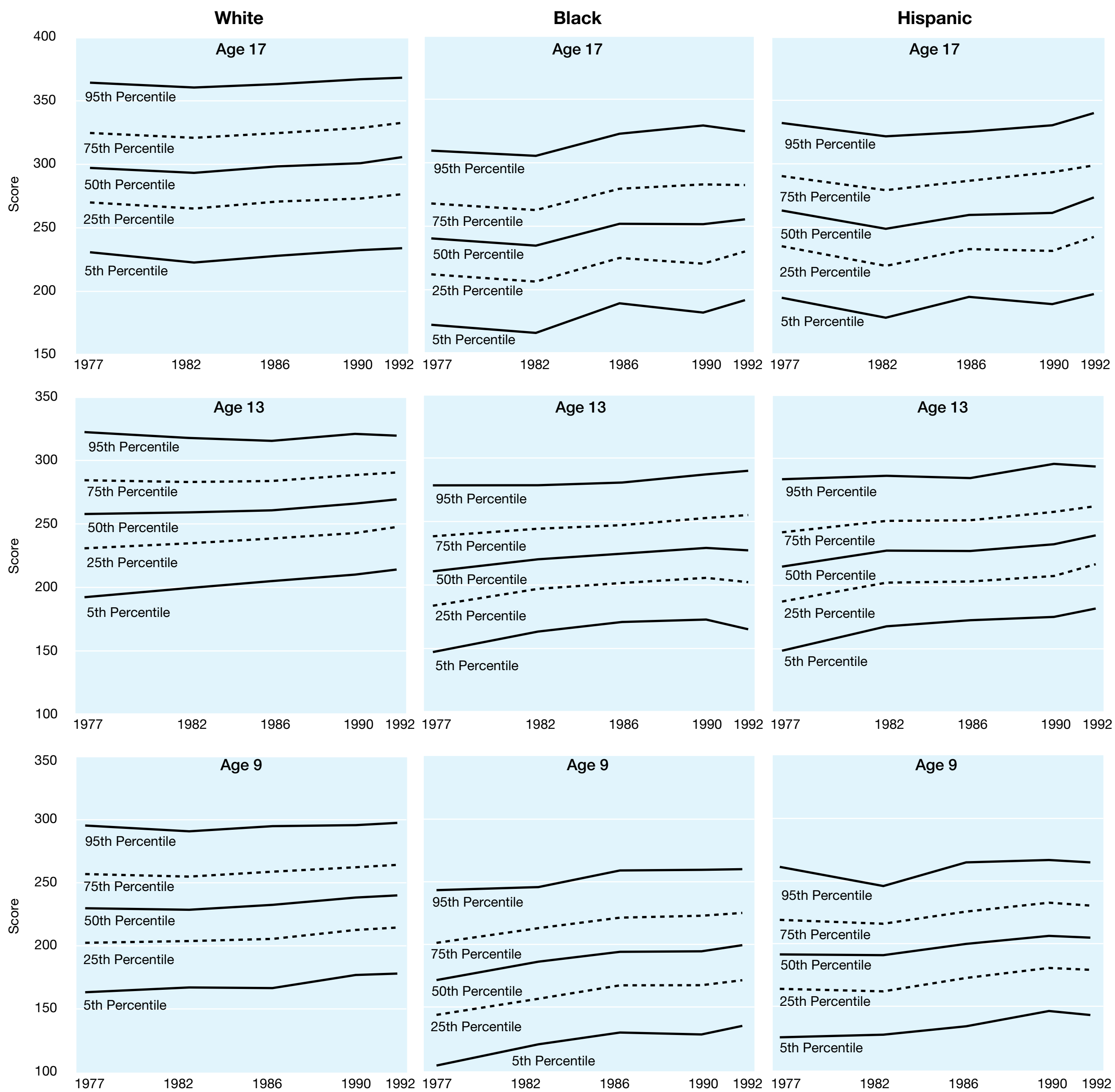
SOURCE: Rock, D.A., Pollack, J.M., & Hafner, A. (1991). *The tested achievement of the national education longitudinal study of the 1988 eighth grade class* (NCES 91-460). Washington, DC: U.S. Department of Education.
See appendix table 2-3.

scoring students. Both science and mathematics achievement scores of black and Hispanic students in the 5th and 25th percentiles increased significantly between the late 1970s and 1992. For example, the achievement level of 13-year-old black students scoring at the 5th percentile in mathematics increased 17 percent between 1978 and 1992. Similarly, the achievement level of 13-year-old Hispanic students scoring at the 5th percentile increased 18 percent during the same period, and the achievement level of 13-year-old white students scoring at the 5th percentile increased 9 percent. (See figures 2-4 and 2-5.)

The achievement level of all students, of every race or

FIGURE 2–4

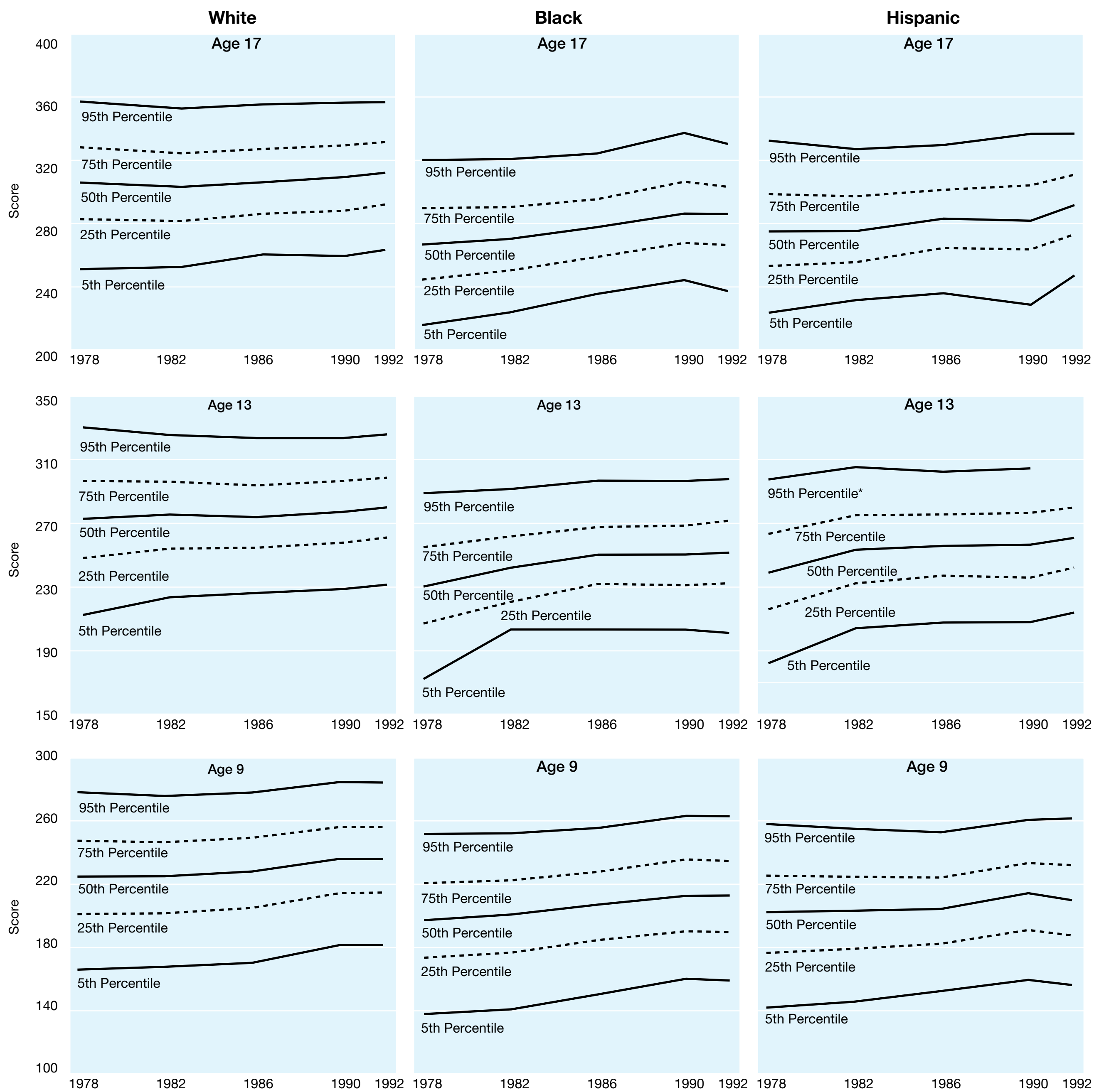
NAEP mean science score percentile distributions: 1977 to 1992



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

FIGURE 2-5

NAEP mean mathematics score percentile distributions: 1978 to 1992



*Data are unavailable for 1992.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

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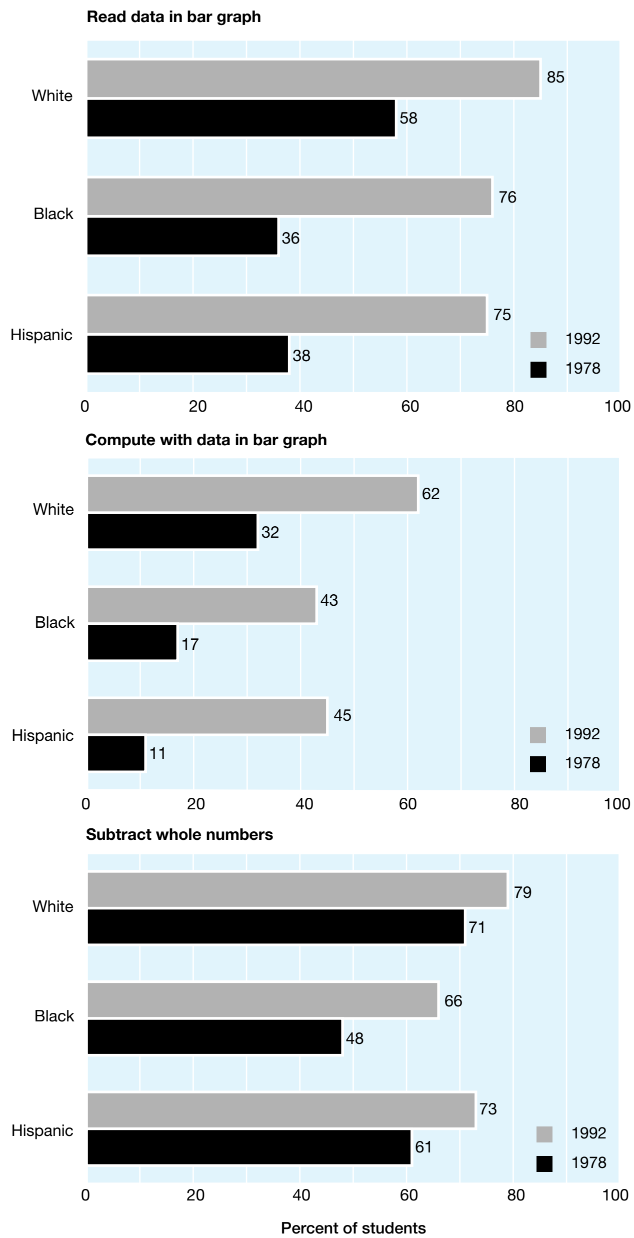
ethnic origin, scoring at the 75th and 95th percentiles did not increase as much or at all during the same period. For example, the achievement level of 13-year-old black students scoring at the 95th percentile in mathematics increased only 3 percent between 1978 and 1992; for Hispanic students, it increased only 4 percent; and the achievement level of white students actually declined 1 percent during the same period.

FIGURE 2–6

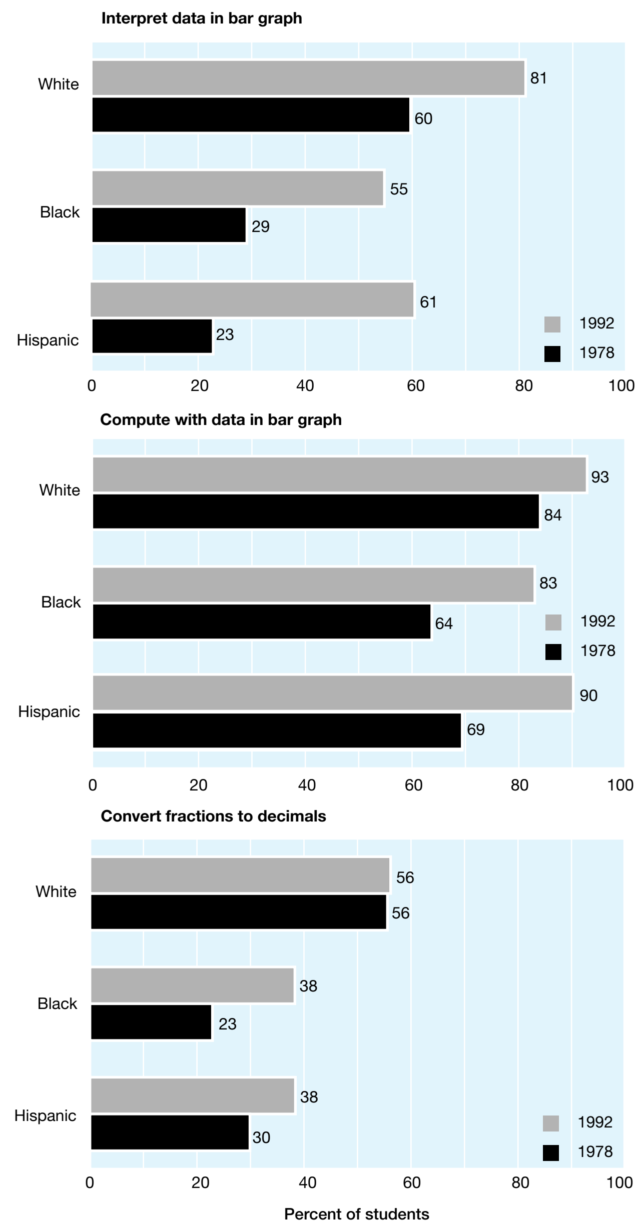
Percent of age 9 students answering NAEP mathematics questions correctly, by race or ethnic origin: 1978 and 1992



NOTE: Numbers shown are rounded to the nearest whole number.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

FIGURE 2–7

Percent of age 13 students answering NAEP mathematics questions correctly, by race or ethnic origin: 1978 and 1992



NOTE: Numbers shown are rounded to the nearest whole number.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

Analysis of Individual NAEP Items

An examination of student performance on individual NAEP mathematics test items provides a detailed look at trends in student achievement. Between 1978 and 1992, students made dramatic progress on some kinds of test items. (See figures 2-6 and 2-7.) In particular, 9- and 13-year-old black and Hispanic students significantly improved their scores on items that required reading and interpreting data from a chart, table, or graph.

For example, on a test item requiring students to read data in a bar graph, more than twice as many black and Hispanic students at age 9 gave correct answers in 1992 as in 1978. A recent emphasis on graphing and charting in elementary schools could help account for these gains.

Among all students, achievement also increased significantly on items involving the use of computational skills, such as subtracting whole numbers and converting fractions to decimals, and knowledge of basic geometry. Between 1978 and 1992, NAEP mathematics achievement declined on only a few items (10 percent of the published items), such as solving number sentences, relating parts to the whole, estimating metric measures, and applying the concept of inequality (Mullis et al., 1994).

Student Achievement in Mathematical Problem Solving

Problem solving is a critical skill in mathematics. To tap students' achievement in this area, the 1992 NAEP included two types of question format, in addition to multiple-choice items:

- short constructed-response questions that asked students to carry out a calculation and write an answer, examine a situation and describe why one alternative or another was correct, or measure or draw a geometric figure given some boundary conditions; or
- extended constructed-response questions that provided students the opportunity to express mathematical ideas and demonstrate the depth of their understanding of a problem (Dossey, Mullis, & Jones, 1993).

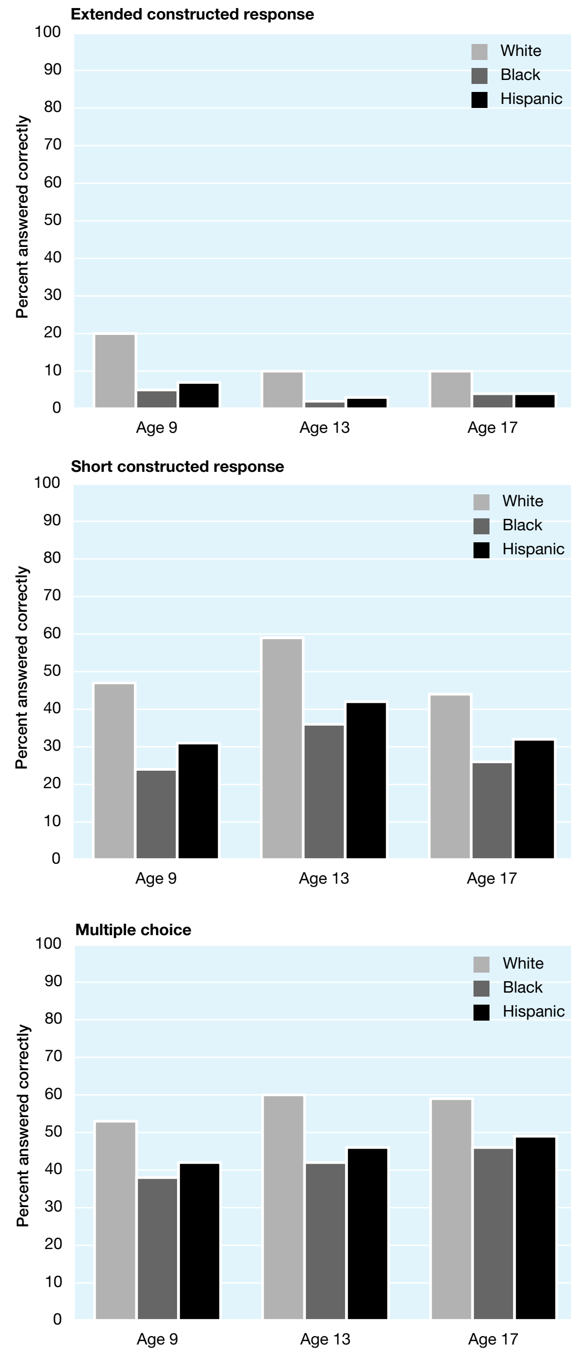
Few students of any race or ethnic origin demonstrated proficiency in mathematical problem solving by correctly answering the more challenging, extended constructed-response questions of NAEP. (See figure 2-8 and appendix table 2-4.) Black and Hispanic students' scores were lower than white students on all of these questions, especially on questions that required sophisticated kinds of problem solving skills. The gap was most pronounced on questions that emphasized application to real-life settings.

Performance of College-Bound Students

Although the population of 18-year-olds declined between 1987 and 1993, the number of students taking college preparation tests remained about the same. (See sidebar about entrance examinations and figure 2-9.) One reason was that increasing numbers of female and minority students took the examinations. Females took more than half of the Scholastic Aptitude Tests (SAT) and American College Tests (ACT) administered during the past few years. In 1993, 27 percent of SAT test takers were minorities, compared with 21 percent in 1987 (College Board, 1987 & 1993). About 30 percent of students taking the ACT in 1994 were minorities (American College Testing, 1994).

FIGURE 2–8

Average percent of NAEP mathematics questions answered correctly, by type of question, race or ethnic origin, and age: 1992



SOURCE: Dossey, J.A., Mullis, I.V.S., & Jones, C.O. (1993). *Can students do mathematical problem solving? Results from constructed-response questions in NAEP's 1992 mathematics assessment.* Washington, DC: U.S. Department of Education.
See appendix table 2-4.

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Science

On the 1993 ACT science reasoning section, the mean scores of students from various races and ethnic groups ranged widely. The mean score of Asian students was considerably higher than the mean score of white students, and the mean score of all other minority groups was considerably lower than the mean score of white students. (See figure 2-10.) The ACT's science reasoning section is designed to measure students' interpretation, analysis, evaluation, reasoning, and problem-solving skills in the natural sciences. The SAT does not have a science section.

Mathematics

Between 1987 and 1993, the mean scores on the mathematics section of the SAT and ACT increased for students from all races and ethnic groups. For example, the mean score of all students taking the SAT increased 2 points during this period, while the mean score of black students increased 11 points (College Board, 1987 & 1993). With the exception of Asian students, the gains on both tests within each race or ethnic group represent a decrease in the percent of students scoring at the lowest levels and little or no change in the percent of students scoring at the highest levels. (See figure 2-11.) This finding is consistent with the pattern for NAEP scores.

Large gaps remain between the SAT and ACT mathematics scores of students from various races and ethnic groups. Asian students score considerably higher than white students on both tests, and all other minority groups score considerably lower than either Asian or white students.

In 1993, black students had the lowest mean score (388) on the mathematics section of the SAT, with the largest percentage of students scoring below 400 (57 percent) and the smallest percentage scoring above 600 (4 percent). In fact, only 0.5 percent of black students (479 students) scored above 700, and only 0.1 percent (103 students) scored above 750. As low as these percentages are, they represent improvement—in 1987, 63 percent of black students scored below 400 (College Board, 1987 & 1993). The trends among Hispanic students are similar.

The scores of Asian students improved between 1987 and 1993, especially among top-scoring students. In 1993, Asian students' mean score on the mathematics section of the SAT was 535, up from 521 in 1987. The proportion of Asian students scoring above 600 increased from 32 percent in 1987 to 36 percent in 1993. The percentage of Asian students with scores over 750 increased from 3.3 percent (1,945 students) to 5.4 percent (4,276 students) in this same period. The scores of white students changed very little between 1987 and 1993.

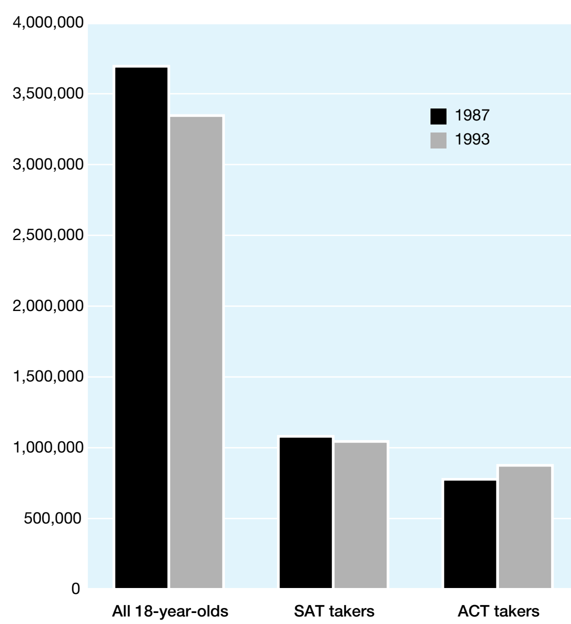
College Entrance Exams Reveal Trends on College-Bound Youth

The Scholastic Aptitude Test (SAT) is a rich source of background data on college-bound youth and a predictor of college success. However, any interpretations about SAT data must be tempered because students who take the SAT are not representative of the Nation's students. This chapter examines SAT scores from 1987 (the first year extensive information on the performance of various ethnic groups across the distribution of scores was available) and 1993.

The American College Test (ACT) is another predictor of college success. As with the SAT, students taking the ACT are not representative of all students. This chapter draws from data on the population of students who took the ACT. Because a new mathematics test was introduced in 1990 and a new science test in 1991, comparisons with earlier years are impossible. ■

FIGURE 2–9

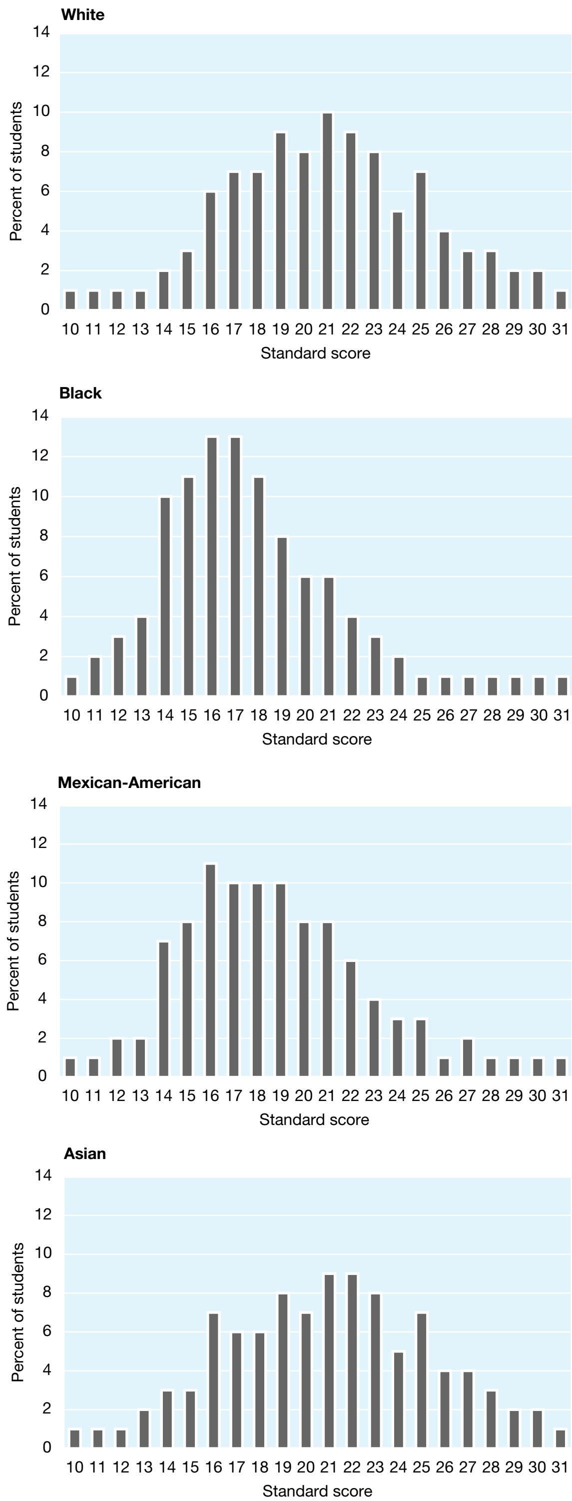
18-year-old population compared with number of college preparation test takers: 1987 and 1993



SOURCES: U.S. Department of Commerce. (1987). *Projections of the population of the United States, by age, sex, and race: 1983 to 2080* (Current Population Report Series P-25, No. 952). Washington, DC: U.S. Bureau of Census; U.S. Department of Commerce. (1993). *Projections of the population of the United States, by age, sex, and race: 1988 to 2080* (Current Population Report Series P-25, No. 1018). Washington, DC: U.S. Bureau of Census; National Center for Education Statistics. (1993). *Digest of education statistics 1993* (NCES 93-292). Washington, DC: U.S. Government Printing Office; College Board. (1987). *National college-bound seniors: 1987 SAT profile.* New York: College Board; College Board. (1993). *National college-bound seniors: 1993 SAT profile.* New York: College Board.

FIGURE 2–10

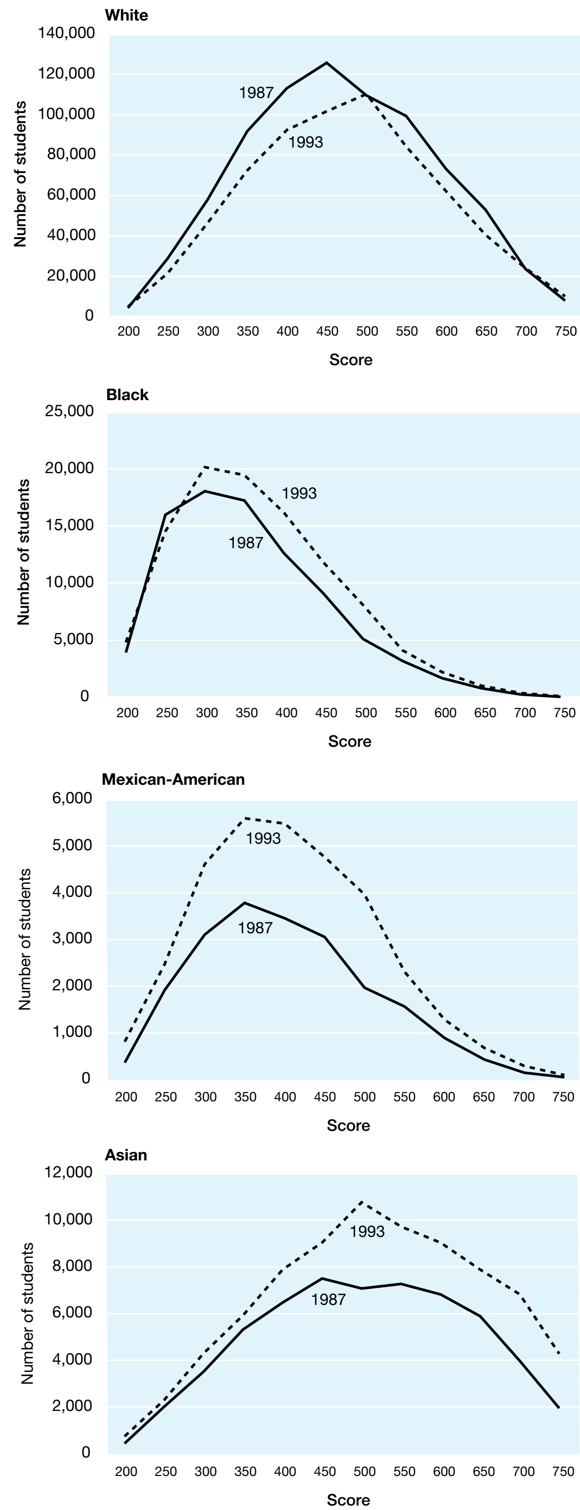
Percent of students earning each standard score in science reasoning on the ACT, by race or ethnic origin: 1993



SOURCE: American College Testing (ACT). (1993). *Reference norms for spring 1993 ACT tested H.S. graduates.* Iowa City, IA: ACT.

FIGURE 2–11

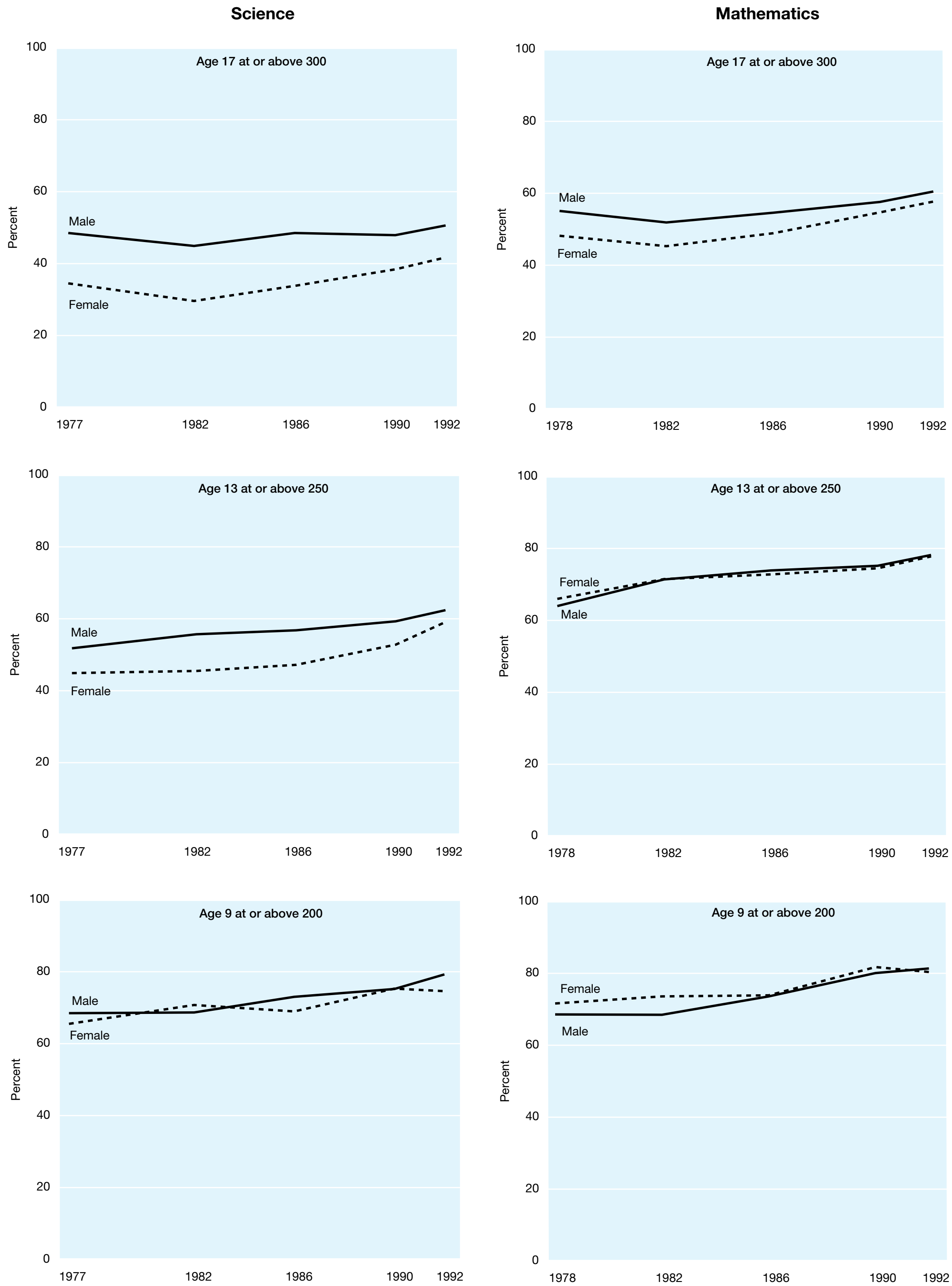
Distribution of SAT mathematics scores, by race or ethnic origin: 1987 and 1993



SOURCES: College Board. (1987). *National college-bound seniors: 1987 SAT profile.* New York: College Board; College Board. (1993). *National college-bound seniors: 1993 SAT profile.* New York: College Board.

FIGURE 2–12

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



SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.
See appendix tables 2-5 and 2-6.

Achievement of Students by Sex

Between 1977 and 1992, little difference existed between the NAEP science scores of elementary males and females; however, during that period, males in middle and high schools outscored females. (See figure 2-12 on page 23 and appendix table 2-5.) For example, 9 percent more 17-year-old males than 17-year-old females scored 300 or more on the 1992 NAEP science test. Notably, this difference was less than in 1977, when 14 percent more 17-year-old males than 17-year-old females scored 300 or more.

Between 1978 and 1992, males and females in elementary and middle schools scored equally well on NAEP and NELS mathematics tests. (See figure 2-12 on page 23 and appendix table 2-6.) During that period, the difference between the NAEP mathematics scores of males and females in high schools narrowed considerably.

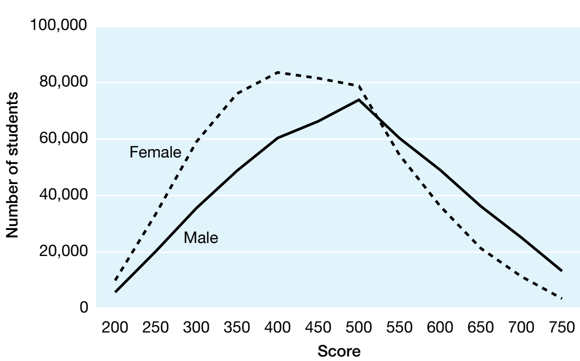
In contrast to the performance of male and female students on NAEP and NELS mathematics tests, females score significantly lower than their male counterparts on the mathematics portion of the SAT. (See figure 2-13.) For example, in 1987, the mean score for all females taking the SAT was 47 points lower than the mean score for males—453 versus 500. Although the mean score of females rose slightly by 1993, it was still 45 points lower than the mean score of men—457 versus 502.

Furthermore, females are overrepresented in the lower end of the scale and underrepresented in the high end of the scale. In 1993, while only 22 percent of males scored below 400, 32 percent of females did. Conversely, while 25 percent of males scored over 600, only 13 percent of females did. That same year, less than 0.1 percent of minority females scored over 750.

On the ACT science reasoning test, males scored 6 percent higher than females in both 1991 and 1994. On the ACT mathematics test, males scored 6 percent higher than females in 1994 and 7 percent higher in 1990 (American College Testing, 1994).

FIGURE 2–13

Distribution of SAT mathematics scores, by sex: 1993



SOURCE: College Board. (1993). *National college-bound seniors: 1993 SAT profile.* New York: College Board.

Indicators of Science and Mathematics Education 1995

State, Regional, and International Achievement

NAEP mathematics scores for white students in some southern states and Appalachia are significantly lower than scores for similar students in the rest of the country (See sidebar on state NAEP scores.) For example, the mean NAEP mathematics scores of 13-year-old white students range from 260 in West Virginia to 284 in North Dakota, Minnesota, and Iowa. (See figure 2-14.) The scores of 9-year-olds follow the same pattern. The pattern for the mean scores of Hispanic students is also similar. (See figure 2-15.)

The mean scores of black students do not vary regionally in the same pattern as the mean scores for white students; indeed, few statistically significant differences exist among scores of black students in different parts of the country. (See figure 2-16.) The mean scores of 13-year-old black students in states where white students attain above-average scores, such as New York, California, and Michigan, are about the same as the mean scores of 13-year-old black students in states where whites show below-average achievement, such as Mississippi and Tennessee. None of the average scores of black or Hispanic students is as high as the lowest average scores for white students.

On the International Assessment of Educational Progress (IAEP), which was administered in 1991, U.S. students scored rather poorly. (See sidebar on IAEP.) Most alarming were striking differences between the scores of 9- and 13-year-old students, especially in science, which suggest that U.S. students do not receive the same type of science and mathematics education between ages 9 and 13 as their foreign counterparts.

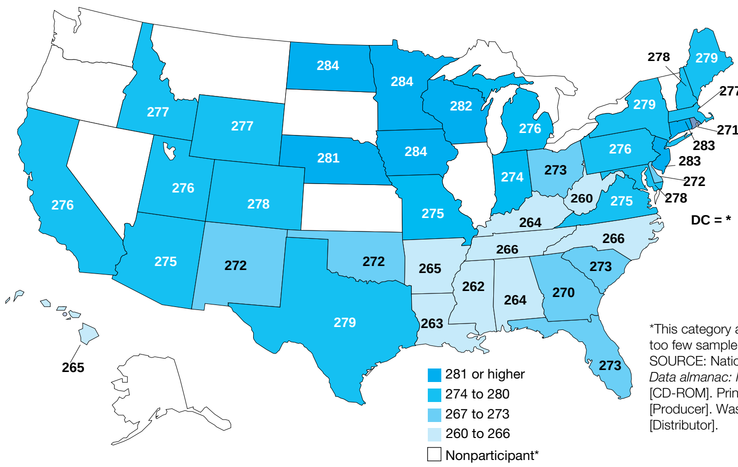
Although 9-year-old students in the United States earned competitive scores on the IAEP science test,

State NAEP Scores Allow Regional Comparisons

NAEP began a Trial State Assessment Program of eighth-grade students in 1990; the program expanded in 1992 to include both fourth- and eighth-grade students. In 1992, the NAEP Trial State Assessments produced data on the mathematics performance of students from 37 states. Although the data have limited value for comparisons across time and do not lend themselves to direct comparisons among the various states' education systems, they reveal interesting regional patterns of achievement. Unfortunately, few researchers have examined the existence or absence of regional differences in NAEP scores; certainly, social, economic, and cultural factors need to be examined. ■

FIGURE 2–14

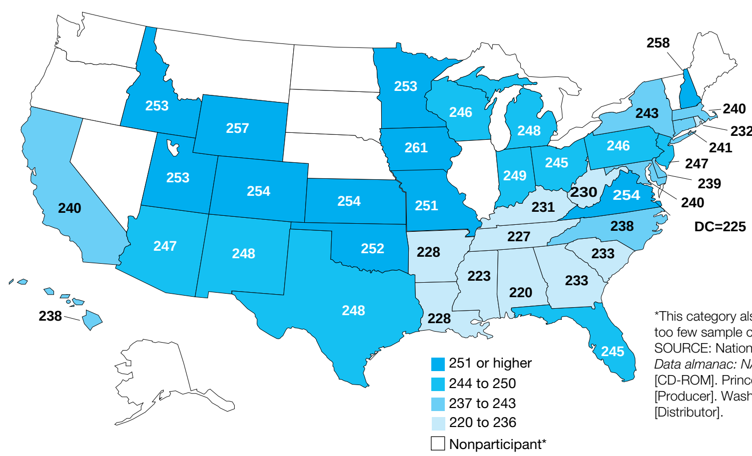
Mean scores of 13-year-old public school white students on NAEP mathematics test: 1992



*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 2–15

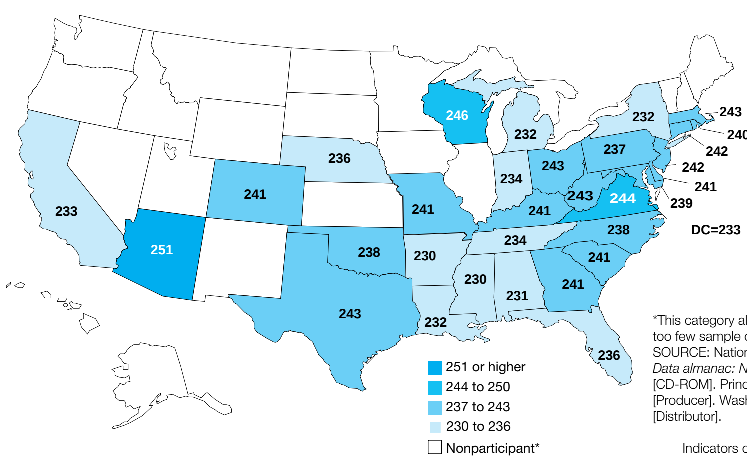
Mean scores of 13-year-old public school Hispanic students on NAEP mathematics test: 1992



*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 2–16

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



*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].

IAEP Allows International Comparisons

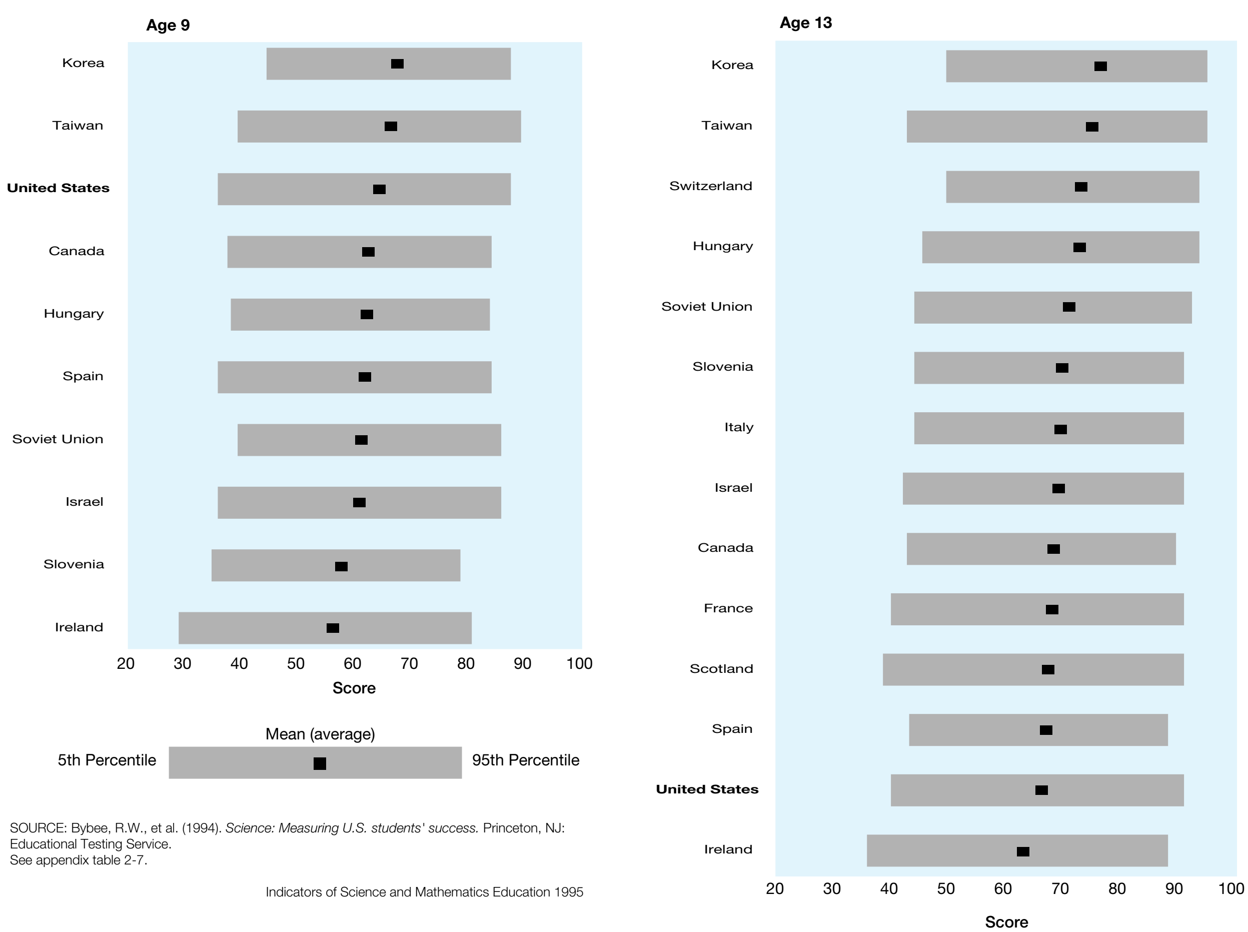
The International Assessment of Educational Progress, conducted in 1991, was an international comparison study of mathematics and science achievement—20 countries assessed science and mathematics achievement of 13-year-old students; 14 countries assessed science and mathematics achievement of 9-year-olds. The data in this chapter for 9-year-olds are based on a subset of 10 countries and for 13-year-olds on a subset of 14 countries. The countries selected for comparison are those "that assessed comprehensive target populations and that represent important political and economic collaborators" (Dossey et al., 1994). International data must be interpreted with particular caution, given differences in student samples, curricula, languages, translations, and testing practices (Bracey, 1991). ■

13-year-old students performed poorly relative to those in other countries. (See figure 2-17 and appendix table 2-7.) Overall, 9-year-old students ranked third, with an average of 65 percent of questions answered correctly. Korea, the top-scoring country, answered an average of 68 percent correctly. The mean score of U.S. 9-year-olds at the 95th percentile was identical to the score of Korean students at the 95th percentile; only students in Taiwan averaged higher scores. U.S. 9-year-olds scored above the international average in each of the content areas measured by the test, including life science, earth and space science, and the nature of science, except physical science.

Among 13-year-olds, the United States had the second lowest mean score. U.S. students answered an average of 67 percent of questions correctly. Top students in five countries outperformed U.S. students who scored at the 95th percentile, and 10 of the 13 other countries outperformed U.S. students who scored at the 5th percentile. U.S. 13-year-olds scored below the international average in each of the content areas measured by the test, except the nature of science.

FIGURE 2–17

IAEP science scores for selected countries at 5th percentile, mean, and 95th percentile, by age: 1991



On the IAEP mathematics test, 9- and 13-year-old students in the United States scored lower than students from most other countries. (See figure 2-18 and appendix table 2-8.) Of all countries in the sample, 9-year-olds in the United States scored second lowest. They answered only 58 percent of questions correctly; Korean students—who were the top performers—answered an average of 75 percent of questions correctly. Moreover, U.S. students who scored at the 95th percentile scored 3 to 5 percentage points lower than their counterparts in the top-scoring countries. U.S. students in the 5th percentile performed worse than students in all countries except Ireland. U.S. 13-year-olds scored worse than students in any other country on the mathematics portion of the IAEP; they answered only 55 percent of questions correctly.

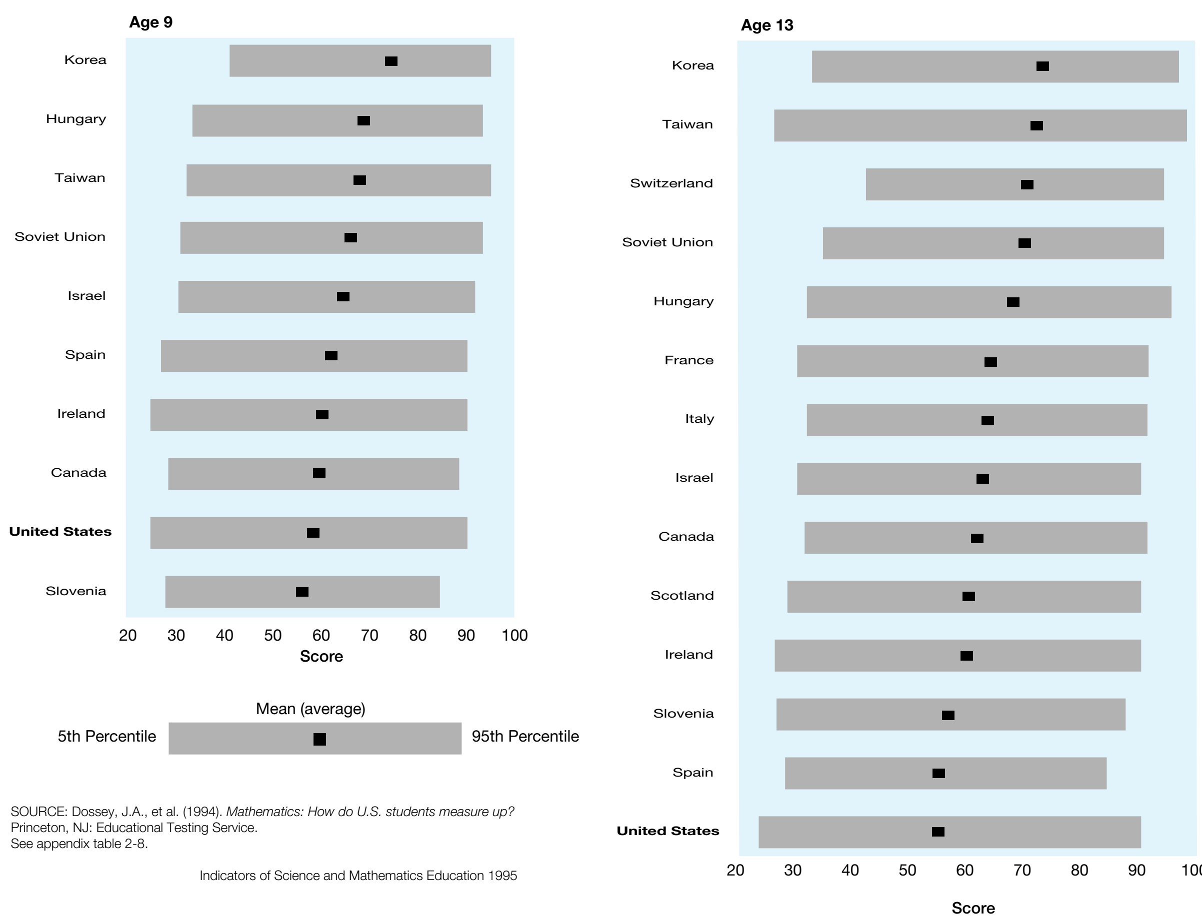
U.S. 9-year-olds performed below the international average in all areas except data analysis, statistics, and probability. U.S. 13-year-old students performed below the international average on most of the areas measured by the test, including numbers and operations; measurement; geometry; data analysis, statistics, and probability; and algebra and functions.

When a special study ranked NAEP and IAEP mathematics scores together, a startling picture of the diversity within the United States emerged. (See figure 2-19.) Students in the highest performing states—Iowa, North Dakota, Minnesota, Maine, and New Hampshire—performed at the same level as students in the top-performing countries—Taiwan, Korea, Soviet Union, and Switzerland. Furthermore, the students in the lowest performing states—Alabama, Louisiana, and Mississippi—performed at the same level as students in the lowest performing country—Jordan.

Moreover, the range of scores within each state was greater than the range of scores within most countries. Thus, the top-performing students within some states score higher than the top-performing students in many countries, and the lowest performing students score lower than the lowest performing students in many countries.

FIGURE 2–18

IAEP mathematics scores for selected countries at 5th percentile, mean, and 95th percentile, by age: 1991



SOURCE: Dossey, J.A., et al. (1994). *Mathematics: How do U.S. students measure up?* Princeton, NJ: Educational Testing Service.
See appendix table 2-8.

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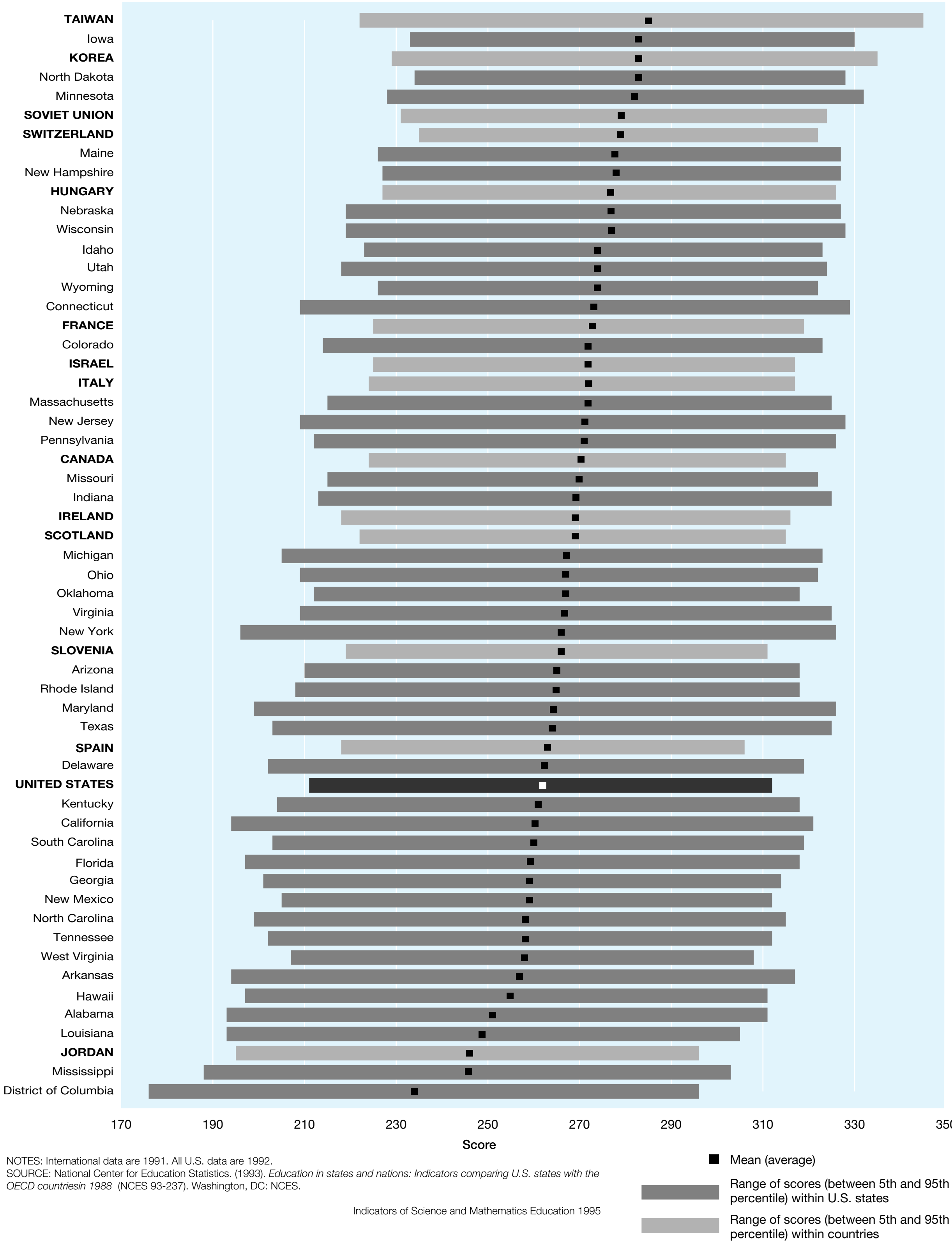
FIGURE 2–19

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



NOTES: International data are 1991. All U.S. data are 1992.
SOURCE: National Center for Education Statistics. (1993). *Education in states and nations: Indicators comparing U.S. states with the OECD countriesin 1988* (NCES 93-237). Washington, DC: NCES.

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Conclusion

This chapter discusses science and mathematics performance of students by race and ethnic origin and sex as a basis for discussion of the science and mathematics learning environment in Chapter 3. Over the past 15 years, U.S. students have received higher scores on a variety of science and mathematics achievement tests. During the same period, the differences among the scores of students from various races and ethnic groups have narrowed; however, black and Hispanic students continue to score significantly lower than white and Asian students. In addition, although few differences exist among the achievement scores of males and females on NAEP and NELS tests, males score significantly higher than females on science and mathematics college entrance examinations.

In the international arena, U.S. elementary school students compete favorably on science tests with students from other countries, but U.S. middle school students have some of the lowest mathematics scores in the world. Nevertheless, a direct comparison between the mathematics performance of countries and individual states shows as much diversity within the country as worldwide—generally, states in the Midwest rank as high as the highest performing countries, and states in the South and Appalachia rank as low as the lowest performing countries.

These trends in student achievement remain unexplained. Educators could make some progress toward explanation if NAEP tests differentiated racial and ethnic groups more finely and used larger sample sizes; still, many questions would linger. NAEP and NELS offer a very narrow window on the complexities of student achievement. They measure just a small portion of what students learn in school, and they measure it imperfectly.

The next generation of assessments should measure students' cognitive skills in a way that will illuminate how education reform efforts under way across the United States affect what students learn. In addition, they ought to measure students' ability to apply concepts and solve problems. Finally, educators should explore how economic and cultural values affect students' achievement. ■

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Chapter 3

The Elementary and Secondary Learning Environment

The U.S. elementary and secondary education system is under considerable pressure to improve performance—particularly performance in science and mathematics—of elementary and secondary schoolchildren. The need for action was reinforced when international test scores for science and mathematics ranked students in the United States behind students in much of the rest of the world. (See Chapter 2.) Subsequently, the U.S. Government committed to achieve a set of National Education Goals by the year 2000.

Concurrently, groups within the science and mathematics community began to develop national standards on teaching, curriculum, and content for science and mathematics education. The science community, represented by the National Research Council, is working on a science standards document. This document builds on the American Association for the Advancement of Science's *Project 2061* (1993) and the National Science Teachers Association's (NSTA's) *The Content Core*. The National Council of Teachers of Mathematics (NCTM) released its standards for mathematics in 1989. (See sidebar on the standards on page 36.)

Both the science and the mathematics standards address two major goals: equity and excellence. To this end, they assert that science and mathematics should be accessible to all students and that all students should achieve a thorough understanding of the subjects. Furthermore, both sets of standards recommend highly prepared teachers working in well-equipped, facilitative, and supportive environments; curricula organized around central, unifying concepts; and instructional practices and resources that emphasize problem solving, active student involvement, and hands-on participation.

This chapter provides an overview of how well, and to what extent, elementary and secondary school systems across the country are measuring up to these standards by presenting available data for selected indicators of the elementary and secondary learning environment as they relate to the national standards. (See text table 3-1.)

The learning environment is described by the four components reflected in this chapter:

- curriculum—the adequacy of science and mathematics courses as indicated by state curriculum frameworks, graduation requirements, coursetaking patterns, and ability grouping;
- teachers—their characteristics, preparation, and professional development;
- instructional practices—use of in-class time, student participation in long-term projects, participation in other instructional activities, and use of traditional and alternative assessment techniques; and
- resources—the availability and sufficiency of textbooks, classroom supplies and facilities, computers and networks, and calculators.

For each component of the learning environment, this chapter examines the current data and, where possible, changes in the components over time.

Both the science and the mathematics standards address two major goals: equity and excellence.

Curriculum

The standards for curriculum recommend that all students take science and mathematics continually in elementary and secondary school. The indicators selected as measures of these standards are related to state curriculum frameworks, graduation requirements, coursetaking, and ability grouping.

State Curriculum Frameworks

There is no official, recognized, or approved national curriculum in the United States. Instead, states develop their own curriculum frameworks, content standards, or curriculum guides that establish goals or standards for elementary and secondary instruction. After the release of the NCTM standards in 1989, states began modifying their curriculum frameworks for science and mathematics. By 1994, 24 states had published revisions, and by 1995, still more states were in the process of publishing new or revised guidelines—37 in science and 33 in mathematics (Blank, 1995a). A study by the Council of Chief State School Officers (CCSSO) found that the new state guidelines are responding to the new standards for mathematics and science by increasing the quality of their own recommendations for science and mathematics coursework and school assessments (Blank & Pechman, 1995).

TEXT TABLE 3-1

Indicators for equity and excellence standards of the learning environment

	Equity standard	Excellence standard	Indicator
Curriculum	Science and mathematics courses should be accessible to all students.	· Students should enroll in science and mathematics courses throughout high school. · Students should study specific content to develop an understanding of key unifying concepts.	· State curriculum frameworks · Graduation requirements · Coursetaking · Ability grouping
Teachers	Teachers of both sexes and of different races and ethnic groups should be equally well prepared and have similar approaches.	· Teachers should have a firm content background. · Teachers should have a supportive work environment that encourages reflection. · Teachers should have opportunities for professional development.	· Teacher characteristics · Teacher beliefs about teaching reforms · Teacher preparation · Teacher perceptions of their own preparation · Professional development
Instructional practices	Teacher beliefs about instruction and their instructional practices should not vary according to the race or ethnic origin of the students in the class.	· Instructional practices should require – "minds-on" student involvement – hands-on interaction – problem-solving experiences – prolonged, in-depth contact with central or unifying concepts – a community of scholars in which both teachers and students learn and where respect is shown for student opinions and prior knowledge – communication, demonstrated by presentations of ideas and group interactions – assessment that emphasizes the process of arriving at the answer and application of knowledge to new situations	· Use of in-class time · Participation in long-term projects · Participation in other instructional activities · Use of traditional or alternative assessment techniques
Resources	Students in all classes, regardless of their race or ethnic origin, should have the same resources.	· Classes should have access to – hands-on activities – technology, including computers and calculators – appropriate textbooks – supplemental and varied resource reading materials	· Teacher ratings of textbook use and quality · Teacher ratings of and reported problems with supplies and facilities · Access to and use of computers and networks · Use of calculators

NOTE: This table was designed as an organizing framework by the authors of Chapter 3.

Standards for School Science and Mathematics: Background, Purpose, Goals, Principles

by Lynn Arthur Steen

In contrast to other countries, the United States has always favored local over national control of education. But by 1983, mounting evidence of failures of U.S. education moved the authors of *A Nation at Risk* to recommend strengthened requirements, rigorous standards, and higher expectations for all students. This challenge was followed by a profusion of headlines citing poor performance of U.S. students on international educational comparisons, especially in science and mathematics.

By 1989, rising public disillusionment with U.S. education led the Federal Government and state governors to set national goals for education. Among the goals they adopted are two that lay the foundation for national curriculum standards: One goal urges that all students demonstrate competency in challenging subjects including English, history, science, mathematics, and geography, while another goal declares that by the year 2000 the United States should be first in the world in mathematics and science education. Four years later, Congress wrote these goals into legislation.

Independently, but also in response to *A Nation at Risk,* the National Council of Teachers of Mathematics (NCTM) began to develop the first national discipline-based educational standards. These voluntary standards were the product of a multiyear consensus-building effort led by the Nation's mathematics teachers and mathematicians. The authority of these standards rests not on governmental mandate, but on the evidence and logic invoked by the standards themselves. Published in 1989, the NCTM Standards quickly became the Nation's premier example of educational "standards"—a set of public expectations, rooted in research and practice, that is intended to raise the academic achievement of all students.

Since 1989, the Nation has embarked on a standards-setting process in many subjects. Draft standards and benchmarks for science education have now joined those in mathematics. As the movement toward national standards gains momentum, it has taken on many different forms and often serves quite different purposes. Depending on the context, educational standards can offer

- a vision of learning and teaching to guide educators at all levels;
- a yardstick to measure the quality of educational programs;
- a strategy to promote equality of educational opportunity;
- a symbol of what society values in educational accomplishment;
- a tool to enhance public accountability of the educational system;
- a concrete expression of national goals for which all can strive;
- a banner around which educators, parents, and politicians can rally; and
- a public statement of support for exemplary practice.

Standards create a shared vision of educational excellence, which can bring coherence and consistency to the many separate components of the educational system—to schools and colleges, publishers and test-makers, and teachers and administrators. Also, since standards give public expression to educational expectations, they enlist students, teachers, and parents in support for a compelling vision of educational excellence. In this way, standards can express expectations, communicate goals, and facilitate reform.

As standards serve many different purposes, so they also come in many different forms. Different standards documents may include

- Content Standards—what students should know and be able to do;
- Curriculum Standards—what students should learn and how they should learn it;
- Professional Development Standards—what support teachers need to be effective;
- Program Standards—what departments must provide for learning to take place;
- Teaching Standards—how teachers are expected to perform as professionals;
- Delivery Standards—what schools must provide in order that students can learn;
- Assessment Standards—how to monitor performance of students and programs;
- Evaluation Standards—how to measure what students know and can do;
- Opportunity-To-Learn Standards—what is necessary to enable students to learn;
- Performance Standards—how much students should know and be able to do;
- Skills Standards—what must be mastered as a prerequisite for specific jobs; and
- System Standards—how the components of a school system must work together.

Standards continued on page 37.

Graduation Requirements

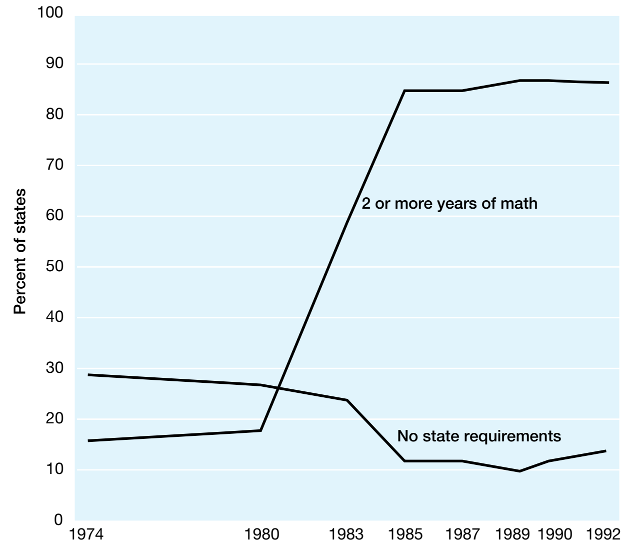
States dramatically influence the elementary and secondary curricula by setting and enforcing graduation requirements. Since 1980, when less than 20 percent of states required 2 or more years of mathematics, states have begun to require that high school students complete substantially more classes as a prerequisite for graduation. This change, however, does not bring states into conformity with the standards, which advocate, among other things, that students take science and mathematics each year during their 4 years of high school. Still, according to the CCSSO, in 1992, only 84 percent of states required two or more courses in science, and 86 percent of states required two or more courses in mathematics (Blank & Gruebel, 1993). The remaining states permitted local districts to set graduation requirements. (See figure 3-1 and appendix table 3-1.)

Coursetaking

In elementary schools, all students receive science and mathematics instruction. Therefore, it is impossible to examine coursetaking behavior; however, it is possible to say that elementary teachers are spending more time than in the past teaching science and mathematics (Weiss,

FIGURE 3–1

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.
See appendix table 3–1.

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Standards continued from page 36.

Among the many different subject matter standards, those in science and mathematics bear a special burden concerning the goal of achieving equity in educational achievement. Historically, science and mathematics education has served more as a filter than as a pump in the Nation's educational system. Both public and professional attitudes reinforce this "elitist" view of science and mathematics by emphasizing talent over effort as the essential predictor of success.

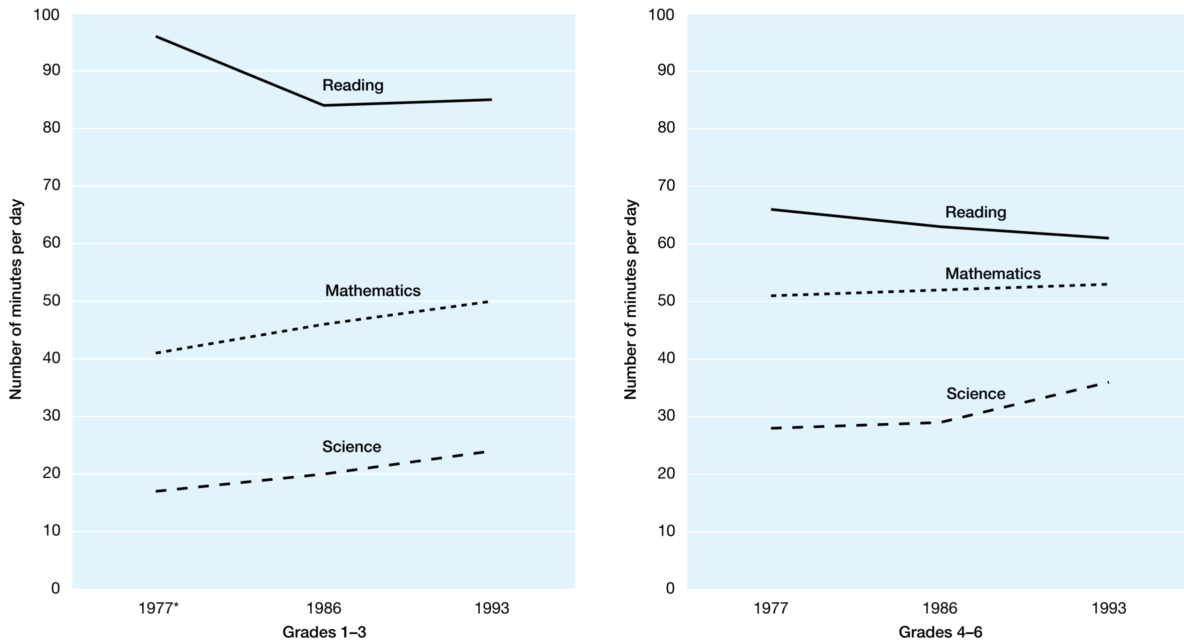
National standards reverse this elitist perspective by stressing the importance of science and mathematics for all. These standards offer a coherent vision of science and mathematics education that provides literacy sufficient for citizenship and competency sufficient for life and work in a technological age. With such standards available for public review and discussion, everyone—especially students, parents, teachers, and administrators—will know what is expected. These expectations flow from a set of goals on which there is now broad consensus:

- all students should be expected to attain high levels of scientific and mathematic competency;
- students should learn science and mathematics as active processes focused on several powerful concepts;
- science and mathematics in the school should reflect science and mathematics in practice—activities rich in connections, exploration, and inquiry;
- curricula should stress understanding, reasoning, and problem solving to provide context for facts, terminology, and algorithms;
- teachers should engage students in meaningful activities that regularly employ calculators, computers, and other tools in an appropriate manner;
- assessment should be an integral part of instruction, and tests should measure what is important for students to learn;
- teachers need both a deep understanding of subject matter and an opportunity to learn to teach in a manner that reflects research on how students learn; and
- the educational system must recognize that teaching is a complex activity that requires ongoing support for classroom teachers. ■

Steen is a professor of mathematics at St. Olaf College in Northfield, Minn. He also has served as executive director of the Mathematical Sciences Education Board in Washington, D.C.

FIGURE 3–2

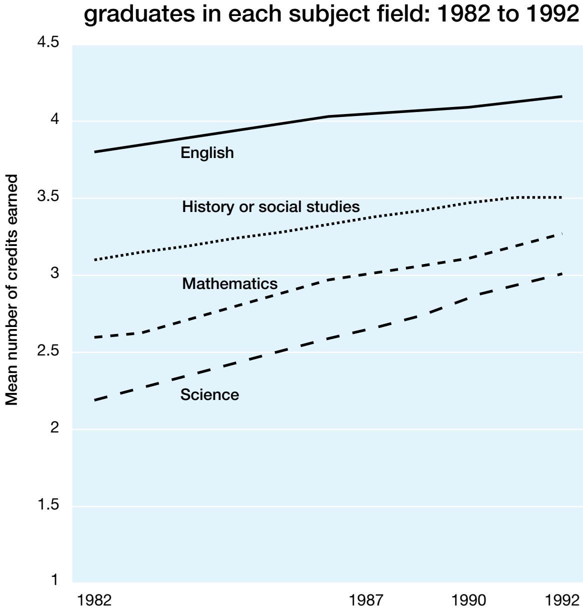
Average number of minutes per day spent teaching each subject to self-contained classes, by grade range: 1977 to 1993



* 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.
See appendix table 3–2.

FIGURE 3–3

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.
See appendix table 3–3.

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Matti, & Smith, 1994). (See figure 3-2 and appendix table 3-2.) According to the National Survey of Science and Mathematics Education (NSSME), between 1977 and 1993, the amount of time teachers allocated to science and mathematics increased slightly; concomitantly, the amount of time devoted to reading decreased slightly. These changes were especially apparent at grades 1–3. However, the relative position of the three areas remained constant, with reading receiving the most time, followed by mathematics and science.

High school coursetaking patterns naturally mirror graduation requirements, which typically mandate 4 years of English, 3 or 4 years of history or social studies, and 2 or 3 years each of science and mathematics. Of course, as requirements have become more stringent over time, coursetaking has increased for several subjects. Overall, students are taking more science and mathematics courses, even advanced courses, which is in accord with the recommendations of the standards. (See figure 3-3 and appendix table 3-3.) Coursetaking in advanced science and mathematics classes remains lower than in basic science and mathematics courses. (See figures 3-4, 3-5, and 3-6 and appendix tables 3-4 and 3-5.)

The National Center for Education Statistics (NCES) High School Transcript Study (Legum et al., 1993) reported that the percentage of high school graduates who had earned credits in science and mathematics courses increased substantially between 1982 and 1992. For instance, while 79 percent of 1982 high school graduates had taken biology, 93 percent of 1992 high school graduates had taken the course, and while 68 percent of 1982 high school graduates took algebra I, 79 percent of 1992 high school graduates had taken the course. The percentage of high school graduates completing chemistry increased from 32 percent in 1982 to 56 percent in 1992, and the percentage of high school graduates completing algebra II increased from 37 percent in 1982 to 56 percent in 1992.

Increases in coursetaking may be due to increases in state requirements, changes in state course curricular guidelines, or other factors. Certainly, science and mathematics classes are widely available. In 1990, 99 percent of the high school students in the United States were in schools that offered biology, chemistry, and physics[1] (NCES, 1990). Similarly, 98 percent of U.S. high school students were in schools that offered algebra I and II, geometry, and trigonometry, and 79 percent were in schools that offered calculus (NCES, 1990).

A study by the Consortium for Policy Research in Education (CPRE) in 1990 determined that increases in coursetaking could not be attributed to classes that were "watered down" by teachers to be palatable to a broader student population (Porter, Kirst, Osthoff, Smithson, & Schneider, 1993). CPRE examined mathematics and science classroom practices in 18 high schools from six states and found that the content of courses in high schools where all students were required to complete college preparatory classes was the same as in high schools without the requirement. Thus, they found no evidence that greater participation of students in a course is linked with less demanding academic content. (For additional information on coursetaking, see Blank & Dalkilic, 1990; Blank & Gruebel, 1993; Blank & Gruebel, 1995.)

Sex

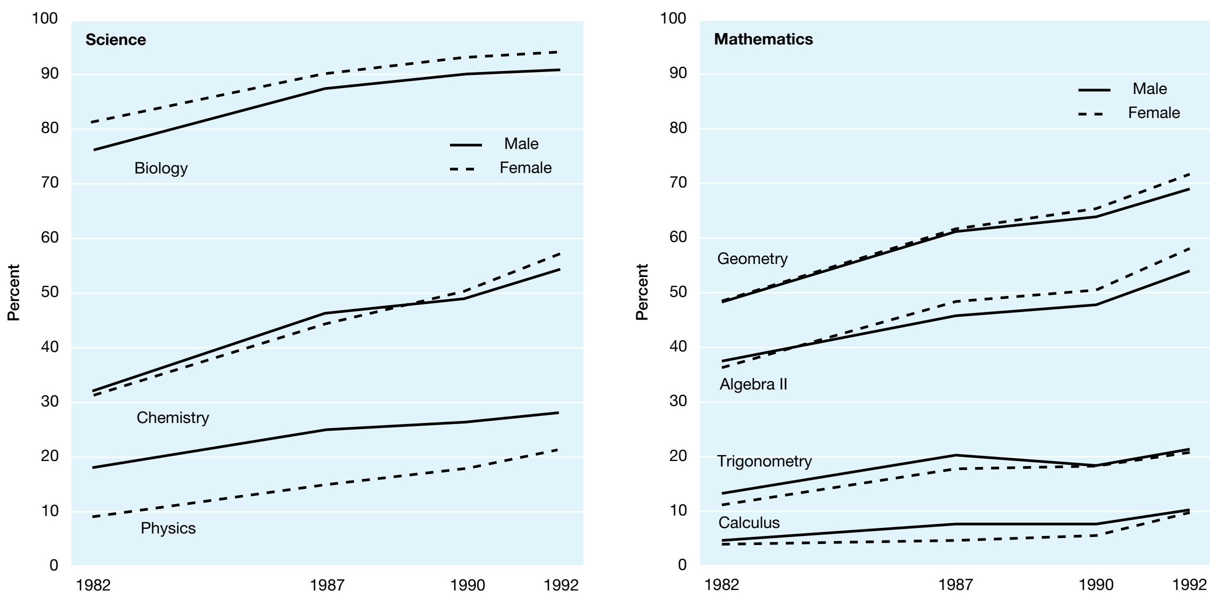
Few differences exist in the science and mathematics coursetaking patterns of high school male and female graduates, except in physics. (See figure 3-4.) In 1992, 28 percent of male graduates versus 21 percent of female graduates had completed physics; the difference between the two was about the same in 1982, when 18 percent of male graduates and 9 percent of female graduates had completed physics.

Race and Ethnic Origin

Minority students are taking more science and mathematics courses than in the past, and the gap between

FIGURE 3–4

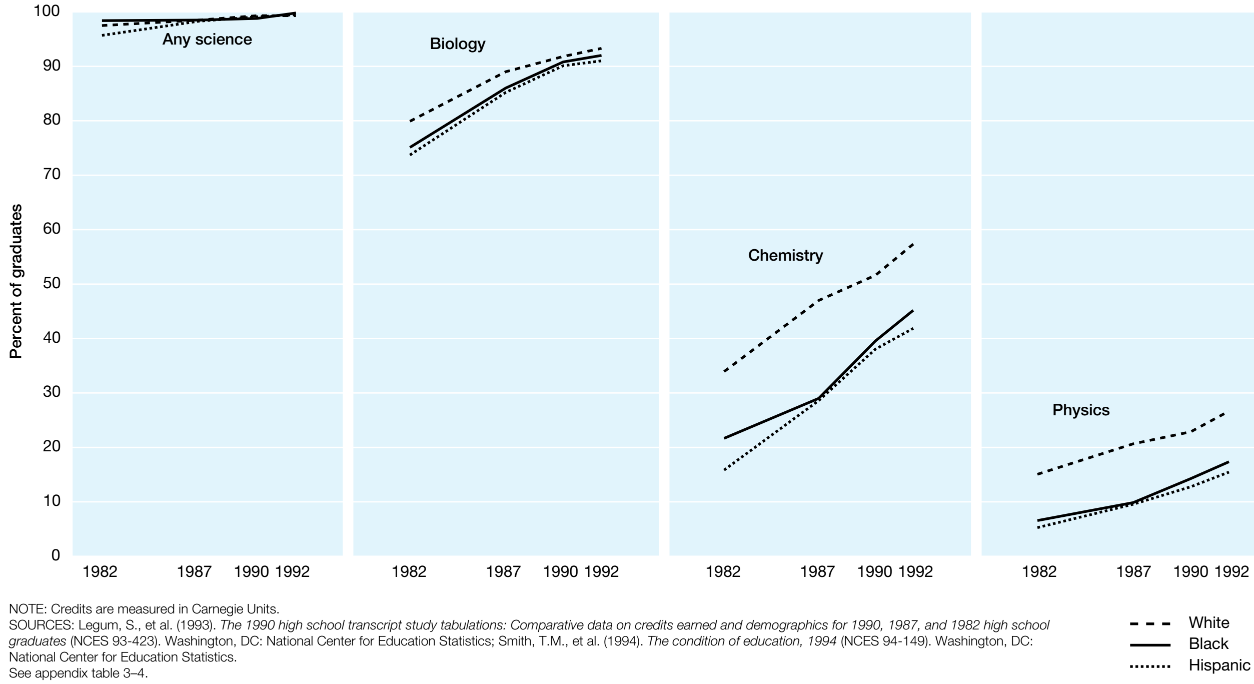
Percent of high school graduates earning credits in science and mathematics courses, by subject and sex: 1982 to 1992



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: NCES.
See appendix tables 3-4 and 3-5.

FIGURE 3–5

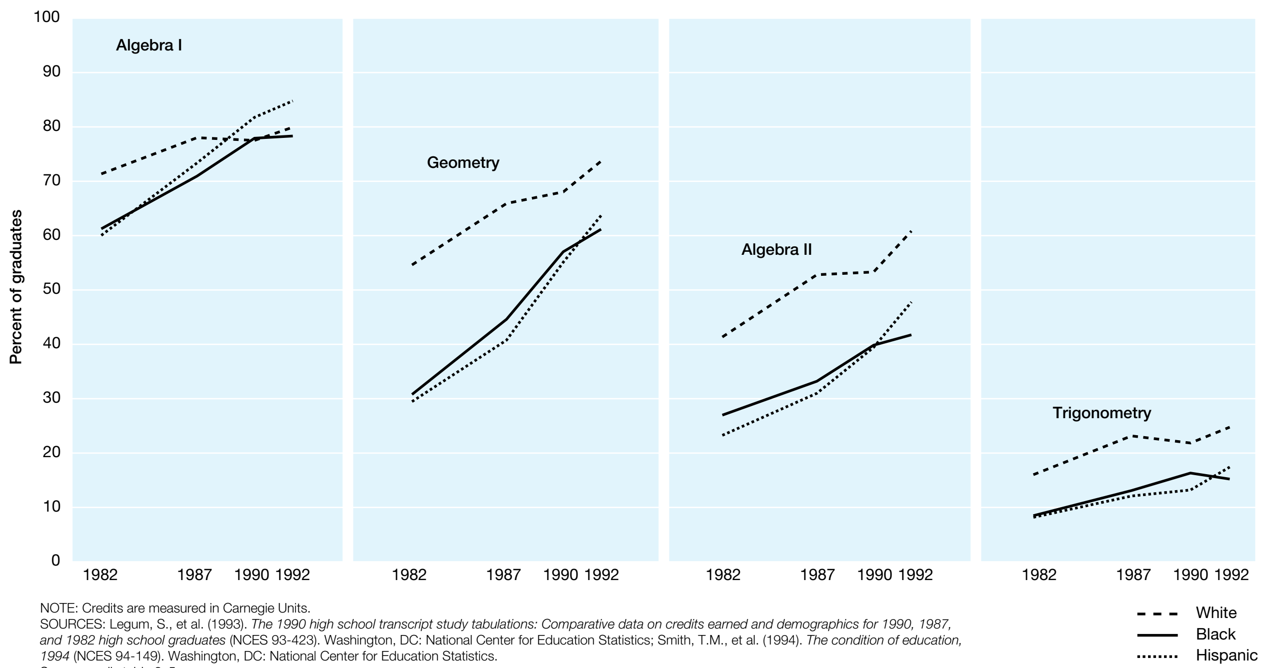
Percent of high school graduates earning credits in science courses, by race or ethnic origin: 1982 to 1992



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.
See appendix table 3–4.

FIGURE 3–6

Percent of high school graduates earning credits in 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.
See appendix table 3–5.

the coursetaking of minority students and white students has narrowed. However, in 1992, white students were still more likely than black or Hispanic students to take advanced science or mathematics courses. (See figures 3-5 and 3-6.)

For example, in 1982, 71 percent of white graduates, 61 percent of black graduates, and 60 percent of Hispanic graduates had taken algebra I; whereas in 1992, 80 percent of white graduates, 78 percent of black graduates, and 84 percent of Hispanic graduates had taken the course. However, in 1992, while 23 percent of white graduates had taken trigonometry, only 13 percent of black graduates and 15 percent of Hispanic graduates had taken the course. All of these percentages are higher than in 1982, when only 14 percent of white graduates, 6 percent of black graduates, and 7 percent of Hispanic graduates had taken trigonometry. The results are similar in science.

About 34 percent of Asian students complete the traditional sequence of biology, chemistry, and physics. Only 21 percent of white students, 12 percent of black students, and 10 percent of Hispanic students complete that sequence. (See text table 3-2.) About 38 percent of white and Asian students complete the traditional sequence of algebra I, geometry, and algebra II; only about 30 percent of black and Hispanic students complete this sequence (Legum et al., 1993).

Ability Grouping

Both the science and the mathematics standards recommend that science and mathematics be available to all students and that schools give all students the opportunity to achieve. Often, these goals and ability grouping—a practice common at many schools—are considered opposites, because ability grouping denies some students access to challenging concepts. For example, according to the NSSME, students who are encouraged to take introductory mathematics instead of algebra I at the eighth- or ninth-grade level often do not have the opportunity to take a traditional sequence of advanced science and mathematics courses. Despite the statistics, ability grouping could be valuable and could support the standards, if it provided alternative routes to the same knowledge.

Ability grouping is more common in high schools than at middle or junior high schools and is more common in mathematics than in science. In 1993, 57 percent of high schools assigned incoming students to mathematics courses by ability, compared with 46 percent of middle and junior high schools; 34 percent of high schools assigned incoming students to science courses by ability, compared with only 11 percent of middle and junior high schools (Weiss, 1994).

In schools with ability grouping, classes consisting of a large percentage of minority students are more likely to be categorized by their teachers as low ability than classes with a small percentage of minority students. The opposite holds true for high-ability groups: Classes with a small

TEXT TABLE 3-2

Percent of high school graduates completing a three-course sequence in science or mathematics during grades 9–12, by race or ethnic origin: 1990

Course sequence	White	Black	Hispanic	Asian
Biology, chemistry, and physics	21 (0.8)	12 (1.3)	10 (1.2)	34 (2.4)
Algebra I, geometry, and algebra II	38 (1.6)	29 (2.4)	30 (2.5)	38 (2.4)

NOTES: Courses completed in grades 7 and 8 were not counted as part of a sequence. Standard errors appear in parentheses.
SOURCE: 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.

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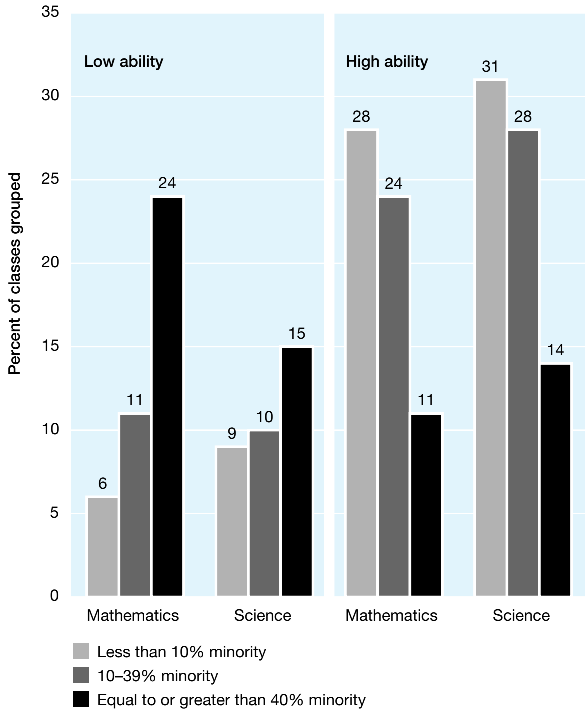
Both the science and the mathematics standards recommend that science and mathematics be available to all students and that schools give all students the opportunity to achieve. Often, these goals and ability grouping—a practice common at many schools—are considered opposites, because ability grouping denies some students access to challenging concepts.

FIGURE 3–7

Percent of high school science and mathematics classes grouped by ability, according to percent minority in class: 1993



NOTE: High school includes grades 9–12.
SOURCE: Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.
See appendix table 3–6.

percentage of minority students are more likely to be categorized as high ability than classes with a large percentage of minority students. (See figure 3-7 and appendix table 3-6.) Nevertheless, high school teachers report that science and mathematics classes are becoming more heterogeneous. (See figure 3-8 and appendix table 3-7.)

Teachers

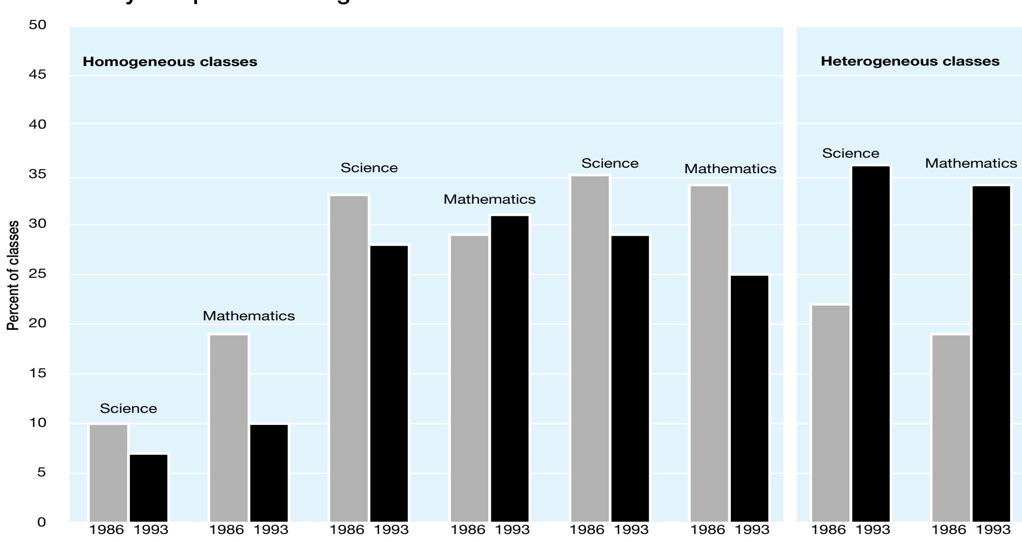
A well-prepared teaching force is critical to effective science and mathematics education. This section paints a picture of the teaching population and addresses teacher characteristics, teacher preparation, and professional development.

Teacher Characteristics

According to tabulations from NCES (1994), in the United States, approximately 2.9 million teachers (full-time and part-time) taught elementary and secondary classes in 1991 (the latest national estimate available), compared with 2.6 million in 1988. In 1991, nearly one-half million secondary (grades 7–12) teachers were specifically assigned to teach science or mathematics; approximately 380,000 of these teachers had science or mathematics as either a main or secondary assignment. (See appendix table 3-8.)

FIGURE 3–8

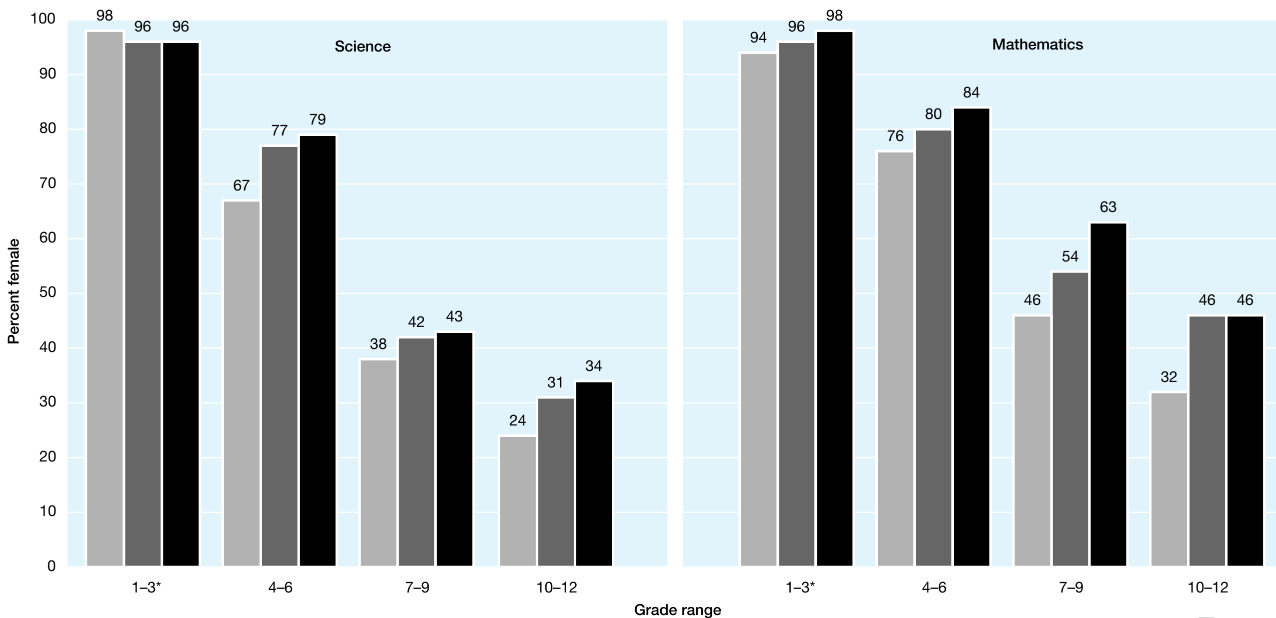
Ability composition of high school science and mathematics classes: 1986 and 1993



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.
See appendix table 3–7.

FIGURE 3-9

Percent of science and mathematics teachers who are female, 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.

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Sex

In 1993, the vast majority of science and mathematics teachers in grades 1–3 were female. (See figure 3-9.) According to the NSSME, the percentage of female teachers decreases as students get older. In 1993, by grades 10–12, only 34 percent of science teachers and 46 percent of mathematics teachers were female. The percentage of female middle and high school mathematics teachers has increased considerably in recent years. For example, in 1977, 46 percent of grades 7–9 mathematics teachers were female, compared with 63 percent in 1993. (See figure 3-9.)

The distribution by sex of the science and mathematics teaching force varies by state and region. (See figures 3-10 and 3-11 and appendix table 3-9.) For example, according to the Schools and Staffing Survey, in 1991, while less than 40 percent of the high school mathematics teachers in the Northwest were female, 60 percent or more of the high school mathematics teachers in the Southeast were female.

Race and Ethnic Origin

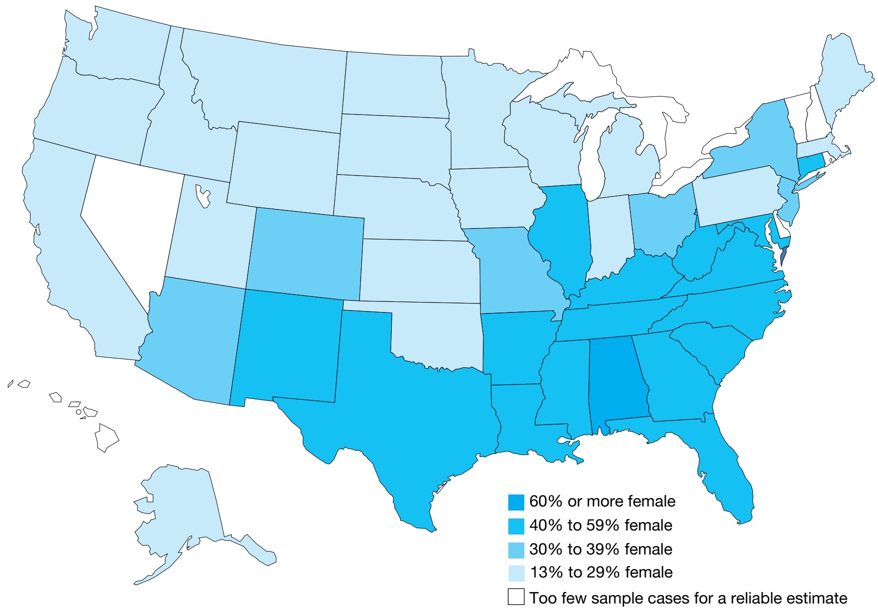
Blacks, Hispanics, and other minority groups continue to be underrepresented in the science and mathematics teaching force; in 1993, when minorities constituted roughly 30 percent of student enrollment, only 6 to 10 percent of science and mathematics teachers, depending on grade range, were members of minority groups. (See Chapter 1 and appendix table 3-10.) This distribution was approximately the same in 1986, although there is some evidence that the percent of black science and mathematics teachers in elementary schools decreased between 1986 and 1993. (See appendix table 3-10.) The NSSME reported that in 1986 10 percent of grades 1–6 teachers were black, compared with 5 percent in 1993.

The National Educational Longitudinal Study of 1988 (NELS:88) Second Follow-Up Study provides additional support that minorities are underrepresented in teaching. In 1992, white teachers taught about 93 percent of 12th-grade science and mathematics students. The remaining students were divided fairly equally among teachers who were black, Hispanic, or other races (NCES, 1992).

Blacks, Hispanics, and other minority groups continue to be underrepresented in the science and mathematics teaching force.

FIGURE 3-10

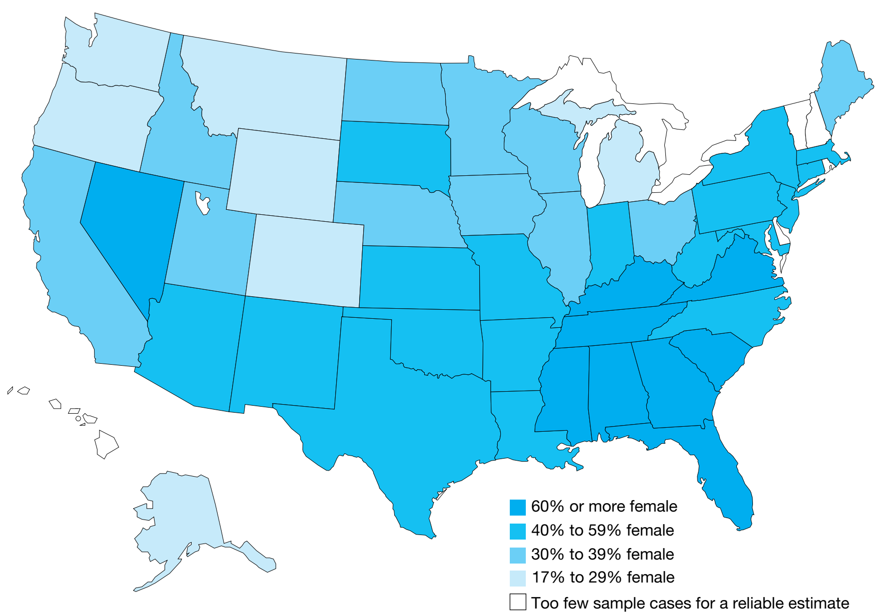
Percent of public high school science teachers who are female, by state: 1991



NOTE: High school includes grades 9–12.
SOURCE: Blank, R.K., Matti, M.C., Weiss, I.R., Broughman, S., & Rollefson, M. (1994). *SASS by state, 1990–91 schools and staffing survey: Selected state results* (NCES 94-343). Washington, DC: National Center for Education Statistics.
See appendix table 3-9.

FIGURE 3-11

Percent of public high school mathematics teachers who are female, by state: 1991



NOTE: High school includes grades 9–12.
SOURCE: Blank, R.K., Matti, M.C., Weiss, I.R., Broughman, S., & Rollefson, M. (1994). *SASS by state, 1990–91 schools and staffing survey: Selected state results* (NCES 94-343). Washington, DC: National Center for Education Statistics.
See appendix table 3-9.

TEXT TABLE 3-3

Average age of science and mathematics teachers, by grade range: 1986 and 1993

Grade range	1986	1993
1-6	40.0 (0.4)	42.1 (0.5)
7-9	39.2 (0.6)	42.0 (0.4)
10-12	40.4 (0.5)	43.3 (0.3)

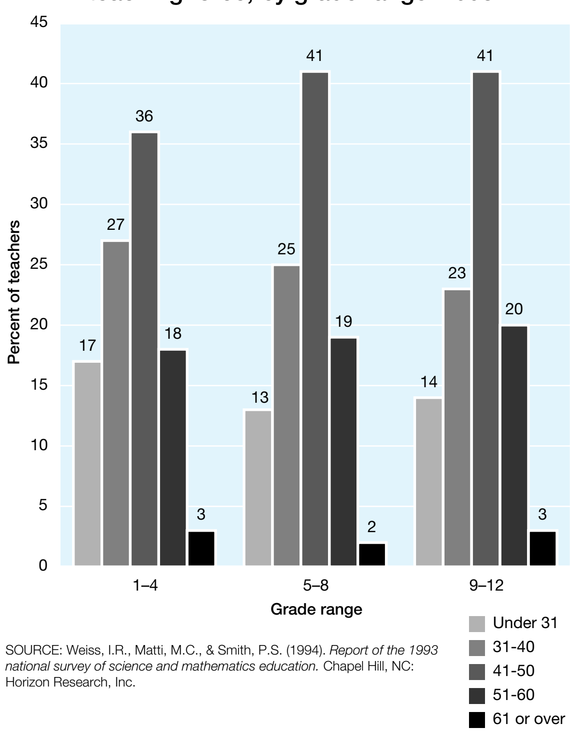
NOTE: Standard errors appear in parentheses.
SOURCES: Weiss, I.R. (1987). *Report of the 1985-86 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute; Weiss, I.R., Matti, M.C., & Smith, P.S. (1994). *Report of the 1993 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research, Inc.

Age

The science and mathematics teaching force is growing older. The average age of teachers at all grade levels increased by approximately 2 years between 1986 and 1993, from about 40 years to about 42 years. (See text table 3-3.) In 1993, roughly 20 percent of science and mathematics teachers in each grade range were over age 50. (See figure 3-12.) This may have an effect on the availability of teachers as many in the current teaching force reach retirement age in the next 10 years.

FIGURE 3-12

Age distribution of the science and mathematics teaching force, by grade range: 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.

Graduate Education

According to the NSSME, in 1993, about 31 percent of science and mathematics teachers in grades 1–4 had earned a degree beyond the bachelor's, increasing to about 34 percent in grades 5–8 and about 46 percent in grades 9–12. The percent of teachers with master's degrees was higher for people with the most years of teaching experience; for example, in 1993, only 21 percent of grades 9–12 science and mathematics teachers who had 2 or fewer years previous teaching experience had master's degrees, compared with 72 percent of those with 21 or more years prior teaching experience. (See figure 3-13 and appendix table 3-11.)

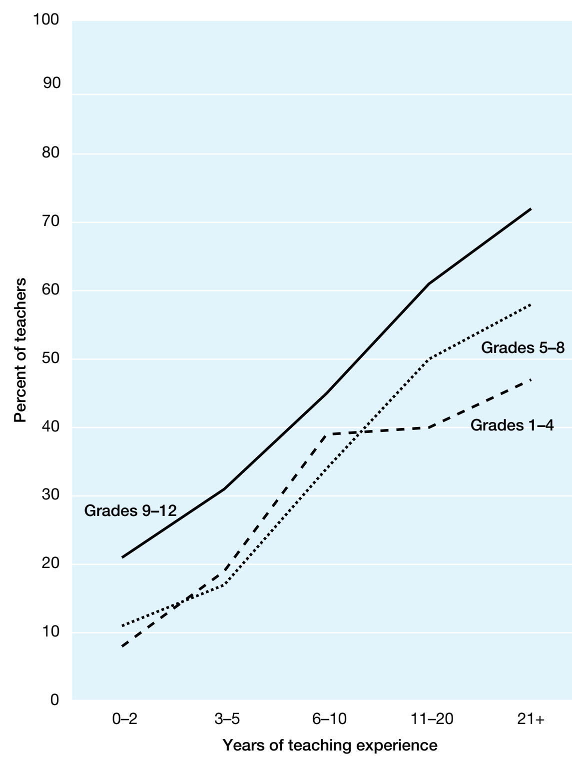
Autonomy

Underlying many educational reform efforts is the notion that, since classroom teachers are in the best position to know their students' needs and interests, they should be the ones to make decisions about tailoring instruction to a particular group of students.

Both the NELS:88 Second Follow-Up Study and the 1993 NSSME asked teachers about how much control

FIGURE 3-13

Percent of science and mathematics teachers with master's degrees, by years of teaching experience and by grade range: 1993



SOURCE: Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.
See appendix table 3–11.

they exercised over a number of curriculum and instructional decisions for their classes. (See appendix table 3-12.) Science and mathematics teachers at all grade ranges are likely to perceive that they have the most autonomy in selecting teaching techniques and determining the amount of homework to be assigned; their self-perceived autonomy is less, but still strong, when it comes to setting the pace for covering topics, choosing criteria for grading students, and selecting the sequence for covering topics. Fewer science and mathematics teachers—especially in the elementary and middle grades—believe they have strong control over selecting instructional materials; determining the goals and objectives of their courses; selecting the content, topics, and skills to be taught; or selecting textbooks. (See appendix table 3-12.)

Similarly, the NELS:88 Second Follow-Up Study found that larger percentages of 12th-grade students had teachers who believed they had "complete control" over decisions related to teaching techniques and amount of homework than over decisions related to disciplining students, selecting content, or selecting textbooks and other instructional materials. (See sidebar on homework, text table 3-4, and appendix table 3-13.)

Interesting differences emerge in these responses when they are examined by region and class proficiency level. For example, 12th-grade teachers in the South are less likely to believe they have control over content decisions than are teachers in other regions. (See appendix table 3-14.) Also, teachers of students who performed at the lowest levels on the NELS:88 Second Follow-Up Study proficiency tests are least likely to believe that they have control over content decisions. (See appendix table 3-15.) This last finding indicates that students who are in the greatest need of having teachers use their professional judgment in making decisions are the least likely to have teachers who feel empowered to do so.

Teacher Job Satisfaction

Overall, science and mathematics teachers enjoy their jobs. For example, in the NELS:88 Second Follow-Up Study, 80 percent of 12th-grade science and mathematics students were taught by teachers who felt satisfied most or all of the time, and only 2 percent had teachers who were "almost never" satisfied with their jobs. (See figure 3-14.) The NSSME found that teacher satisfaction slightly increased between 1986 and 1993. (See figure 3-15.)

Homework Matters

Homework is a significant component of the instructional system, and it is one practice over which teachers have considerable control. Higher average NAEP mathematics proficiency is associated with the completion of mathematics homework. (See text table 3-4.) Students reporting never doing homework had the lowest proficiencies. The results are similar in the High School and Beyond and the NELS:88 Second Follow-Up Study databases. ■

TEXT TABLE 3-4

NAEP mathematics proficiency of 17-year-old students, by frequency of homework performed: 1978 to 1992

	Often		Sometimes		Never	
Year	Percent of students	Average NAEP mathematics proficiency	Percent of students	Average NAEP mathematics proficiency	Percent of students	Average NAEP mathematics proficiency
1978	59 (2.0)	309 (1.6)	35 (1.9)	291 (2.1)	6 (0.7)	284 (3.5)
1982	65 (1.7)	307 (1.5)	29 (1.6)	291 (2.1)	6 (0.6)	284 (3.4)
1986	74 (1.2)	304 (1.1)	20 (1.4)	296 (1.8)	5 (0.7)	291 (5.5)
1990	77 (1.3)	310 (1.7)	18 (1.1)	295 (2.0)	5 (0.7)	281 (3.5)
1992	76 (1.2)	310 (1.1)	19 (0.9)	295 (1.8)	5 (0.7)	285 (4.1)

NOTES: Standard errors appear in parentheses. Totals may not equal 100 percent as a result of rounding.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

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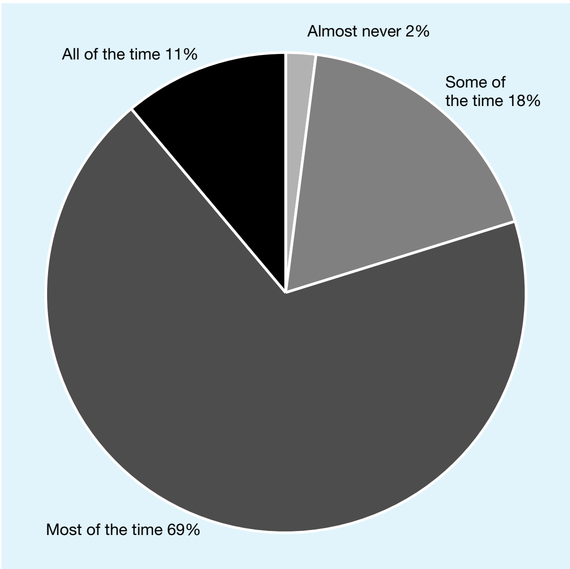
FIGURE 3–14

Percent of 12th-grade science and mathematics students taught by teachers who are satisfied with their jobs: 1992



SOURCE: National Center for Education Statistics. (1992). *National education longitudinal study of 1988: Second teacher follow-up study.* Unpublished tabulations.

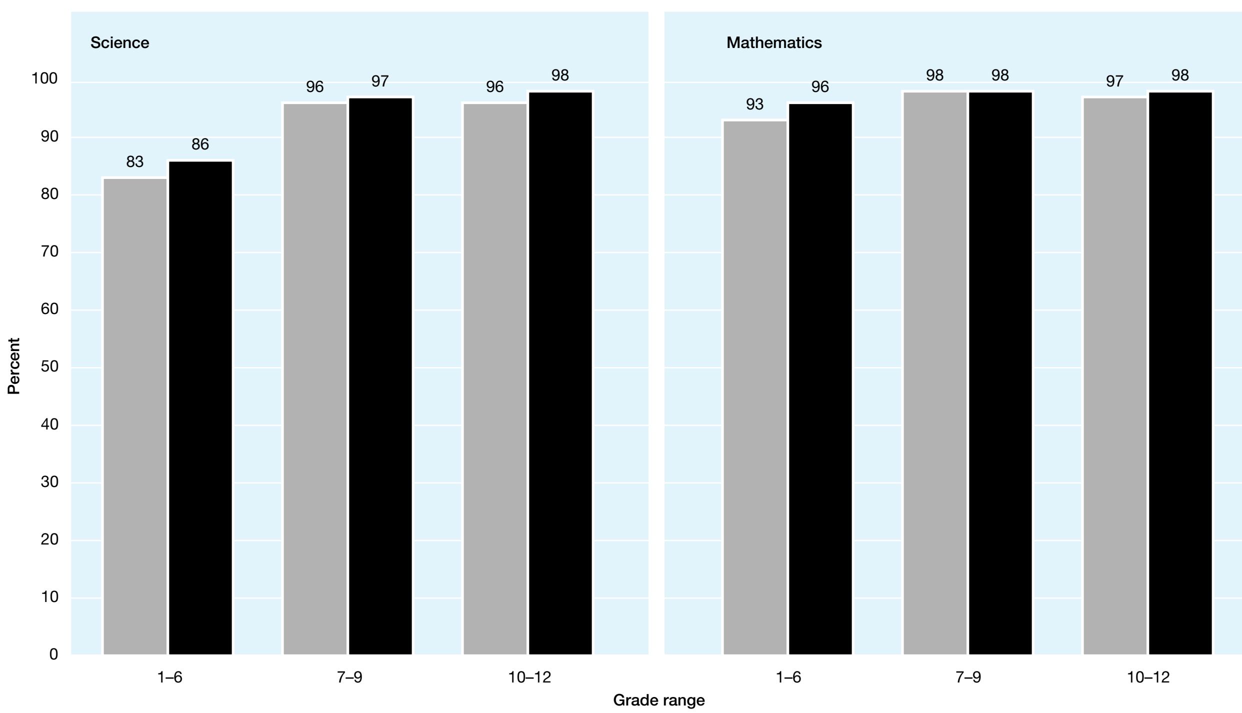
In 1986, about 92 percent of science teachers and 96 percent of mathematics teachers said they enjoyed teaching, compared with 1993, when 94 percent of science teachers and 97 percent of mathematics teachers said the same. Elementary science teachers were the group least likely to enjoy teaching in both 1986 and 1993.

Teachers' Beliefs About Classroom Reforms

Although the NCTM published its *Curriculum and Evaluation Standards* in 1989 and *Professional Standards for Teaching* in 1991, not all teachers are familiar with them. In 1993, mathematics teachers in higher grades were more likely than their counterparts in lower grades to be familiar with these documents. Roughly one in five elementary, one in four middle, and one in two high school mathematics teachers said they were "well aware" of the *Curriculum and Evaluation Standards;* fewer teachers in each grade range were familiar with the *Professional Standards for Teaching*. (See figure 3-16 and appendix table 3-16.)

FIGURE 3–15

Percent of teachers who say they enjoy teaching subject, by subject and grade range: 1986 and 1993



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.

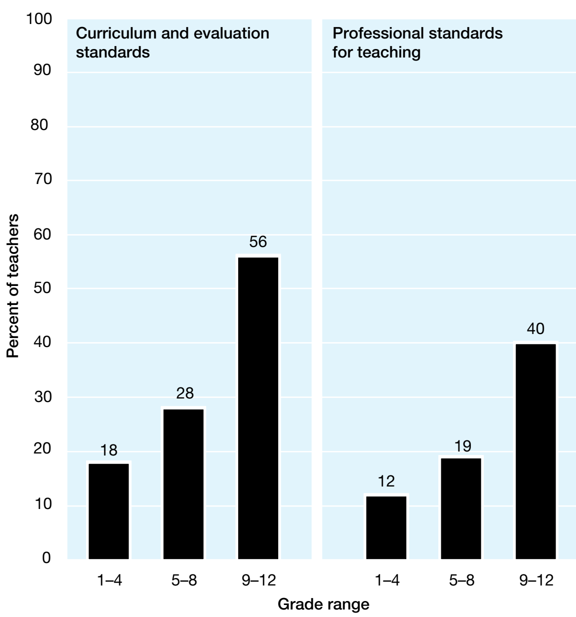
In the 1993 NSSME, science and mathematics teachers reported mixed views about the principles underlying the standards and the recommendations that flow from them:

- Although most science and mathematics teachers believed that "virtually all students can learn to think scientifically and mathematically," sizable proportions reported that such learning is best accomplished by placing students in classes with others of similar abilities. (See figures 3-17 and 3-18 and appendix table 3-17.) More mathematics than science teachers, and more high school teachers than middle school teachers or elementary school teachers, said they support ability grouping. (See the section about ability grouping on page 41.)
- Mathematics teachers did not support the earlier introduction of algebraic concepts. Most elementary, middle, and high school mathematics teachers reported that they believe students must master arithmetic computation before going on to algebra. (See figure 3-19 and appendix table 3-17.)
- Similarly, although most middle and high school science teachers reported that they believe science is best learned in the context of a personal or social application and that laboratory-based classes are more effective than nonlaboratory classes, many appear to resist teaching science concepts before they teach the terminology associated with those concepts. Almost one-third of elementary school teachers and more than one-half of high school science teachers indicated that "it is important for students to learn basic scientific terms and formulas before learning underlying concepts and principles." (See appendix table 3-17.)

Roughly three out of four science teachers in all grades indicated that hands-on activities should definitely be a part of science instruction, and nearly that many considered teaching of applications of science in daily life to be essential.

FIGURE 3–16

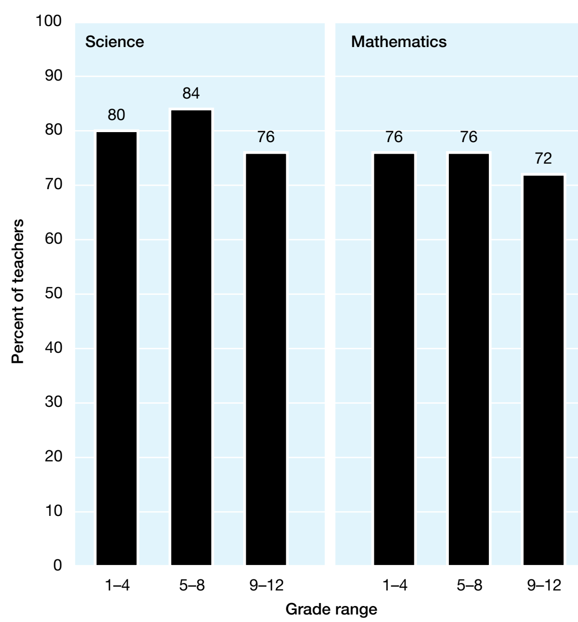
Percent of mathematics teachers who are "well aware" of the NCTM standards documents, by grade range: 1993



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.
See appendix table 3–16.

FIGURE 3–17

Percent of mathematics teachers agreeing that virtually all students can learn to think scientifically or mathematically, by subject and grade range: 1993



NOTE: Includes teachers who indicated "Strongly Agree" or "Agree" to each statement.
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.
See appendix table 3–17.

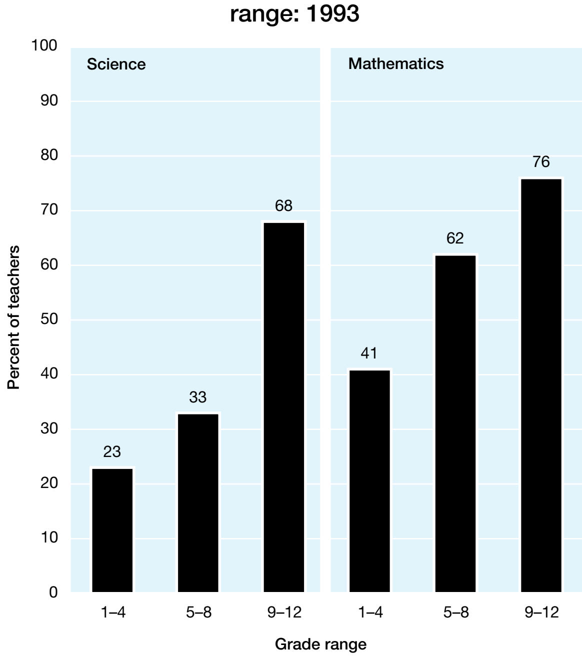
- High school mathematics teachers supported the frequent use of calculators—73 percent indicated that “students should be able to use calculators most of the time.” Elementary mathematics teachers were less likely to support extensive use of calculators. (See figure 3-19 and appendix table 3-17.)
- More than 80 percent of elementary mathematics teachers—but only 50 percent of middle school teachers and 25 percent of high school teachers—considered hands-on or manipulative activities essential for effective mathematics instruction. (See appendix table 3-18.) Similarly, mathematics teachers in the higher grades were less likely than those in the lower grades to support the use of new teaching strategies—such as concrete experiences before abstract treatments, applications of mathematics in daily life, cooperative learning groups for students, use of computers, and the effect that students’ prior conceptions about a topic should have on curriculum and instruction.
- Roughly three out of four science teachers in all grades indicated that hands-on activities should definitely be a part of science instruction, and nearly that many considered teaching of applications of science in daily life to be essential. (See sidebar on hands-on activities and figure 3-20.) However, fewer teachers—especially at the high school level—considered it important to teach concrete experience before abstract treatments or place students in cooperative learning groups. Only about one in five high school science teachers considered it essential to take student conceptions about natural phenomena into account when planning curriculum and instruction; to have deeper coverage of fewer science concepts; or to revisit science topics, each time in greater depth. (See appendix table 3-20.)

Teacher Preparation

The science and mathematics standards advocate the introduction of challenging science and mathematics content to all students beginning in the early grades; however, only teachers who have a firm grasp of powerful science and mathematics concepts themselves can guide students’ exploration of science and mathematics.

FIGURE 3–18

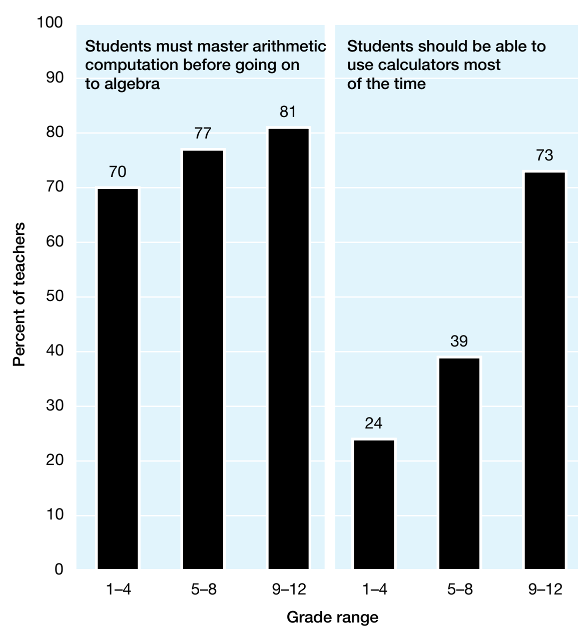
Percent of science and mathematics teachers agreeing that students learn science or mathematics best in classes with students of similar abilities, by subject and grade range: 1993



NOTE: Includes teachers who indicated "Strongly Agree" or "Agree" to each statement.
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.
See appendix table 3–17.

FIGURE 3–19

Percent of mathematics teachers agreeing with statements about reform, by grade range: 1993



NOTE: Includes teachers who indicated "Strongly Agree" or "Agree" to each statement.
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.
See appendix table 3–17.

Proxy measures, such as an evaluation of undergraduate or graduate major or number of courses completed in the field of assignment, are one way to gauge how well teachers understand science and mathematics. In 1993, less than 5 percent of elementary school science or mathematics teachers had majored in science or science education or mathematics or mathematics education at either the undergraduate or graduate level. (See figure 3-21.) Of course, this figure is not surprising, given that most elementary teachers teach all or most academic subjects, rather than specialize in science or mathematics.

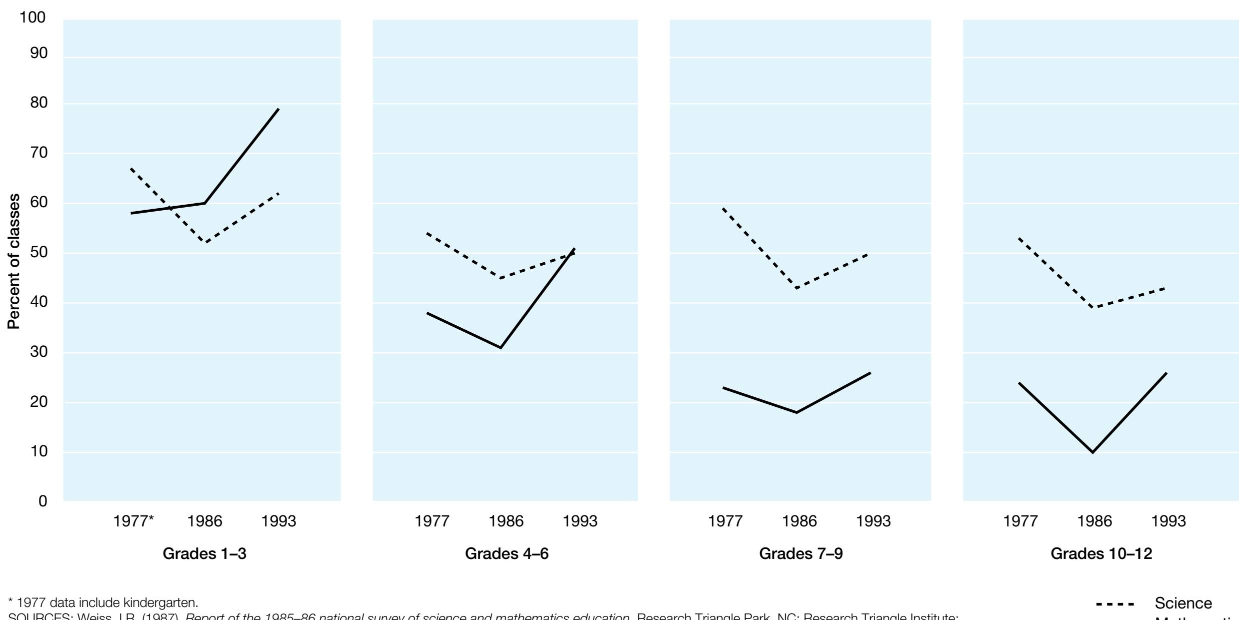
Science and mathematics teachers in grades 9–12 are more likely to have majored in science or mathematics at the undergraduate or graduate levels than their elementary counterparts. However, nearly 30 percent of high school science teachers and 40 percent of high school mathematics teachers had neither an undergraduate nor graduate major in science or science education or mathematics or mathematics education. Moreover, although more than 90 percent of high school science teachers had at least a minor in science or science education, only 81 percent of high school mathematics teachers had at least a minor in mathematics or mathematics education. (See text table 3-5.)

Use of Hands-On Activities Gains Favor After Sharp Drop in the 1980s

Both the science and mathematics standards call for increased use of hands-on activities, because concrete experiences allow students to use and reorganize their existing knowledge structures. Data from the 1993 NSSME show that use of hands-on activities varies by grade—more elementary school classes than secondary school classes use them. In addition, at the secondary level, more science classes than math classes use them. Other differences exist over time. In almost all grades and subjects, their use dropped—sometimes dramatically—between 1977 and 1986. (See figure 3-20 and appendix table 3-19.) This overall decrease in attention to hands-on classwork may have been due to the "back to basics" movement of the mid-1980s, which emphasized a more direct instructional style with less use of manipulatives—educators used drills; they didn't want students to play in the classroom. Interest in hands-on activities increased in 1993—especially in grades 4–6 mathematics classrooms, where the percentages rebounded to levels higher than in 1977. Despite the resurgence in 1993, the percentage of science classes using hands-on activities was still not up to the 1977 levels. Notwithstanding these recent increases, it is important to note that, except at the earliest grades, only about half of science classes and about 30 percent of mathematics classes use hands-on activities on a given day. ■

FIGURE 3–20

Percent of science and mathematics 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.

See appendix table 3-19.

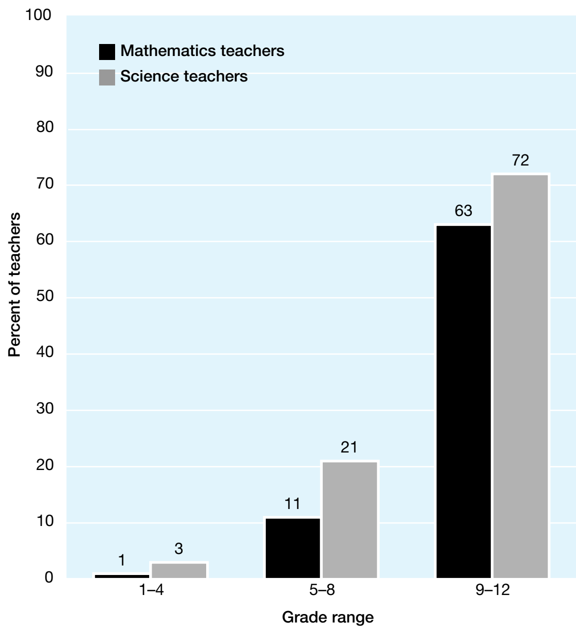
Indicators of Science and Mathematics Education 1995

Science Teachers' Preparation

A similar picture emerges with an examination of the total number of semesters of college science coursework completed by science teachers. In 1993, elementary teachers had less extensive backgrounds in science than their middle school counterparts, who in turn had less science coursework than their high school counterparts. (See figure 3-22.) The percent of high school science

FIGURE 3–21

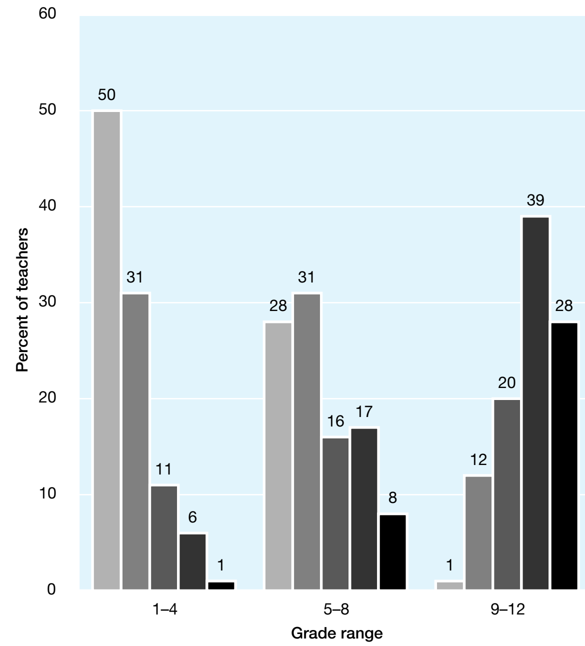
Percent of science and mathematics teachers with undergraduate or graduate majors in science or mathematics fields, by grade range: 1993



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.

FIGURE 3–22

Total number of semesters of college science coursework completed by science teachers, by grade range: 1993



NOTE: The highest number of semesters a teacher could indicate for each of the four categories—life science, chemistry, physics/physical science, and earth/space science—was "8"; therefore, these figures underestimate the total for any teacher who completed more than eight courses in a particular category.
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.

TEXT TABLE 3-5

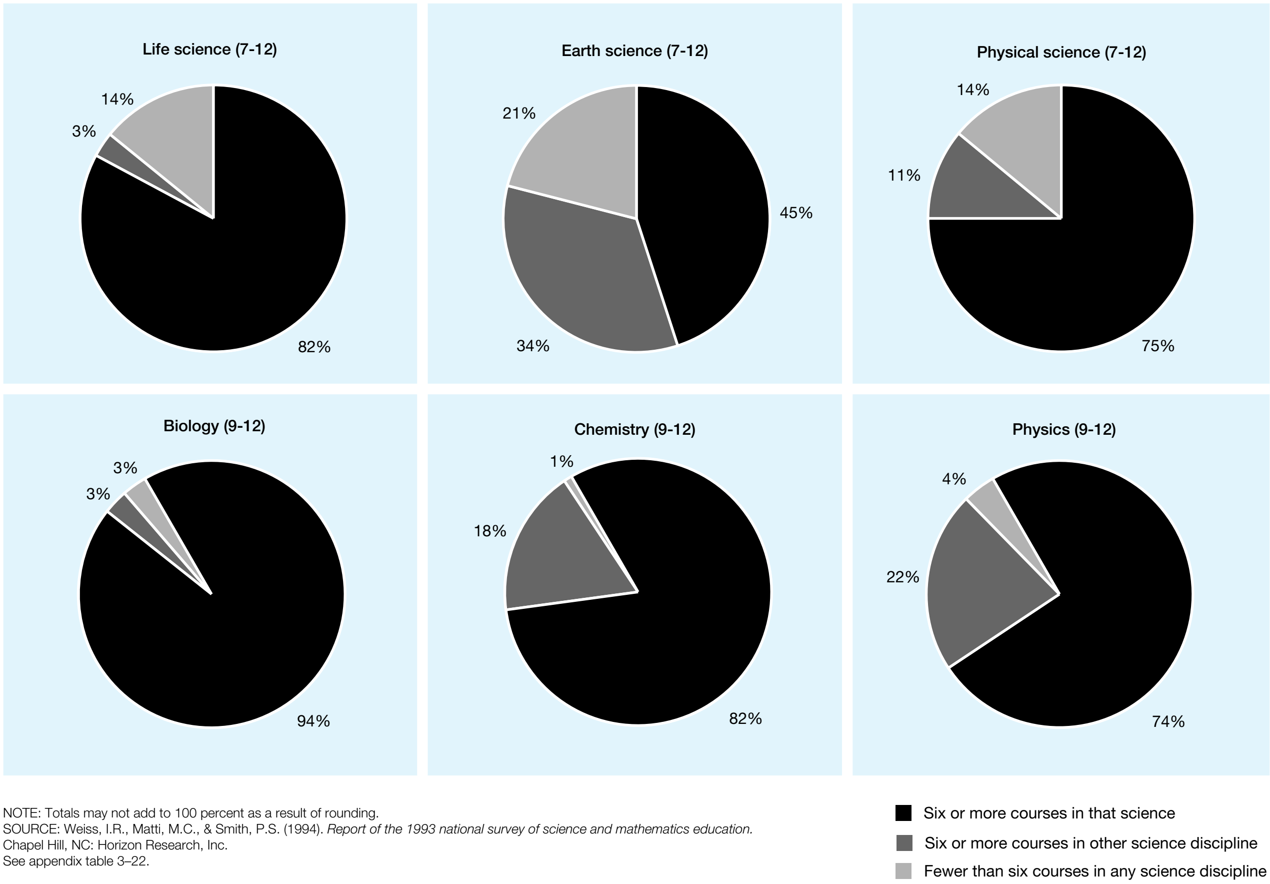
Percent of teachers with majors and minors in science or mathematics and science or mathematics education, by grade range: 1993

Field of class taught and field of study	Grade range 1-4	5-8	9-12
Science			
Undergraduate major in science	3 (0.7)	18 (2.1)	63 (2.1)
Undergraduate or graduate major in science or science education	3 (0.7)	21 (2.3)	72 (2.2)
Undergraduate or graduate major or minor in science or science education	7 (1.6)	32 (2.5)	94 (1.2)
Mathematics			
Undergraduate major in mathematics	1 (0.4)	7 (0.8)	41 (2.5)
Undergraduate or graduate major in mathematics or mathematics education	1 (1.0)	11 (1.5)	63 (3.4)
Undergraduate or graduate major or minor in mathematics or mathematics education	7 (1.9)	18 (2.1)	81 (3.2)

NOTE: Standard errors appear in parentheses.
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.

FIGURE 3–23

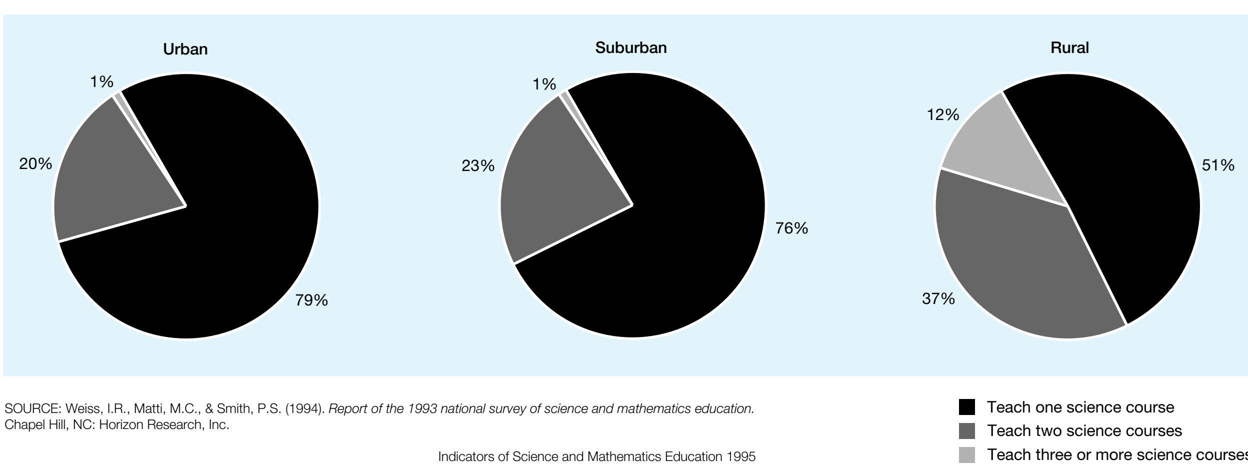
Percent of science classes taught by teachers with varying levels of preparation in science, by discipline: 1993



NOTE: Totals may not add to 100 percent as a result of rounding.
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.
See appendix table 3–22.

FIGURE 3–24

Percent of science teachers teaching courses in one, two, or three or more science subjects, by type of community: 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.

teachers who completed more than 20 semesters of college science coursework increased to 24 percent in 1993 from 15 percent in 1986 (Weiss, 1987; Weiss, Matti, & Smith, 1993).

The NSTA has recommended that elementary teachers have at least one college course in each of three science areas—biological sciences, physical sciences, and earth sciences. According to the NSSME, about two-thirds of grades 1–8 teachers met this standard in 1993. (See appendix table 3-21.)

NSTA's recommendations are much more detailed at the secondary level, including lists of specific courses that teachers of each discipline should complete. Because very few teachers, even those with extensive coursework in their field, meet the NSTA recommendations, the NSSME defined "well-prepared teachers" as ones with in-depth preparation—six or more courses in their field.

Based on this measure, the level of teacher preparation at the secondary level varies considerably. (See figure 3-23 and appendix table 3-22). For example, in 1993, 82 percent of grades 7–12 life science classes and 94 percent of grades 9–12 biology classes were taught by teachers who had taken six or more biology courses, but only 45 percent of grades 7–12 earth science classes were taught by teachers who had six or more earth science courses.

Also, although almost all biology, chemistry, and physics classes were taught by teachers who had in-depth preparation in some science discipline, more than 10 percent of grades 7–12 life, earth, and physical science classes were taught by teachers who did not have in-depth preparation in any science discipline. (See figure 3-23 and appendix table 3-22.)

Although most prospective secondary school science teachers have in-depth preparation in one discipline, many science teachers are assigned to teach courses in more than one discipline, resulting in extensive out-of-field teaching. In rural schools, where this situation is particularly prevalent, more than one in three teachers teach courses in two science disciplines and one in eight teaches courses in three or more science disciplines. (See figure 3-24.)

Mathematics Teachers' Preparation

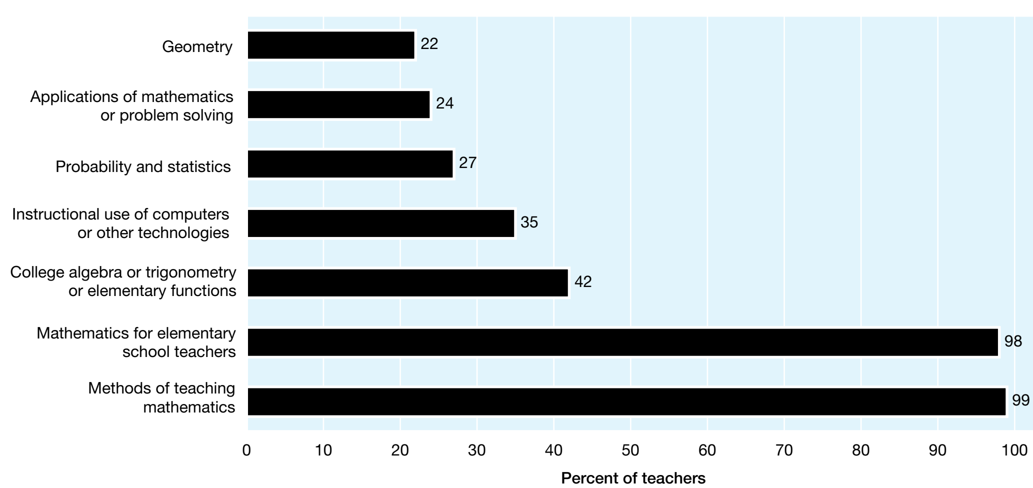
Almost all elementary school mathematics teachers have taken college courses in mathematics for elementary school teachers and in methods of teaching mathematics. However, far fewer have had college coursework in geometry or probability and statistics—areas that the *NCTM Curriculum and Evaluation Standards* suggest should be addressed in the primary grades. (See figure 3-25 and appendix table 3-23.)

NCTM recommends that grades 7–9 mathematics teachers have college coursework in calculus, geometry, probability and statistics, abstract algebra or number theory, and applications of mathematics or problem solving. Although 1993 data show that more than 70 percent of these teachers had completed calculus, only about 40 percent had completed a course focused mainly on applications of mathematics. These percentages are essentially the same as in 1986. (See appendix table 3-24.)

NCTM recommends that high school mathematics teachers complete advanced calculus, differential equations, linear algebra, and history of mathematics in addition to the five courses previously mentioned. In 1993, although 95 percent of high school mathematics teachers

FIGURE 3–25

Percent of elementary school mathematics teachers with college coursework in each area: 1993



NOTE: Elementary school includes grades 1–4.
SOURCES: 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.; Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.
See appendix table 3–23.

had completed calculus, only 46 percent had completed history of mathematics. Between 1986 and 1993, the percent of high school mathematics teachers who completed the recommended courses increased significantly; for instance, 13 percent more teachers completed linear algebra, and 11 percent more teachers completed abstract algebra. (See appendix table 3-24.)

Within high schools, teachers with more in-depth preparation in advanced mathematics are more likely to teach the advanced classes. (See figure 3-26.) These teachers are also more likely to teach classes with a low proportion of minority students. For example, in 1993, only 47 percent of high school mathematics classes containing more than 40 percent minority students were taught by teachers with an undergraduate or graduate major in mathematics or mathematics education, compared with 62 percent of classes containing fewer than 10 percent minority students. This pattern was not evident in high school science classes, where all classes were about as likely to have teachers with undergraduate or graduate majors in science or science education. (See figure 3-27 and appendix table 3-25.)

Teachers' Perceptions of Their Own Preparation

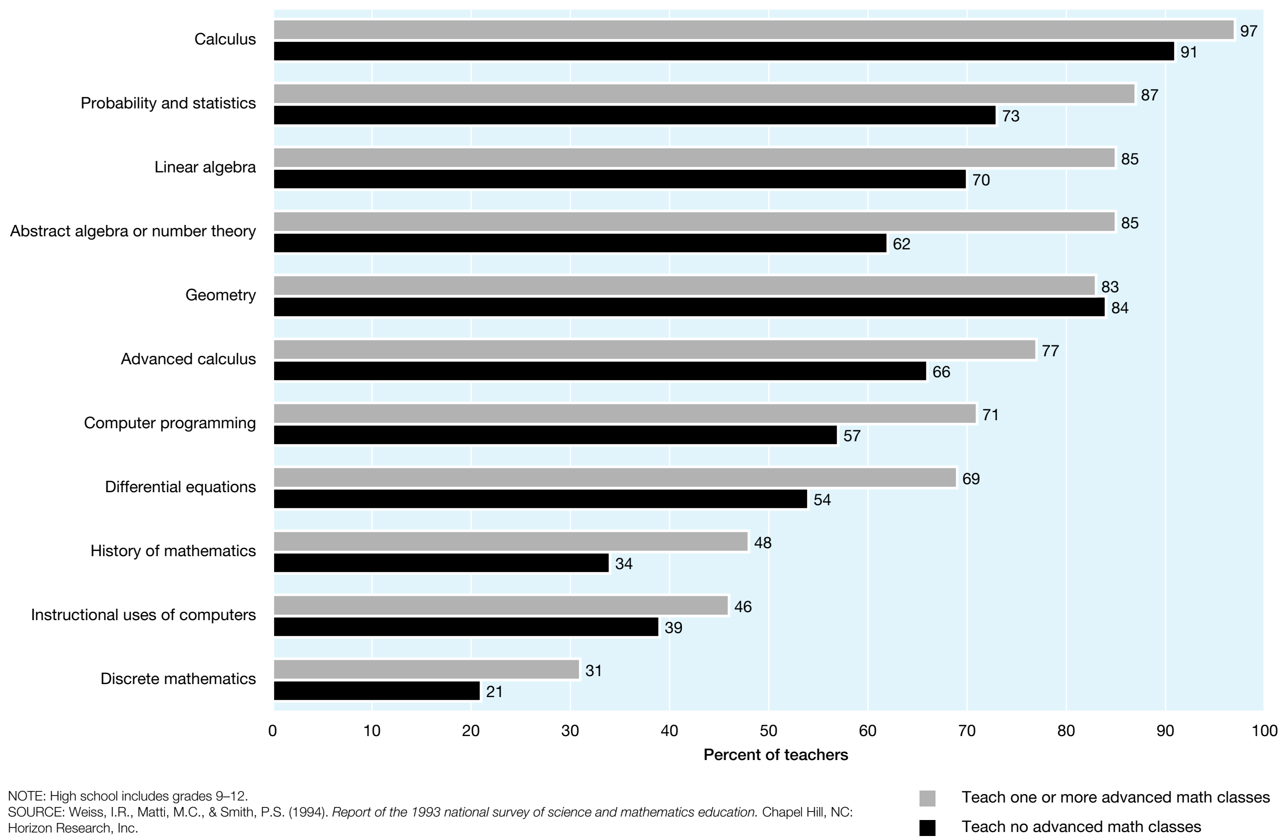
An evaluation of teachers' undergraduate or graduate majors and the number of courses they complete in their field of assignment are two ways to gauge how well teachers understand science and mathematics. Another way is to evaluate teachers' perceptions of their own preparation—how well prepared they feel to teach the various content areas and to use the various instructional strategies recommended for science and mathematics education.

Elementary teachers typically teach science, mathematics, reading and language arts, and social studies to a single group of students, but they do not feel equally qualified to teach all of these subjects. For example, in 1993, 76 percent of elementary school teachers assigned to teach all four subjects indicated that they felt very well qualified to teach reading and language arts, roughly 60 percent felt very well qualified to teach mathematics and social studies, but only 26 percent felt very well qualified to teach science. (See figure 3-28 and appendix table 3-26.)

According to the NSSME, in 1993, most elementary teachers felt well qualified to teach 4 of the 14 mathematics topics recommended by the *NCTM Curriculum and*

FIGURE 3–26

Percent of high school mathematics teachers completing college courses in mathematics, by teaching assignment: 1993



NOTE: High school includes grades 9–12.
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.

Evaluation Standards—estimation, number sense, measurement, and patterns and relationships. Just 11 percent of elementary teachers said they felt well qualified to teach probability and statistics. (See appendix table 3-27.)

Most middle school mathematics teachers said they felt well qualified to teach several of the subjects recommended by the NCTM standards—fractions and decimals; number sense and numeration; estimation; measurement; number systems and number theory; patterns and relationships; and geometry and spatial sense. (See appendix table 3-27.) Although nearly one-half of all middle school teachers felt well qualified to teach functions and algebra, just 28 percent felt well qualified to teach probability and statistics.

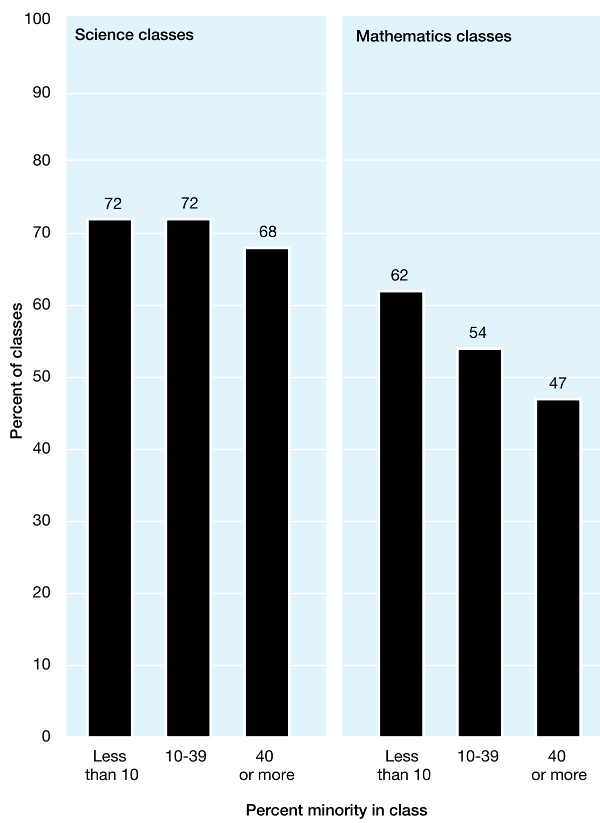
Most high school mathematics teachers felt well qualified to teach most of the recommended topics; however, only about 30 percent of these teachers felt well qualified to teach probability and statistics, mathematical structure, and the conceptual underpinnings of calculus. (See appendix table 3-27.) Only 20 percent felt well qualified to teach discrete mathematics.

In 1993, teachers of advanced mathematics classes were more likely to perceive themselves as well qualified to teach various mathematics topics. (See figure 3-29.) The difference was marked with regard to teachers' perception of their qualification to teach mathematical structure: 41 percent of teachers assigned to one or more advanced high school mathematics classes felt qualified to teach this topic, compared with only 18 percent of those who did not teach advanced classes.

Most science and mathematics teachers at all grade levels perceived that they were well prepared to perform tasks such as presenting the applications of science or mathematics concepts and encouraging participation of females; however, most science and mathematics teachers perceived that they were not prepared to teach students who had limited English proficiency and, except in grades 1–4, students who had learning disabilities. Also, only about one-

FIGURE 3–27

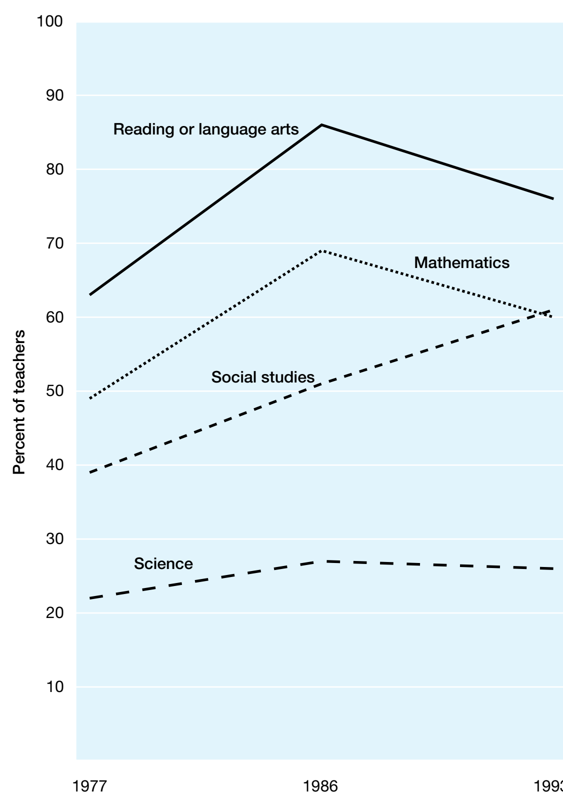
Percent of grades 7–12 science and mathematics classes taught by teachers with undergraduate or graduate major in the field, by percent of minority students in class: 1993



SOURCE: Weiss, I.R. (1994). *1993 national survey of science and mathematics education.* Unpublished tabulations.
See appendix table 3-25.

FIGURE 3–28

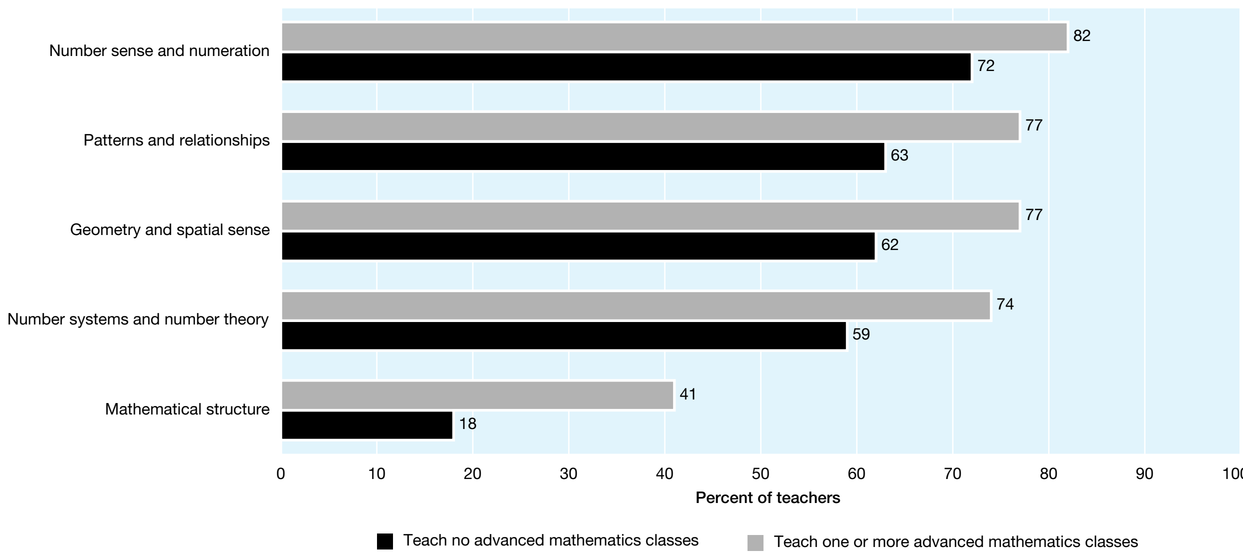
Percent of self-contained elementary teachers feeling very well qualified to teach each subject: 1977 to 1993



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.
See appendix table 3–26.

FIGURE 3–29

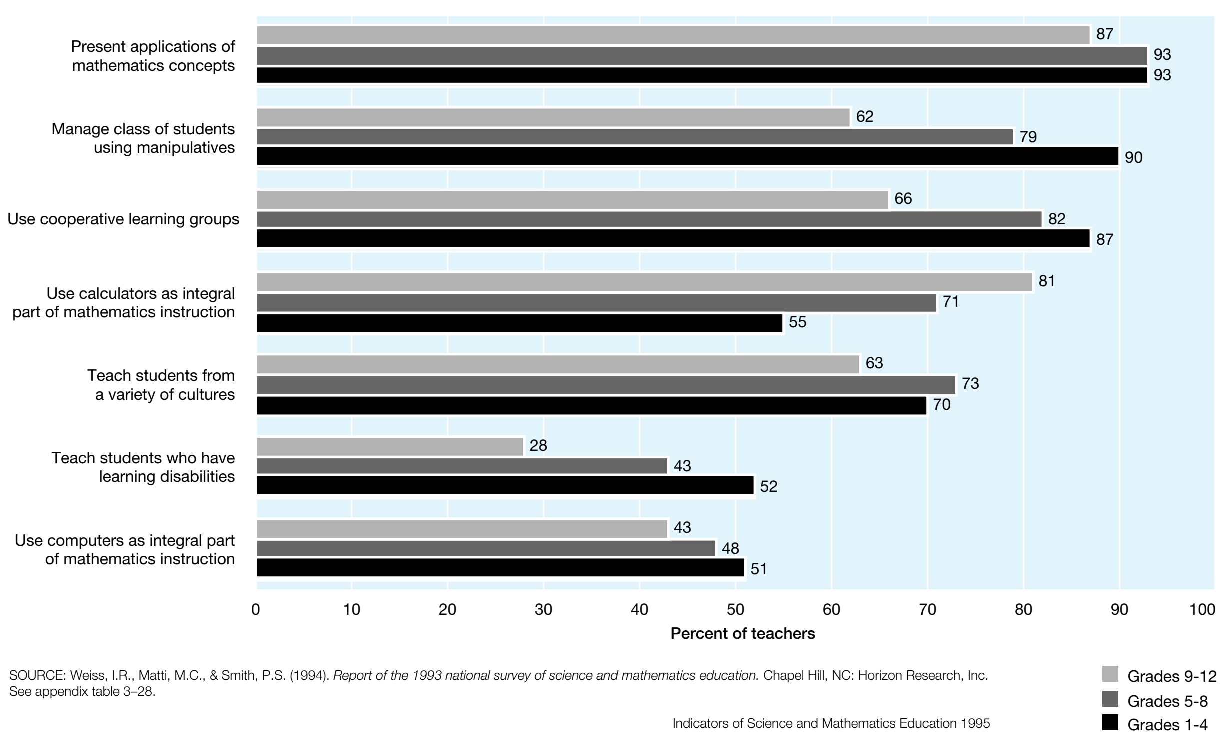
Percent of high school mathematics teachers considering themselves well qualified to teach each mathematics topic, by teaching assignment: 1993



NOTE: High school includes grades 9–12.
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.

FIGURE 3–30

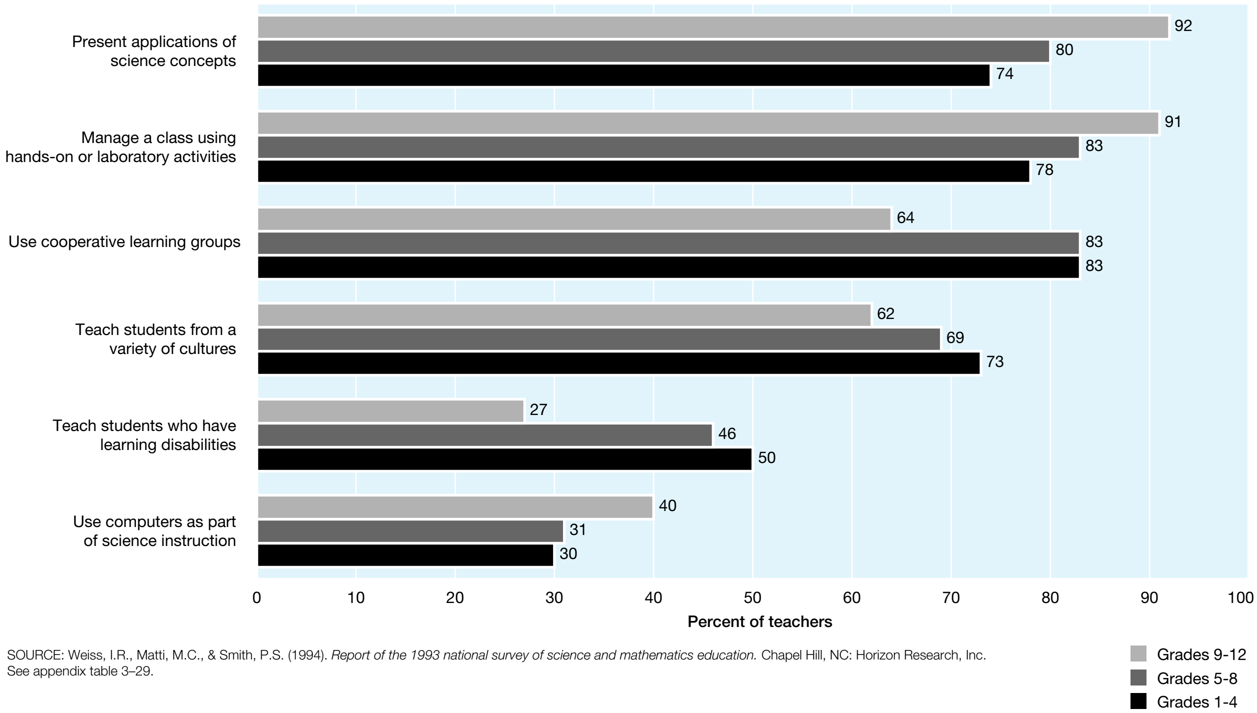
Percent of mathematics teachers considering themselves well prepared for mathematics teaching tasks, by grade range: 1993



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.
See appendix table 3–28.

FIGURE 3–31

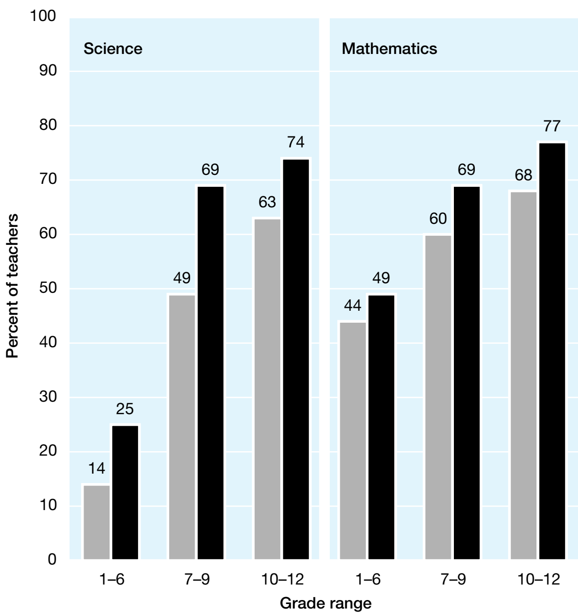
Percent of science teachers considering themselves well prepared for science teaching tasks, by grade range: 1993



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.
See appendix table 3–29.

FIGURE 3–32

Percent of teachers considering themselves "master teachers" of their subject, by subject and grade range: 1986 and 1993



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.

third of elementary and middle school science teachers and only about one-half of elementary and middle school mathematics teachers felt well prepared to use computers as an integral part of instruction, despite the fact that science and mathematics education reform advocates greater use of technology. About 40 percent of high school science and mathematics teachers feel well prepared to use computers as an integral part of instruction. (See figures 3-30 and 3-31 and appendix tables 3-28 and 3-29.)

Although elementary science teachers continued to be far less likely than other science and mathematics teachers to perceive of themselves as "master" teachers of their subject, the percentage of elementary science teachers considering themselves to be "master" science teachers has increased from 14 percent in 1986 to 25 percent in 1993. Indeed, at all grade levels, the percentage of science and mathematics teachers who considered themselves "master" teachers was higher in 1993 than in 1986. (See figure 3-32.)

Professional Development

Both the science and mathematics standards call for development of teachers as professionals, because teachers who see themselves as professionals are more likely to be proactive about teaching—to share authority among colleagues, further their education, and participate in professional activities. Proactive teachers tend to perform to a higher standard, thereby enhancing students' educational experiences. This section describes the state of teacher development in elementary and secondary education.

Collegiality

According to NELS, in 1992, 12th-grade science and mathematics teachers discussed science and mathematics curriculum issues primarily with teachers in their departments and their department chairs. Fewer teachers discussed curriculum with their principals; teachers outside the department or school; other school administrators; or parents, business leaders, university staff, and others in the community. (See appendix table 3-30.)

In addition, the NSSME reports that in 1993 most primary and secondary science and mathematics teachers believed that their colleagues support new teaching ideas, share ideas and materials on a regular basis, have many opportunities to learn new things in their job, and are supported by administrators. (See appendix table 3-31.) However, fewer than one in four had time during the regular school week to work with peers on science or mathematics curriculum and instruction, and only about one in eight regularly observed other teachers' classes as part of sharing and improving instructional strategies.

Continuing Education

The NSSME reported that in 1993, while most science and mathematics teachers had at least some in-service education in their field during the past 3 years, relatively few had devoted a substantial amount of time to these activities. (See appendix table 3-32.) Even among high school science and mathematics teachers—many of whom are specialists in their field—only about one-half had spent 16 or more hours on in-service education in their field in the previous 3 years.

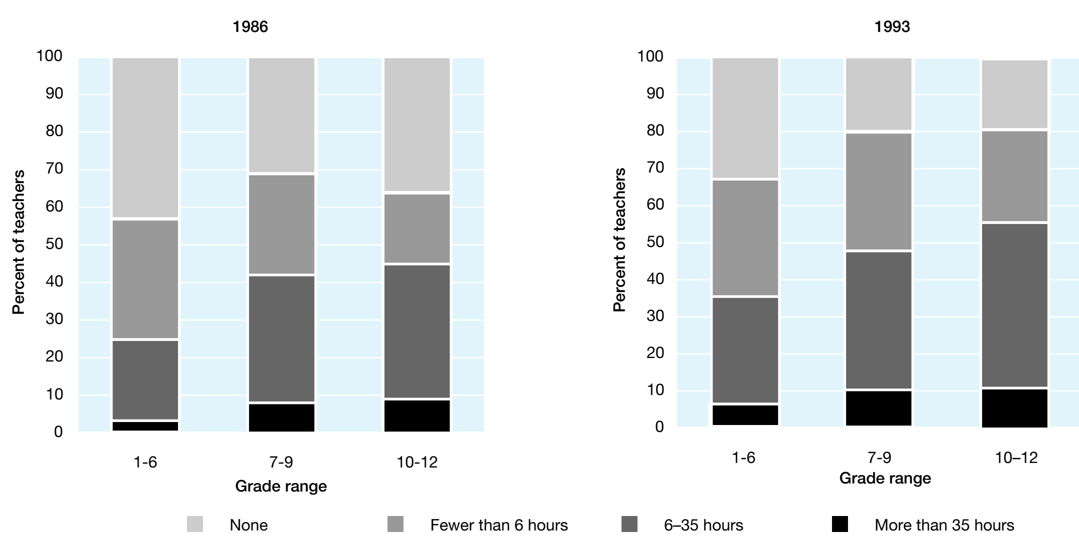
However, between 1986 and 1993, the number of teachers participating in professional development education increased. (See figure 3-33.) For example, in 1993, 81 percent of grades 10–12 mathematics teachers indicated they had participated in at least some professional development activities in mathematics in the past 12 months, up from 65 percent in 1986.

In 1993, high school science and mathematics teachers were the most likely—and elementary teachers the least likely—to have taken a college course in their field in recent years. (See appendix table 3-33.) The pattern was more pronounced in science than in mathematics—55 percent of high school science teachers, compared with 41 percent of middle school science teachers and 26 percent of elementary school science teachers, had taken a science or science education course for college credit since 1989.

Despite indications that high school mathematics teachers who do not teach advanced classes need additional professional development to strengthen their content knowledge (see section on teacher preparation on page 49), they are less likely than teachers of advanced classes

FIGURE 3–33

Total amount of time mathematics teachers spent on in-service education in mathematics during previous 12 months: 1986 and 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.

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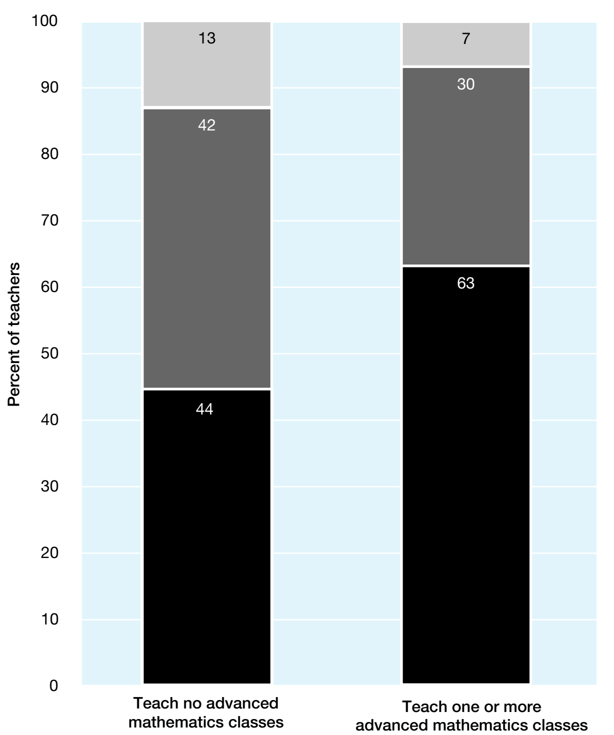
to receive it. In 1993, only 44 percent of the high school mathematics teachers who taught lower level classes had 16 or more hours of in-service education in the past 3 years, compared with 63 percent of those who taught at least one advanced mathematics class. (See figure 3-34.)

Professional Activities

Sizable proportions of high school science and mathematics teachers have participated in some professional activity during the previous 12 months. (See appendix table 3-34.) The 1993 NSSME found that between one-third and one-half of high school science and mathematics teachers had served on school or district curriculum and textbook selection committees or had attended state or national science or mathematics teacher association meetings. Teachers in the lower grades, who are likely to be involved in teaching a variety of subjects, were less likely to participate in science and mathematics professional activities.

FIGURE 3–34

Amount of time high school mathematics teachers spent on mathematics in-service education in the past 3 years, by teaching assignment: 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.

Instructional Practices

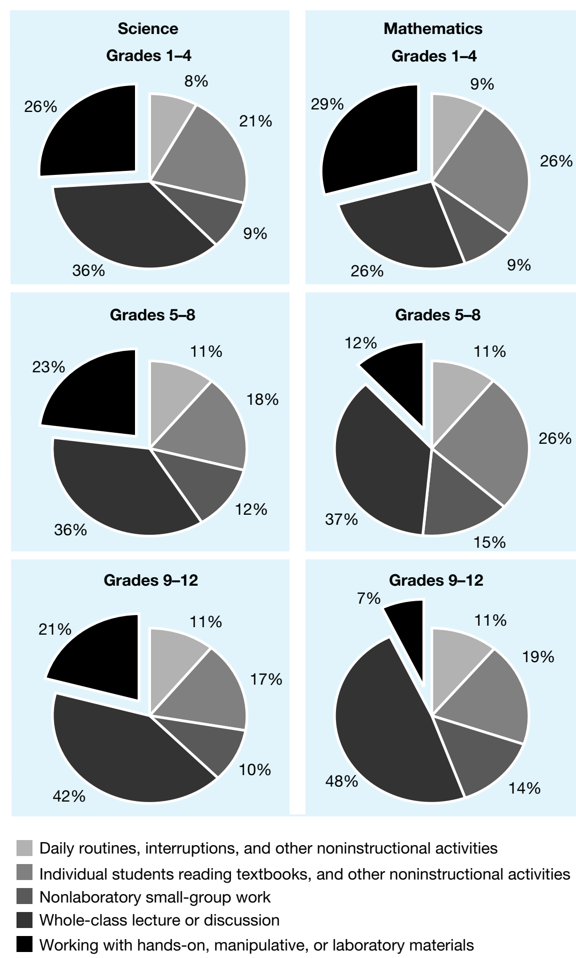
Much of current educational reform calls for changes in the way instruction is delivered within a classroom. The indicators in this section provide a picture—necessarily limited by the available data—of what goes on inside the science and mathematics classrooms. The indicators address use of in-class time, participation in long-term projects, student participation in other instructional activities, and use of traditional and alternative assessment techniques.

Use of In-Class Time

According to the 1993 NSSME, a wide variety of instructional techniques are prevalent in typical science and mathematics classes. (See figure 3-35.) For instance, in

FIGURE 3–35

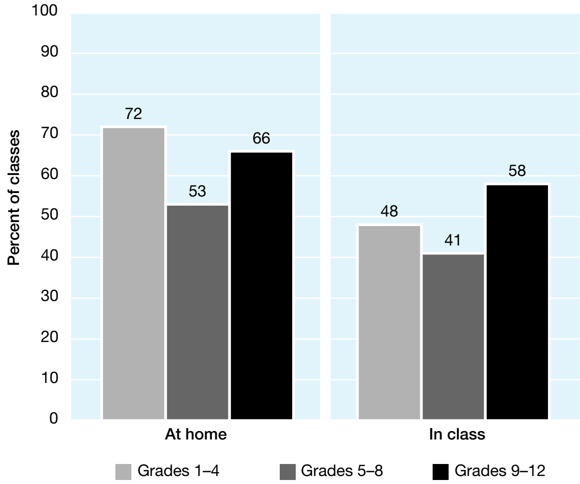
Average percent of science and mathematics class time spent on different types of activity, by grade range: 1993



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.

FIGURE 3-36

Percent of mathematics classes never working on 1-week-long projects at home or in class, by grade range: 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.
See appendix table 3–35.

1993, a typical elementary or secondary science class spent

- almost 40 percent of its time in lecture and discussion involving the entire class,
- about 20 percent of its time working as individuals reading the textbook or completing worksheets,
- about 25 percent of its time working with hands-on materials, and
- the remaining time on daily routines and nonlaboratory small-group work.

The distribution of time across grade levels changed little, except at the high school level, where there was a slight increase in the amount of time spent in lecture or whole-class discussion—with correspondingly less time spent by students working as individuals. (See figure 3-35.) At least superficially, these time distributions appear to fulfill the recommendations for small-group work and work with manipulatives that are set forth in the science and mathematics standards. However, it is not possible to determine from the data if such time is spent in accord with the standards, doing activities such as creative problem solving, or not in accord with the standards, doing routine data verification.

TEXT TABLE 3-6

NAEP science proficiency for students participating in classroom science activities at age 9: 1977 to 1992

Classroom science activity	Year	Students answering "yes": Percent of students	Students answering "yes": Average NAEP science proficiency	Students answering "no": Percent of students	Students answering "no": Average NAEP science proficiency
Experiment with batteries and bulbs	1992	49 (1.9)	233 (1.8)	46 (1.9)	231 (1.7)
	1977	51 (1.4)	225 (2.8)	43 (1.4)	217 (2.1)
Use a microscope	1992	62 (1.4)	237 (1.5)	33 (1.4)	225 (2.0)
	1977	53 (1.4)	222 (2.5)	43 (1.5)	214 (2.1)
Experiment with living plants	1992	64 (1.1)	234 (1.6)	32 (1.0)	226 (1.8)
	1977	70 (1.4)	221 (2.3)	27 (1.3)	217 (2.8)
Use a thermometer	1992	91 (0.6)	234 (1.4)	7 (0.5)	217 (3.5)
	1977	84 (1.0)	222 (2.2)	14 (0.9)	199 (2.7)
Use a calculator	1992	98 (0.3)	233 (1.4)	2 (0.3)	203 (5.8)
	1977	87 (1.2)	222 (2.2)	11 (1.0)	195 (3.4)
Use a scale to weigh things	1992	91 (0.7)	234 (1.4)	8 (0.5)	218 (4.0)
	1977	89 (0.8)	220 (2.3)	9 (0.7)	202 (4.5)

NOTES: Standard errors appear in parentheses. The percent of students does not total 100 percent because a small percent reported that they were not certain whether they had participated in the activities.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

In 1993, the distribution of time in elementary mathematics classes was similar to elementary science classes; however, upper-grade-level mathematics classes spend considerably less time using hands-on activities. (See figure 3-35.) A typical high school mathematics class spent

- almost 50 percent of its time in lecture and discussion involving the entire class,
- about 20 percent of its time with students working as individuals,
- almost 10 percent of its time working with hands-on materials,
- the remaining time on daily routines and small-group work.

In contrast, a typical elementary school mathematics class spent almost 30 percent of its time working with hands-on materials and only 26 percent of its time in whole-class discussion or lecture.

Student Participation in Long-Term Projects

A key principle of the standards is that students, especially in science, receive a better overall education if they spend more time on fewer topics, thereby gaining a better, more in-depth, understanding of each topic. Nevertheless, according to the 1993 NSSME, 58 percent of high school mathematics classes never did projects in the classroom that lasted 1 week or more, and 66 percent did not do any week-long projects at home. (See figure 3-36 and appendix table 3-35.) Also, 43 percent of high school science classes did not do projects in the classroom that lasted 1 week or more, and 49 percent did not do such at home. (See appendix table 3-36.) Elementary and middle school science and mathematics classes were more likely to participate in week-long projects in class than were high school students.

TEXT TABLE 3-7

States with alternative assessments in science and mathematics: Fall 1991 and Fall 1993

Subject and status of alternative assessments	1991	1993
Science total	16	20
In-use	5	1
Developing	11	19
Mathematics total	20	32
In-use	8	7
Developing	12	25

NOTES: Alternative, or nontraditional, assessments include enhanced multiple choice; short, open-ended; extended, open-ended; individual performance; group performance; observation; portfolio; and project.

SOURCE: Blank, R.K. (1995b). *State indicators of science and mathematics education.* Unpublished tabulations.

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Participation in Other Instructional Activities

The most prevalent instructional activities in high school science classrooms in 1993 included listening and taking notes during a presentation by the teacher, watching the teacher demonstrate a scientific principle, participating in dialogue with the teacher to develop an idea, doing hands-on/laboratory science activities, and working in small groups. The results were similar for high school mathematics classes; an additional instructional activity prevalent in mathematics classes was working with problems from a textbook. (See appendix tables 3-35 and 3-36.)

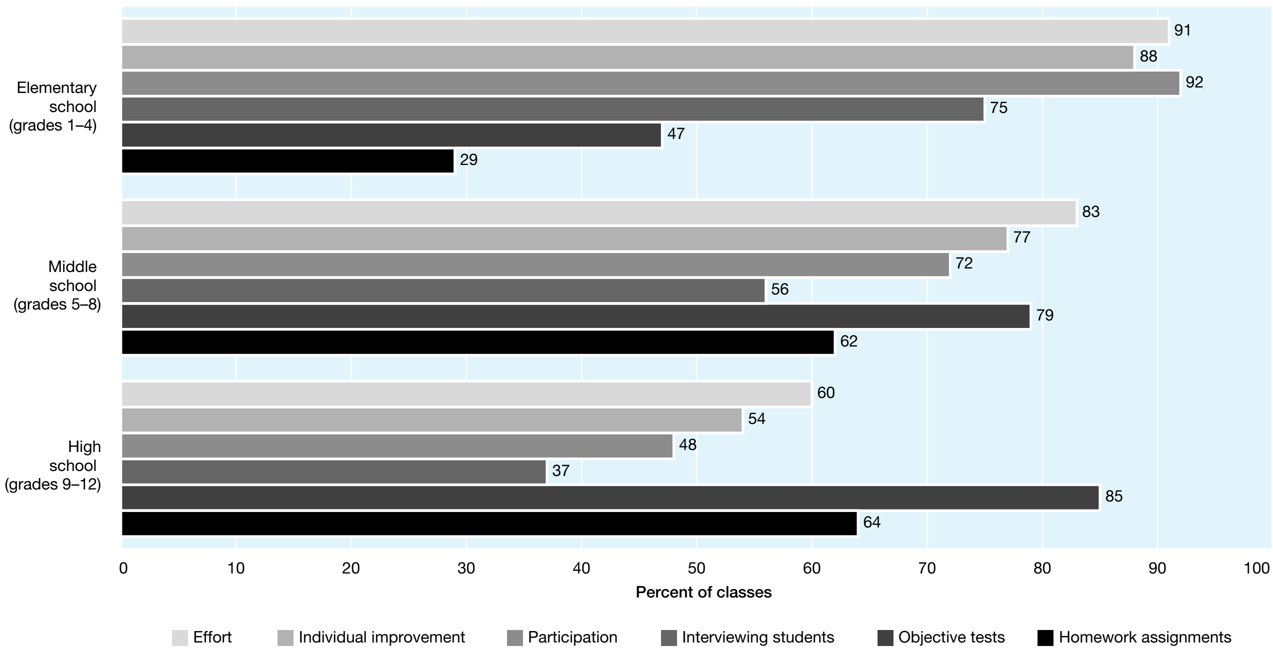
Trends from 1977 to 1992 (Mullis et al., 1994) indicate that students are using more sophisticated and technology-based materials in the classroom. For example, over that period, 9-year-old science students were increasingly likely to use thermometers, microscopes, and calculators, although they experimented less with plants. (See text table 3-6.)

Use of Traditional and Alternative Assessment Techniques

According to the science and mathematics standards, assessment of student performance should require students to solve problems, justify their solutions, and apply knowledge to new situations. This is difficult using traditional assessment mechanisms, such as fact-oriented multiple-choice tests. Alternative, or nontraditional, mechanisms, such as performance, enhanced multiple-choice, or extended performance tests, are better suited for such assessments. Performance tests require students to complete a specified task, enhanced multiple-choice tests allow students to explain their answers, and extended performance tests require students to complete a task or project over a given period of time, such as a week. The use and development of such alternative assessments for science and mathematics increased between 1991 and 1993. (See text table 3-7.) Most significantly, whereas 20

FIGURE 3–37

Percent of science classes about which teachers report various types of activity are important in determining student grades, by grade range: 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.

states were developing or using alternative mathematics assessments in 1991, 32 states were developing or using them by 1993.

In 1993, elementary school teachers were much more likely to use nontraditional assessment techniques—such as participation, effort, the results of interviews with students, and individual progress over past performance—for assessment than were high school teachers. High school teachers tended to use objective tests and homework, but grading methods varied widely. (See figure 3-37.)

Testing, in whatever form, is becoming a more common activity. Between 1978 and 1992, the number of 17-year-old students who reported that testing occurred often in their mathematics classes increased from 64 to 83 percent. (See text table 3-8.) More frequent testing may or may not translate into improved understanding of science and mathematics. A study conducted by the Center for the Study of Testing, Evaluation, and

TEXT TABLE 3-8

NAEP mathematics proficiency of 17-year-old students, by frequency of mathematics tests taken: 1978 to 1992

Year	Often: Percent of students	Often: Average NAEP mathematics proficiency	Sometimes: Percent of students	Sometimes: Average NAEP mathematics proficiency	Never: Percent of students	Never: Average NAEP mathematics proficiency
1978	64 (1.3)	308 (1.7)	33 (1.1)	292 (2.1)	3 (0.5)	270 (4.7)
1992	83 (0.7)	308 (1.2)	16 (0.8)	301 (3.0)	1 (0.4)	270 (5.8)

NOTE: Standard errors appear in parentheses.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

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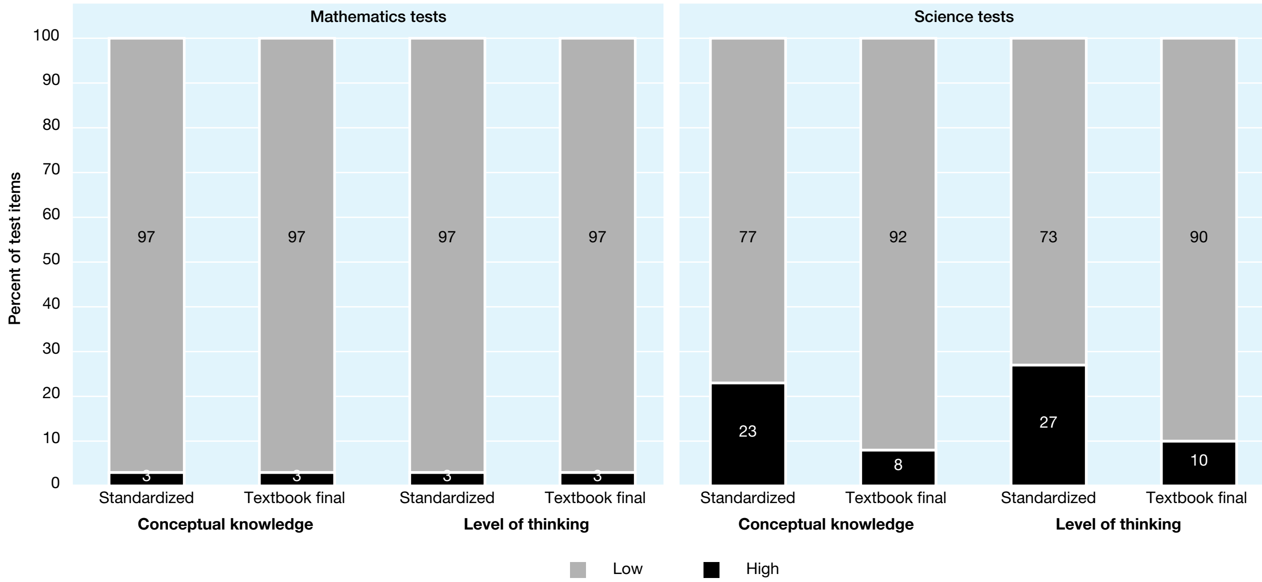
FIGURE 3-38

Percent of test items, by type of test, use of conceptual knowledge, and levels of thinking: 1992



NOTES: The most widely used standardized tests and textbook series were selected for grades 4 and 8 and the most commonly studied high school subjects. All items were classified on conceptual knowledge and level of thinking. High-level conceptual knowledge in math or science is evidenced by ability to paraphrase the definition of a concept, generate examples and nonexamples, use models to represent concepts, recognize meanings and various interpretations of concepts, identify critical properties of a given concept, compare and contrast concepts, and apply concepts (as opposed to applying algorithms). High-level thinking refers to reasoning and other "higher order thinking skills," and low level refers to recall and routine applications. Percents shown were computed by pooling test items across grade levels and across six publishers.

SOURCE: Center for the Study of Testing, Evaluation, and Educational Policy. (1992). *The influence of testing on teaching math and science in grades 4–12.* Boston: Center for the Study of Testing, Evaluation, and Educational Policy.

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Educational Policy (1992) showed that the most widely used standardized texts and textbook series for grade 4, grade 8, and most high school subjects assess predominantly low levels of thinking and conceptual understanding. (See figure 3-38.) This finding was true for both science and mathematics.

Tests that demand low levels of thinking and conceptual understanding are in direct contrast to the standards' call for higher level thinking and in-depth understanding. Tests that demand low levels of thinking and conceptual understanding appear to have more influence on the instruction in classes with large proportions of minority students. For example, teachers of classes with high proportions of minority students reported spending more class time preparing for standardized tests and reported teaching different content in an attempt to more closely match the tests. (See text table 3-9.)

Teachers of classes with high proportions of minority students reported spending more class time preparing for standardized tests and reported teaching different content in an attempt to more closely match the tests.

Resources

Well-equipped classrooms are necessary to provide the quality of instruction called for in the national standards. This section examines the use, availability, and quality of various supplies, materials, and facilities available to science and mathematics teachers, as measured by teachers' opinions of textbooks, classroom supplies and facilities, computers and networks, and calculators.

Textbooks

The most common classroom resource is the textbook. While most science and mathematics teachers reported in 1993 that their textbooks were either "good," "very good," or "excellent," mathematics teachers rated their

TEXT TABLE 3-9

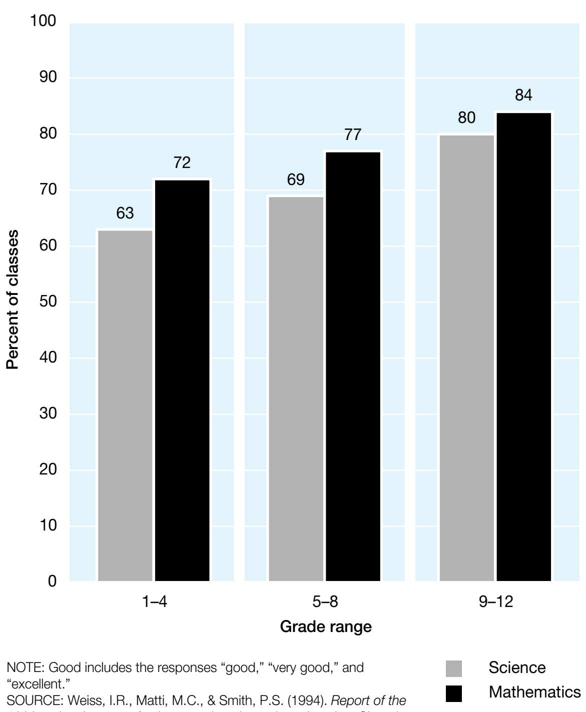
Percent of science and mathematics teachers reporting classroom preparation for mandated standardized tests, by minority presence: 1992

	Minority presence			
	High-minority class		Low-minority class	
Classroom preparation	Science	Mathematics	Science	Mathematics
Teachers prepare students for mandated standardized tests by				
Teaching test-taking skills	75	84	42	55
Encouraging students to work hard on tests	74	61	50	49
Teaching topics known to be on test	60	60	19	37
Providing test-specific material	29	38	6	12
Using state or district test prepared materials	11	14	6	7
Using practice tests	20	32	10	12
Mandated standardized tests influence teachers to				
Include topics not otherwise taught	71	58	23	42
Exclude topics otherwise taught	41	39	16	20
Increase emphasis on certain topics	67	71	38	46

NOTES: "Minority" is defined as black, Hispanic, Asian/Pacific Islander, and Native-American/Alaskan. High-minority classes are those in which more than 60 percent of students are minorities. In low-minority classes, less than 10 percent of students are minorities. Teachers with more than one class were instructed to select their first Monday class. Extent of influence was indicated by responses of "some" or "a lot."
SOURCE: Center for the Study of Testing, Evaluation, and Educational Policy. (1992). *The influence of testing on teaching math and science in grades 4-12.* Boston: Center for the Study of Testing, Evaluation, and Educational Policy.

FIGURE 3–39

Percent of classes for which teachers consider the quality of their science and mathematics textbooks as good, by grade range: 1993



NOTE: Good includes the responses "good," "very good," and "excellent."
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.

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textbooks more favorably than did science teachers. (See figure 3-39.) However, many science and mathematics instructors reported that they tend not to cover all of the material included in textbooks. (See appendix table 3-37.) In fact, between 1986 and 1993, the percent of all science classes and the percent of grades 1–6 mathematics classes covering virtually the entire textbook decreased dramatically. These data do not show whether textbooks have changed in length or quality, how textbooks are used, or if teachers use additional or supplemental reading materials.

Overall, mathematics teachers cover more of their texts than do science teachers. This finding may be because science texts tend to be comprehensive, allowing teachers to pick and choose among the topics. In contrast, mathematics textbooks tend to be streamlined, because there is more consensus within the mathematics community about which topics should be addressed in a particular course.

The resources that are available to schools do not appear to be distributed equally across classes.

TEXT TABLE 3-10

Percent of science and mathematics teachers indicating that each factor is a serious problem for science and mathematics teaching, by grade range: 1977 to 1993

Factor	Grades 1-6			Grades 7-9			Grades 10-12		
	1977*	1986	1993	1977	1986	1993	1977	1986	1993
Science									
Materials for individualizing instruction	30 (2.3)	30 (1.8)	36 (2.1)	27 (2.3)	27 (2.7)	37 (4.5)	28 (2.2)	20 (2.2)	38 (2.4)
Funds for purchasing equipment or supplies	29 (2.3)	30 (1.8)	40 (2.5)	24 (2.2)	26 (2.6)	31 (4.5)	27 (2.2)	23 (2.3)	36 (2.3)
Access to computers	--	18 (1.8)	20 (1.3)	--	23 (2.5)	37 (3.3)	--	17 (2.1)	40 (2.2)
Mathematics									
Materials for individualizing instruction	17 (1.7)	14 (1.4)	21 (3.2)	21 (2.1)	15 (2.2)	22 (2.9)	19 (2.0)	10 (1.2)	24 (1.9)
Funds for purchasing equipment or supplies	13 (1.7)	11 (1.2)	23 (2.9)	13 (1.2)	11 (1.9)	30 (7.4)	15 (1.8)	9 (1.2)	25 (2.1)
Access to computers	--	18 (1.5)	22 (2.1)	--	18 (2.3)	41 (3.4)	--	14 (1.4)	31 (2.5)

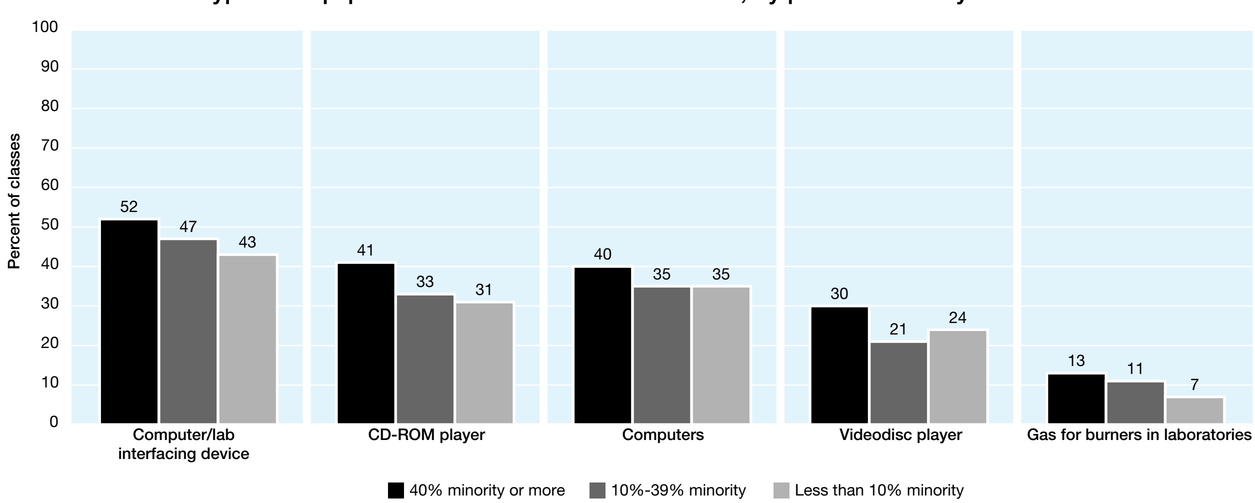
-- Not applicable.
* The 1977 survey used estimates for teachers of grades K-6.
NOTE: Standard errors appear in parentheses.
SOURCES: Weiss, I.R. (1987). *Report of the 1985-86 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute; Weiss, I.R., Matti, M.C., & Smith, P.S. (1994). *Report of the 1993 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research, Inc.; Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.

Classroom Supplies and Facilities

Overall, studies show that science and mathematics classes do not receive adequate support for supplies and equipment. In 1993, about 36 percent of all science teachers and 27 percent of all mathematics teachers reported to the NSSME that a lack of funding for equipment and supplies is one of the most serious problems or barriers they encounter. (See text table 3-10.) The problem grew considerably since 1977, when about 27 percent of all science teachers and 14 percent of all mathematics teachers cited this problem as serious. In 1992, about 40

FIGURE 3–40

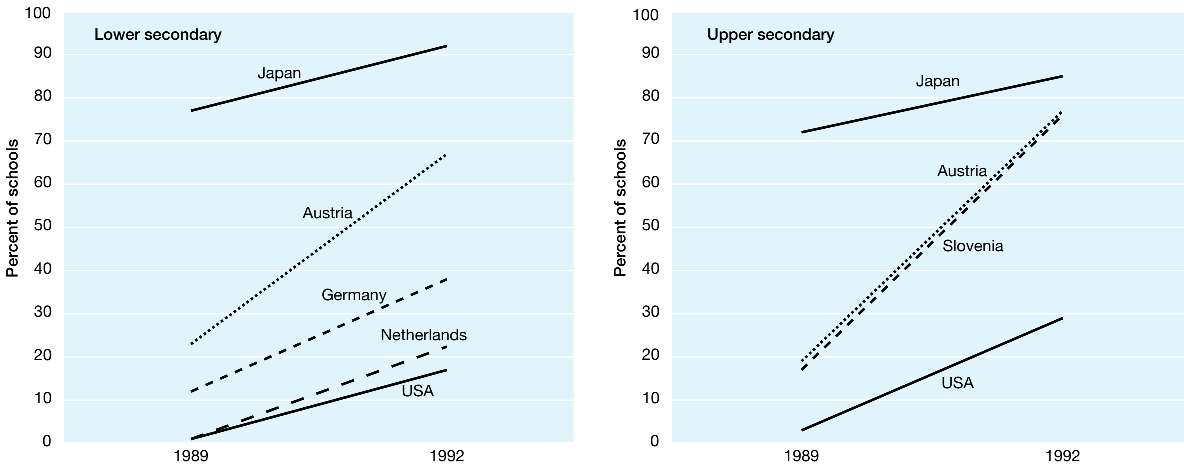
Percent of high school science classes for which teachers report various types of equipment are needed but not available, by percent minority in class: 1993



NOTE: High school includes grades 9-12.
SOURCE: Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.

FIGURE 3–41

Mean percent of schools with computers that use 16+ bit computers (80286 and higher processors): 1989 and 1992



SOURCE: Pelgrum, W.J., Janssen Reinen, I.A.M., & Plomp, T. (Eds.). (1993). *Schools, teachers, students and computers: A cross-national perspective* (IEA COMPED Study Stage 2). Netherlands: IEA. See appendix table 3–40.

percent of 12th-grade science teachers reported that the equipment, facilities, and supplies they had available were only poor or fair. (See appendix table 3-38.)

The resources that are available to schools do not appear to be distributed equally across classes. Teachers report that high school science classes consisting of more than 40 percent minority students are more likely than other high school science classes to need various types of equipment that are not available, including computers, computer/lab interfacing devices, videodisc and CD-ROM players, and gas for burners. (See figure 3-40.)

TEXT TABLE 3-11

Percent of science and mathematics classes reporting computer use: 1993

Type of computer use	Grade range 1-4	5-8	9-12
Ever used in class			
Science	52 (2.4)	50 (3.0)	40 (2.5)
Mathematics	77 (2.1)	60 (3.1)	44 (2.4)
Used in most recent class			
Science	3 (0.6)	4 (0.9)	4 (1.1)
Mathematics	9 (1.1)	6 (1.5)	2 (0.4)

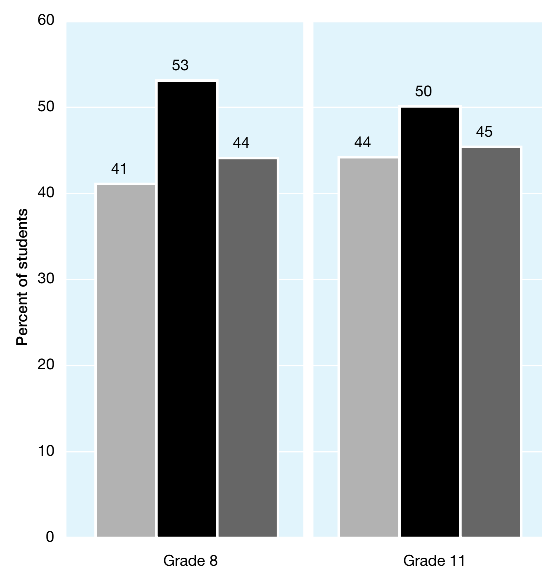
NOTE: Standard errors appear in parentheses.
SOURCE: Weiss, I.R., Matti, M.C., & Smith, P.S. (1994). *Report of the 1993 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research, Inc.

Computers and Networks

Although the standards recommend that computers play an important role in the classroom environment, many science and mathematics teachers report that access to computers is a serious problem. In 1992, the

FIGURE 3–42

Percent of students reporting any use of computers in mathematics or science classes during the academic year, by race or ethnic origin: 1992



NOTE: Numbers shown are rounded to nearest whole number.
SOURCE: Anderson, R.E. (Ed.). (1993). *Computers in American schools, 1992: An overview.* Minneapolis, MN: University of Minnesota.

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median number of secondary students per computer was five, and the mean was eight. (See appendix table 3-39.) Much of this equipment is old and cannot be used to operate the newer and more powerful instructional programs. As of 1992, among U.S. schools that had computers, only 17 percent of lower secondary schools and 29 percent of upper secondary schools had 16+ bit computers, computers at or above the capacity of an IBM 286 or an Apple IIe. (See figure 3-41 and appendix table 3-40.) A much lower percentage of U.S. schools have 16+ bit computers than schools in other countries, especially Japan.

TEXT TABLE 3-12

Percent of U.S. students ever taught a computer skill or programming course, by race within grade level: 1992

		Grade		
Skill or course	Race	5	8	11
Spreadsheet	White	21	44	46
	Black	18	50	51
	Other	28	49	52
Send messages	White	14	20	17
	Black	18	35	27
	Other	27	30	24
Pascal	White	11	13	7
	Black	17	21	13
	Other	18	19	13
Basic	White	27	36	18
	Black	31	38	25
	Other	31	40	25

SOURCE: Anderson, R.E. (Ed.). (1993). *Computers in American schools 1992: An overview.* Minneapolis, MN: University of Minnesota.

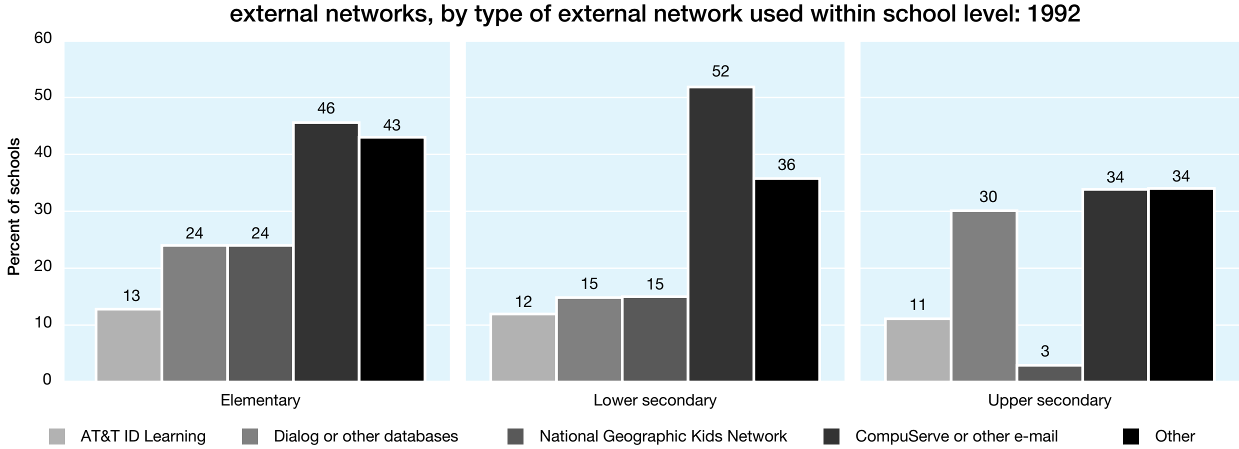
Moreover, simple possession of computers is not sufficient to support the recommendations in the standards for increased and sophisticated use of technology. In 1993, the use of computers in science and mathematics classes was quite low—on a given day, only 3 percent of grades 1–4 science classes, 4 percent of grades 5–8 science classes, and 4 percent of grades 9–12 science classes used computers as part of instruction. Similarly, students used computers during their most recent lesson in only 9 percent of grades 1–4 mathematics classes, 6 percent of grades 5–8 mathematics classes, and 2 percent of grades 9–12 mathematics classes (Weiss, Matti, & Smith, 1994). (See text table 3-11.)

Generally, in 1993, computer use was highest in elementary mathematics, where 77 percent of classes used computers at some point during the semester; in contrast, only 40 percent of high school science classes and 44 percent of high school mathematics classes reported ever using computers. Black students appear to be more likely than white students to use computers in science and mathematics classes. (See figure 3-42.) In 1992, a higher percentage of black students than white students reported having been taught each of a number of computer or programming skills. (See text table 3-12.)

In addition to computer use, network use is beginning to “catch on” in schools as a way to provide more current and realistic information for science and mathematics classes and to help model the discussions and inter-

FIGURE 3–43

Percent of external network use for schools that use external networks, by type of external network used within school level: 1992



SOURCE: Anderson, R.E. (Ed.). (1993). *Computers in American schools, 1992: An overview.* Minneapolis, MN: University of Minnesota.
See appendix table 3–41.

TEXT TABLE 3-13

Percent of mathematics classes where teachers report use of various types of calculator, by grade range: 1993

Calculator type	Grade range 1-4	5-8	9-12
Four function	50 (2.5)	72 (3.0)	65 (2.3)
Fraction	3 (0.7)	26 (2.3)	28 (2.3)
Scientific	1 (0.4)	22 (3.0)	67 (2.0)
Graphing	1 (0.3)	5 (1.0)	40 (2.3)

NOTE: Standard errors appear in parentheses.
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.

changes that occur within the scientific and mathematics communities. CompuServe or other e-mail is most popular across all grade levels. (See figure 3-43 and appendix table 3-41.)

Calculators

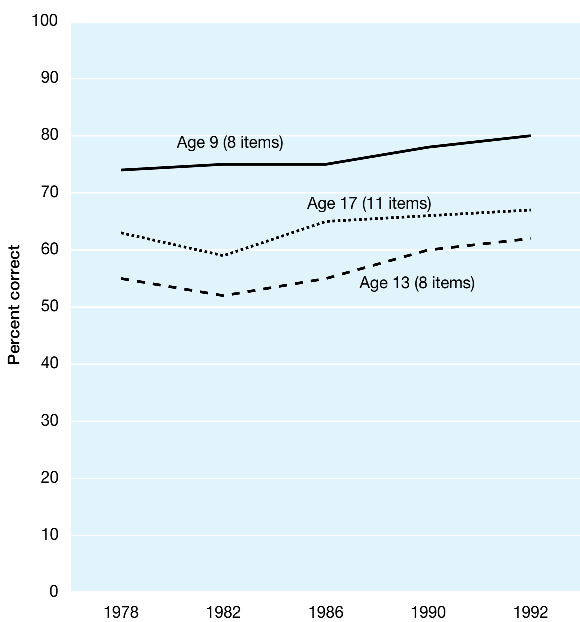
Many different types of calculator are used in mathematics classrooms. In 1993, four-function calculators were popular across all grade levels; whereas, at the high school level, scientific and graphing calculators were becoming more evident. (See text table 3-13.) The large percent of high school mathematics classes using graphing calculators may be indicative of movement toward the standards, which recommend more conceptual approaches to mathematics.

In 1992, almost one-half of 8th- and 11th-grade students reported using calculators in science or mathematics classes (Anderson, 1993). In 1992, black 8th- and 11th-grade students were more likely than students of any other race or ethnic origin to report any use of calculators in mathematics or science classes during the academic year. In 8th grade, 53 percent of black students, 41 percent of white students, and 44 percent of students of another race or ethnic origin reporting any use of calculators in science or mathematics classes during the academic year; in 11th grade, 50 percent of black students, 44 percent of white students, and 45 percent of students from another race or ethnic origin reported any use of calculators during the academic year (Anderson, 1993).

Students appear to have become more adept at operating calculators, considering that in 1992 significantly more students at each grade level got correct answers using a calculator on the NAEP mathematics assessment than in 1978. (See figure 3-44 and appendix table 3-42.)

FIGURE 3–44

Average percentage of mathematics problems correct on test items requiring the use of a calculator, ages 9, 13, and 17: 1978 to 1992



SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics. See appendix table 3–42.

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Conclusion

This chapter examined indicators of the elementary and secondary science and mathematics learning environment in relation to the equity and excellence standards. Based on the indicators presented here, the learning environment is becoming more like the one envisioned in the standards. However, while enrollment in science and mathematics courses is increasing, with few differences between the coursetaking patterns of males and females, students from minority groups continue to be underrepresented in both science and mathematics. And, despite the increases in enrollment, the number of students completing 4 years of high school science and mathematics remains low.

The science and mathematics teaching force is better prepared and more involved in professional development activities than in the past. However, blacks, Hispanics, and Asians remain underrepresented. Teachers are beginning to implement many of the recommendations in the science and mathematics standards. In general, high school teachers are the group most resistant to reform. Despite recommendations to increase the use of hands-on activities and approach subjects in more depth, high school teachers continue to rely heavily on lectures, and less than one-half assign long-term projects. In addition, most are not using computers for science and mathematics instruction. Generally, science and mathematics classes are poorly supported in terms of facilities and supplies. Computers, when available, tend to be unable to run modern software.

Future indicators volumes could be enhanced if additional emphasis were placed on gathering data on classroom and informal[2] learning environments. Currently, little coordination or consensus exists among researchers about what types of data need to be gathered. Accurate financial data and additional data on state, school district, and community goals for science and mathematics education would provide a clearer indication of educational trends in the United States. ■

Endnotes

[1] Physics and chemistry courses may be offered in alternate years.

[2] Informal learning activities occur outside the school setting, are not developed as part of an ongoing school curriculum, and are characterized by voluntary, as opposed to mandatory, participation. Television programs, museums, aquariums, nature centers, and zoos are informal learning settings.

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Chapter 4

Postsecondary Education

The postsecondary system is unique in its mission to create producers of science and technology—scientists, engineers, technologists, and educators—who discover, synthesize, and transmit knowledge that increases understanding of the natural world, enhances the quality of life, and strengthens the economic and social fabric. Recently, however, the postsecondary system has acquired additional roles. (See sidebar on postsecondary education.) These roles involve

- Preparing workers to apply science and technology. To be competitive, workers in nearly all fields must be able to apply a variety of mathematical, engineering, and basic science skills to production of top-quality goods and services. For example, anyone who records and interprets trends in data must comprehend mathematics and statistics; and many workers, from electricians to stockbrokers, use statistical knowledge in their work.
- Informing consumers of science and technology. Citizens are exposed to science and engineering in their everyday lives. They need to be educated about how to interpret scientific and technological information in order to make sound decisions about common activities such as parenting, consuming, and planning retirement.
- Achieving equity within the science and technology community. Current society pressures are increasing recruitment of groups that traditionally have been underrepresented in or underserved by science and technology education—females, blacks, Hispanics, Native Americans, and people with disabilities (Simpson & Anderson, 1992).

Factors Affecting Postsecondary Education

As the year 2000 approaches, factors both external to the postsecondary education system and internal to the system are having a profound effect on the purposes and roles of science, engineering, and technology education. Three of the external factors, summarized in a recent report from the Pew Higher Education Roundtable (1994), were value, budgetary support, and technology.[1]

In terms of value, students, parents, and policy makers are placing increasing pressure on colleges and universities to make college degrees more valuable for the labor market. Alarmed by increases in tuition and student debt, a perceived oversupply of college graduates, and the notion that students graduate without learning what they need to know, parents are asking institutions, "What exactly are we paying for?" They are measuring the quality of postsecondary education in terms of their children's ability to garner secure and well-paying jobs.

State policy makers are taking another look at value with regard to budgetary support. They have used reports of a positive relationship between college education and postgraduation earnings to redefine postsecondary education as a private, rather than public, good. They claim that students from well-off families should not have their college education subsidized at public expense. As a result, in many states public funding of postsecondary education has decreased, and public institutions of postsecondary education have to compete with public safety, health care, elementary and secondary education, and other services for state appropriations. This shift has affected private institutions, as well. They are now competing openly with their public counterparts for support from charitable, corporate, and other private sector sources.

Budgetary constraints are forcing more and more institutions to consider how changes in information technology make the delivery of quality education at a lower cost a possibility, a prospect that most have not yet fully explored. Differences in the way people deal with technology are also making this change possible. For instance, today's high school graduates are better acquainted and more comfortable with computer and information technologies than any generation before them. Moreover, a growing number of adult students hold full-time jobs while attending college and simply want an education, rather than a "campus experience."

Internal factors affecting science, engineering, and technical education include changes in the composition of the U.S. population. The 1990 census showed that during the 1980s the populations of Asians and Pacific Islanders living in the United States increased 99 percent, while the number of Hispanics increased by 54 percent (U.S. Bureau of the Census, 1994). In addition, the proportion of students attending college from groups that historically have been underserved by science and engineering—older students, females, racial and ethnic minorities, and people with disabilities—increased.[2] In light of such factors, educators and policy makers are reexamining how better to meet society's needs and pressures. ■

A Note on Terminology

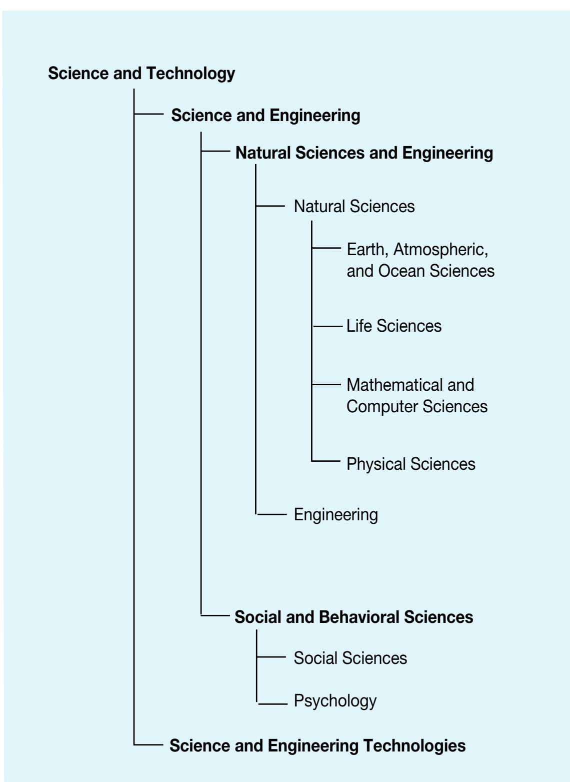
This chapter makes the following distinctions in terminology: Science and technology includes all fields of science and engineering and the development and use of technology; science and engineering encompasses all natural science, engineering, and social and behavioral science fields; natural sciences include study of earth sciences, atmospheric sciences, ocean sciences, life sciences, mathematical and computer sciences, and physical sciences; social and behavioral sciences include the social sciences and psychology. (See figure 4-1.) ■

The significance of these roles has increased because the influence of technology on society has made science and technology education an important contributor to national economic prosperity and societal well-being. (See sidebar on terminology and figure 4-1.)

This chapter considers the characteristics of students within the postsecondary systems and examines the state of science and engineering education within the context of the postsecondary environment.

FIGURE 4–1

A map of the science and technology fields used in this chapter



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

Student Characteristics

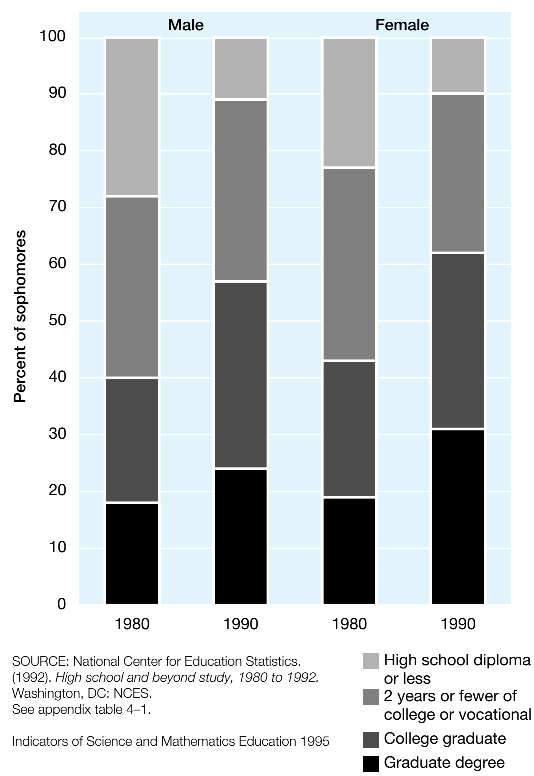
Students today aspire to higher levels of education than their recent predecessors and are enrolling in postsecondary institutions in greater numbers. The section below describes student characteristics in terms of student aspirations, enrollment patterns, and science and engineering coursetaking.

Aspirations

In general, today's high school students aspire to attend college and seek advanced degrees in much larger numbers than did their predecessors. (See sidebar on why more students are attending college on page 76.) About 90 percent of 1990 high school sophomores believed that they would attend at least some college, compared with about 70 percent of 1980 sophomores. (See figure 4-2 and appendix table 4-1.) Almost 60 percent of high school students surveyed in 1990 said they intend to seek a 4-year or graduate degree, up from about 40 percent in 1980. Of note is the growth in the percentage of female students who intend to earn a graduate degree. In 1980,

FIGURE 4–2

Percent of high school sophomores aspiring to various levels of education, by sex: 1980 and 1990



SOURCE: National Center for Education Statistics. (1992). *High school and beyond study, 1980 to 1992.* Washington, DC: NCES.
See appendix table 4–1.

Indicators of Science and Mathematics Education 1995

Why Are More Students Attending College?

One reason more students aspire to higher levels of education than in previous years may lie in students' perceptions of what it takes to get a well-paying job. The U.S. economy has shifted from a manufacturing-based economy, where higher levels of education have traditionally been unnecessary, to a service-based economy, where higher levels of education often are desirable. Between 1990 and 1992, the number of white-collar jobs in the United States increased by about 1 million, while the number of blue-collar jobs fell by about the same number (Bureau of Labor Statistics, 1993). In addition, since 1979, the salaries of individuals who have at least a bachelor's degree increased at much higher rates than those who ended their education after high school (Hecker, 1992). In the past decade, the gap in expected earnings between college and high school graduates increased by 20 percent (Pew, 1994).

This explanation is supported by a 1993 study that asked 1993 college freshmen why they decided to attend college. "Generation X" students placed more emphasis on money than did the freshmen of the baby boom generation. In 1993, 82 percent of freshmen said they decided to attend college "to get a better job," and 75 percent said "to make more money." In 1976, about 71 percent of freshmen said they wanted to get a better job, and 53 percent wanted to make more money. In both 1993 and 1976, about three-quarters of the surveyed students cited a desire to learn more about interesting things as a very important reason for attending college (Dey, Astin, & Korn, 1991; Astin, Korn, & Riggs, 1993). ■

just 19 percent of female high school students aspired to this level, compared with 31 percent in 1990. For comparison, in 1990, 24 percent of male high school sophomores expressed a desire to earn a graduate degree, up from 18 percent in 1980.

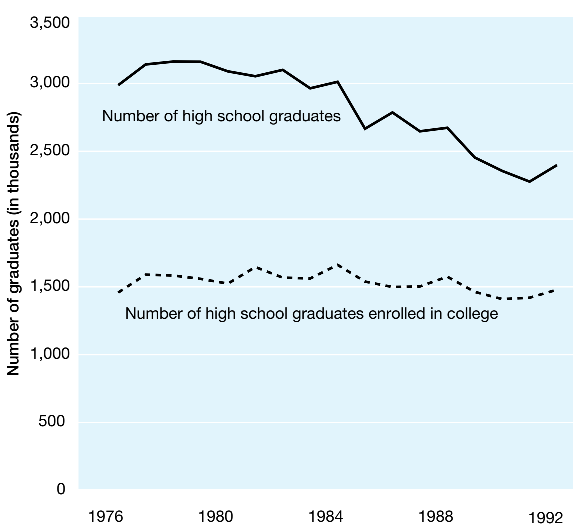
Enrollment

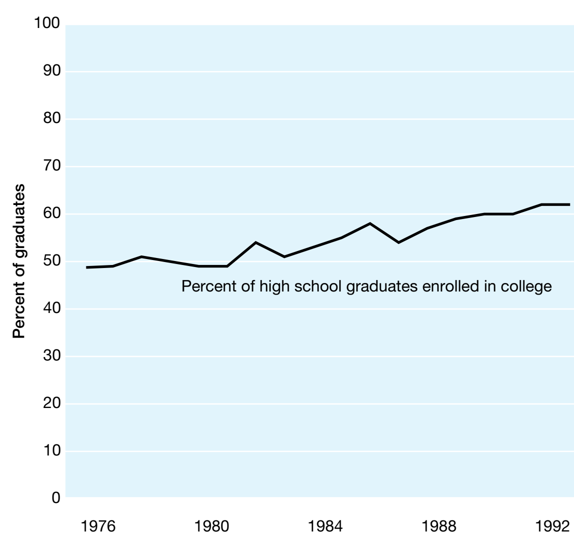
Over the past 20 years, the proportion of high school graduates who go directly on to college has increased from 49 to 62 percent. (See figure 4-3 and appendix table 4-2.) This rate has increased because the number enrolling in college within 12 months of their high school graduation remained steady over the period, while the number of high school graduates declined. The number of postsecondary students with limited English proficiency is growing, also, largely as a result of increases in immigration from Asia, the Pacific Islands, and Latin America (Rosenthal, 1992/1993).

Students enrolled in college in 1991 were more likely than their predecessors to be attending school part time and less likely to be 21 years old and younger. Between

FIGURE 4–3

Number and percent of recent high school graduates and number who enrolled in college: 1972 to 1992

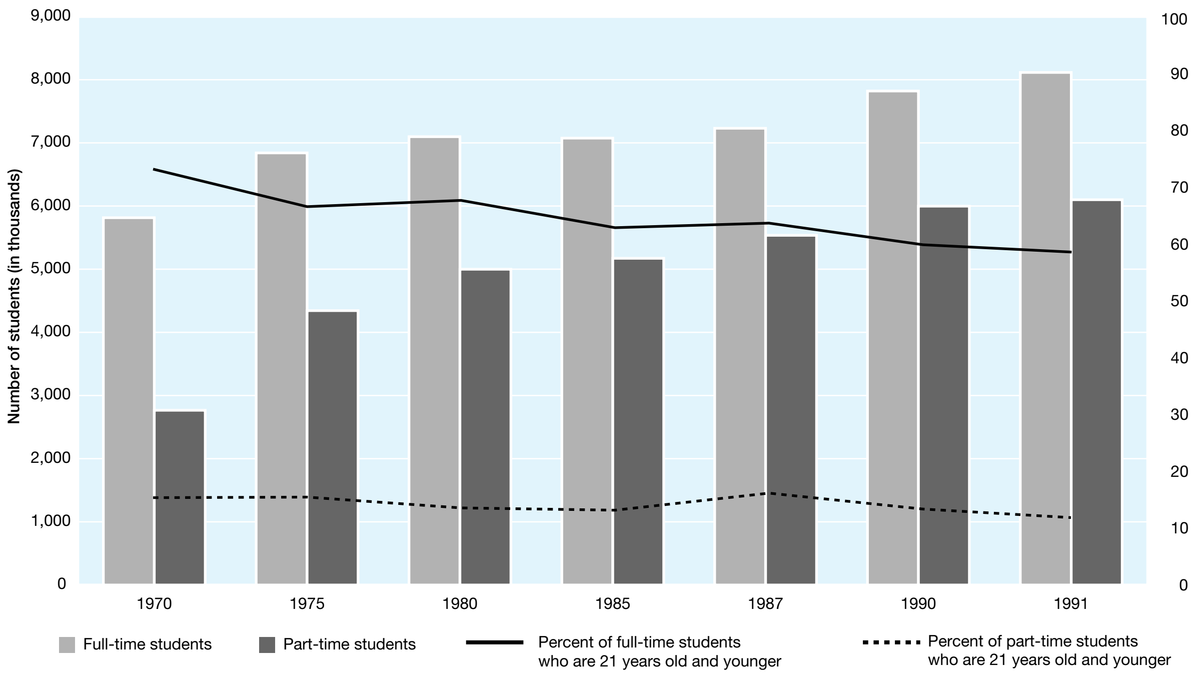




SOURCE: National Center for Education Statistics. (1994c). *Digest of educational statistics 1994* (NCES 94-115). Washington, DC: U.S. Government Printing Office.
See appendix table 4–2.

FIGURE 4–4

Total fall education enrollment, by attendance status and percent of students who are 21 years old and younger: 1970 to 1991



SOURCE: National Center for Education Statistics. (1994c). *Digest of educational statistics 1994* (NCES 94-115). Washington, DC: U.S. Government Printing Office.
See appendix table 4–3.

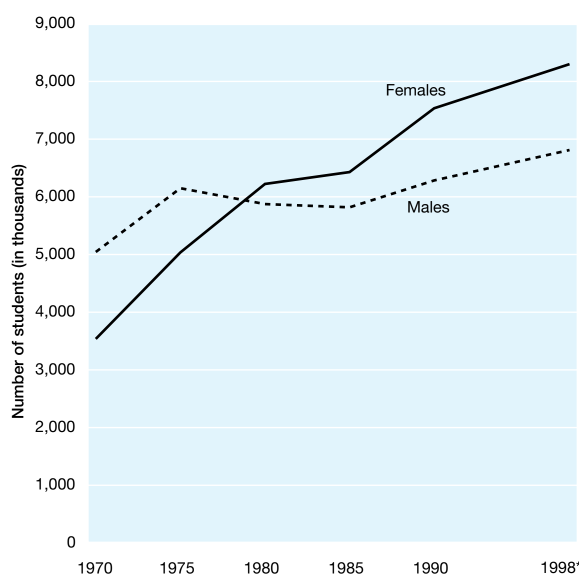
1970 and 1991, the number of postsecondary students who were enrolled part time increased from 2.8 million to 6.2 million, or from 32 percent to 43 percent of the total enrollment in postsecondary institutions. (See figure 4-4 and appendix table 4-3.) The proportion of full-time students 21 years old and younger decreased from 74 percent in 1970 to 59 percent in 1991. The proportion of part-time students 21 years old and younger decreased from 16 percent in 1970 to 13 percent in 1991.

Females

Between 1970 and 1991, there was a large shift in the makeup of postsecondary enrollment. In 1970, females accounted for only 41 percent of total postsecondary enrollment, but they made up 55 percent of enrollment by 1991. (See figure 4-5 and appendix table 4-4.) The postsecondary enrollment of males increased by nearly one-third during this 20-year period, while the number of females going to college more than doubled.

FIGURE 4–5

Total fall enrollment in postsecondary institutions, by sex: 1970 to 1998 (projected)



*1998 data are projected.
SOURCE: National Center for Education Statistics. (1994c). *Digest of educational statistics 1994* (NCES 94-115). Washington, DC: U.S. Government Printing Office.
See appendix table 4–4.

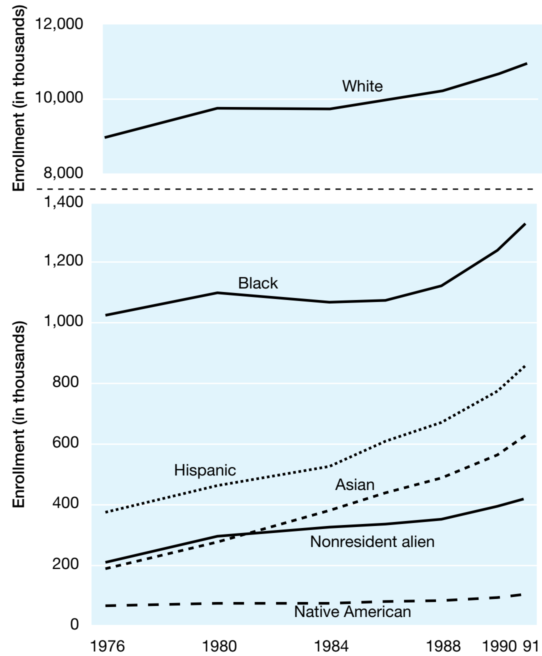
Racial and Ethnic Groups

Similarly, the ethnic and racial composition of postsecondary institutions has changed since the 1970s. (See figure 4-6 and appendix table 4-5.) In 1976,[3] whites made up 84 percent of U.S. citizens enrolled in postsecondary institutions. By 1991, that proportion had fallen to 79 percent. During the intervening 15 years, the enrollment of blacks, Hispanics, and Native Americans increased by 55 percent, while enrollment of whites increased by just 21 percent. Despite these increases in enrollment, the total number of bachelor's degrees earned by these minority groups increased only 33 percent during this period.

One reason for this disparity is that 2-year institutions enroll particularly high proportions of black, Hispanic, and Native American postsecondary students. (See appendix table 4-5.) Together, these groups accounted for 20 percent of the enrollment in 2-year institutions and 14 percent in 4-year institutions. In 1991, about 56 percent of Hispanic students, 55 percent of Native American students, and 43 percent of black students enrolled in postsecondary education were enrolled in 2-year institutions (NCES, 1994a). In comparison, 40 percent of Asian students and 38 percent of white students were enrolled in 2-year institutions.

FIGURE 4–6

Total fall enrollment in postsecondary institutions, by race or ethnic origin: 1976 to 1991



NOTES: Persons of Hispanic origin may be of any race. White enrollment uses a different scale.
SOURCES: National Center for Education Statistics. (1994c). *Digest of educational statistics 1994* (NCES 94-115). Washington, DC: U.S. Government Printing Office; National Center for Education Statistics. (1994d). *Fall enrollment in colleges and universities.* Unpublished tabulations.
See appendix table 4–5.

Indicators of Science and Mathematics Education 1995

Individuals with Disabilities

Access to postsecondary education is a key to individual financial success and independence. A 1987 study (Fairweather & Shaver, 1990) showed that students with disabilities may not be attaining access to postsecondary education in proportions equal to the general population—only 20 percent of orthopedically impaired, 24 percent of speech-impaired, 33 percent of hearing-impaired, and 40 percent of visually impaired high school graduates took at least one course in a 2- or 4-year institution within a year of graduation (Fairweather & Shaver, 1990). In 1990, about 8 percent of all undergraduate students had some form of a disability. About the same proportion of graduate students had some form of disability (NSF, 1994e). The proportion of students with disabilities in science and engineering fields is similar.

Coursetaking

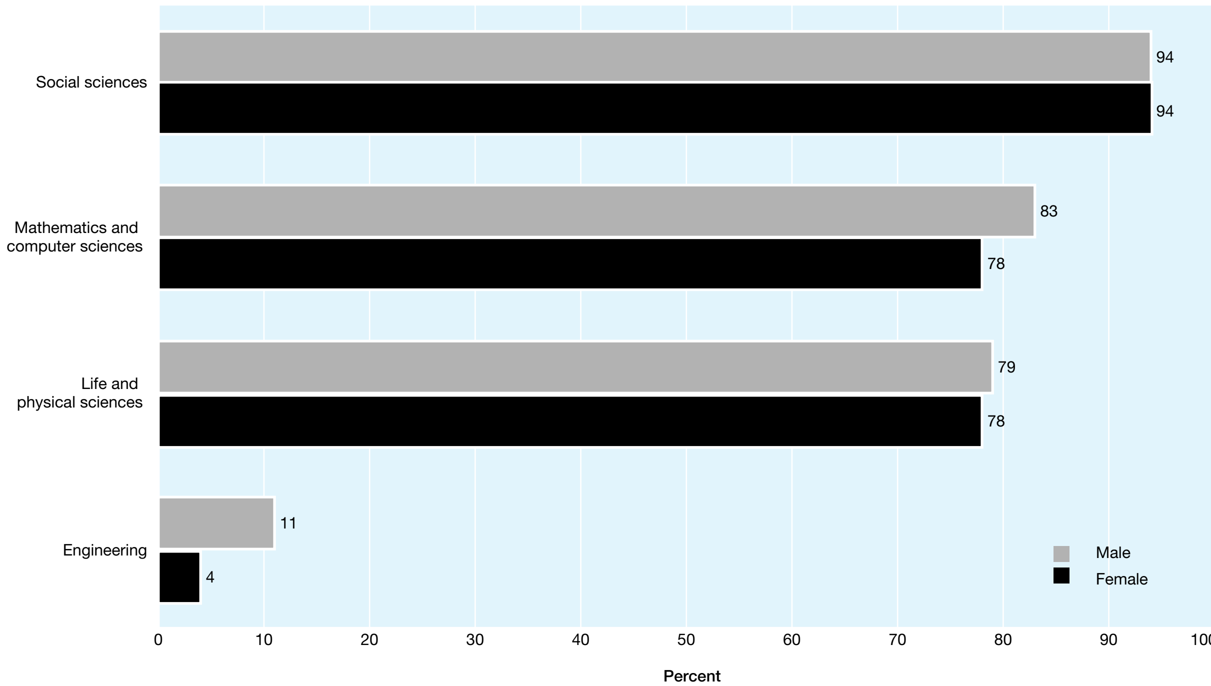
Most students, even those who are not science or engineering majors, take one or more science courses before they graduate. For example, in 1991, about 80 percent of students who earned a bachelor's degree in a field other than the life and physical sciences took one or more courses in these fields; about 17 percent of these took five or more courses. (See figure 4-7 on page 79 and appendix table 4-6.) The same pattern existed for mathematics and computer sciences courses. However, almost all nonmajors took at least one course in the social and behavioral sciences during their undergraduate careers; about half took five or more courses. Few non-science or -engineering majors took engineering courses. Males were slightly more likely to have taken at least one course in any science or engineering field than were females. (See sidebar on female achievement and figure 4-8.)

Females Outperform Males on Science and Engineering Grading Scales

Females tend to outperform males in the science and engineering classroom—and, indeed, in all fields. Overall, 59 percent of females who earned bachelor's degrees in 1991 graduated with a grade point average (GPA) of 3.0 or better on a 1.0 to 4.0 scale. (See figure 4-8 and appendix table 4-7.) Only 47 percent of males earned a 3.0 GPA. Females outperformed males in all science and engineering major fields—the largest disparities were in mathematical and computer sciences and engineering. Males' grades were most similar to females' grades in the life and physical sciences. ■

FIGURE 4–7

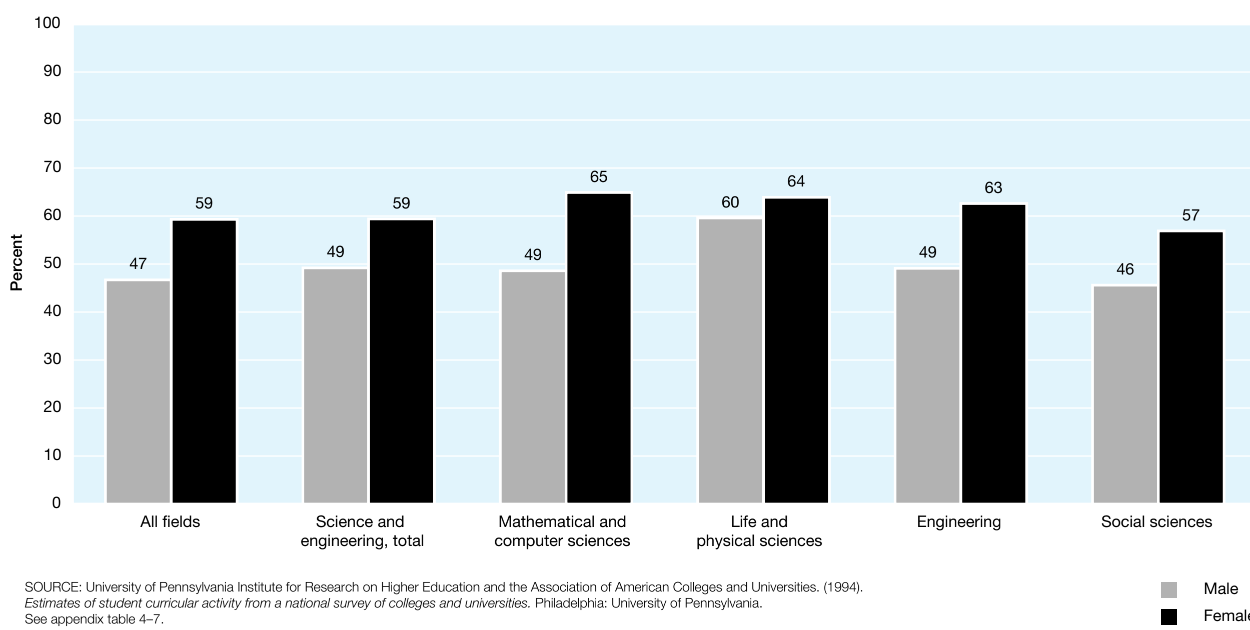
Percent of 1991 bachelor's degree recipients who took one or more courses in selected science and engineering course fields in which they did not major, by course field and sex: 1994



SOURCE: University of Pennsylvania Institute for Research on Higher Education and the Association of American Colleges and Universities. (1994). *Estimates of student curricular activity from a national survey of colleges and universities.* Philadelphia: University of Pennsylvania.
See appendix table 4–6.

FIGURE 4–8

Percent of 1991 bachelor's degree recipients who graduated with a 3.0 GPA or higher, by field and sex: 1991



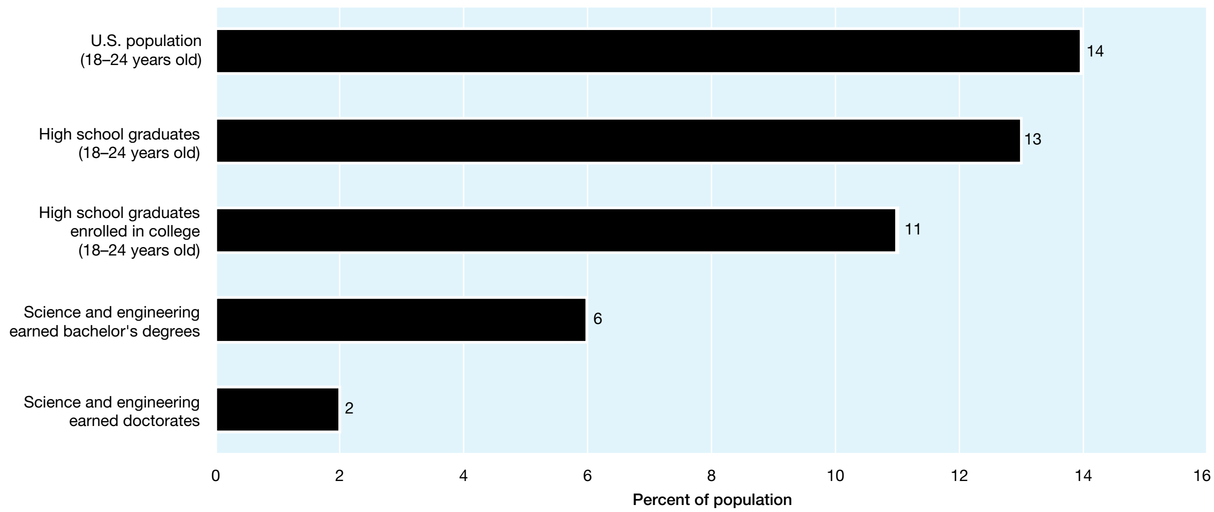
SOURCE: University of Pennsylvania Institute for Research on Higher Education and the Association of American Colleges and Universities. (1994). *Estimates of student curricular activity from a national survey of colleges and universities.* Philadelphia: University of Pennsylvania.
See appendix table 4–7.

Science and Engineering Students

Science and engineering students have many characteristics that make them unique when compared as a group with the general population of postsecondary institutions. For instance, several groups historically have been "underrepresented" in science and engineering, including females, blacks, Hispanics, Native Americans, and individuals with disabilities. (See figures 4-9 and 4-10 and appendix tables 4-8 and 4-9.) This is true particularly within the natural sciences and engineering. With attention to these unique characteristics, this section examines the preparation of students who intend to major in science and engineering fields, the flow of students into and out of science and engineering majors, coursetaking among these students, financial support, and degree production.

FIGURE 4–9

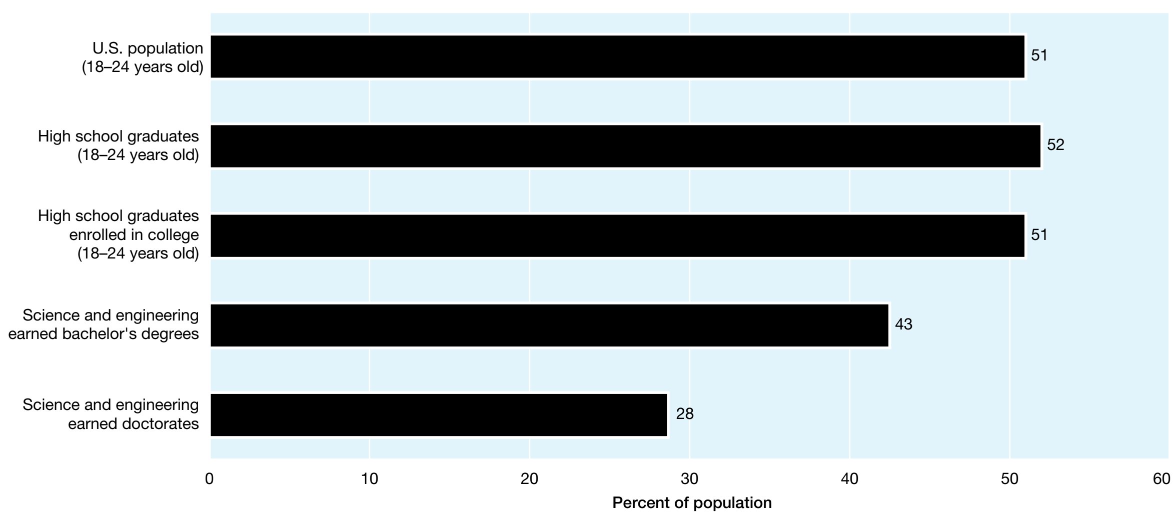
Percent of population that is black, by population group: 1990



SOURCES: National Science Foundation. (1994b). *Science and engineering degrees, by race/ethnicity of recipients: 1977-1991* (NSF 94-306). Arlington, VA: NSF; Bureau of the Census. (1992). *School enrollment– social and economic characteristics of students: October 1990* (Current Population Reports, Series P-20, No. 460). Washington, DC: U.S. Government Printing Office.
See appendix table 4–8.

FIGURE 4–10

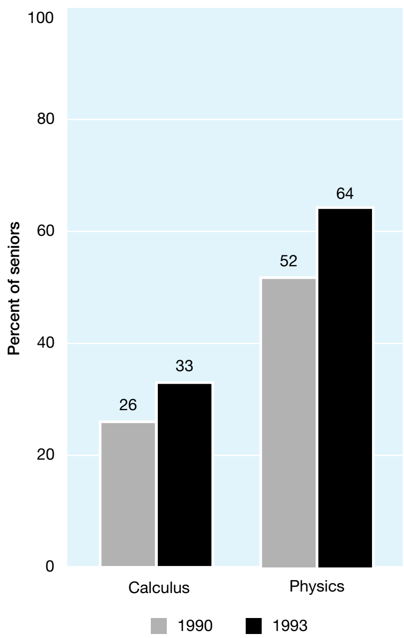
Percent of population that is female, by population group: 1990



SOURCES: National Science Foundation. (1994b). *Science and engineering degrees, by race/ethnicity of recipients: 1977-1991 (NSF 94-306).* Arlington, VA: NSF; U.S. Bureau of the Census. (1992). *School enrollment–social and economic characteristics of students: October 1990* (Current Population Reports, Series P-20, No. 460). Washington, DC: U.S. Government Printing Office.
See appendix table 4–9.

FIGURE 4–11

High school calculus and physics coursetaking of high school seniors who intend to major in natural sciences and engineering in college: 1990 and 1993



SOURCE: National Science Board. (1993). *Science and engineering indicators—1993* (NSB 93-1). Washington, DC: U.S. Government Printing Office.
See appendix table 4–10.

Preparation

Overall, high school students who plan to major in the natural sciences or engineering were better prepared in 1993 than in 1990. For example, between 1990 and 1993, the percentage of intended natural science or engineering majors who took calculus in high school increased from about one-quarter to one-third. (See figure 4-11 and appendix table 4-10.) The proportion who took physics increased by 8 percentage points over the period. Many more students who intend to major in natural sciences and engineering take advanced mathematics and science courses than students who intend some other college major. (See sidebar on preparation and figure 4-12.)

Pipeline

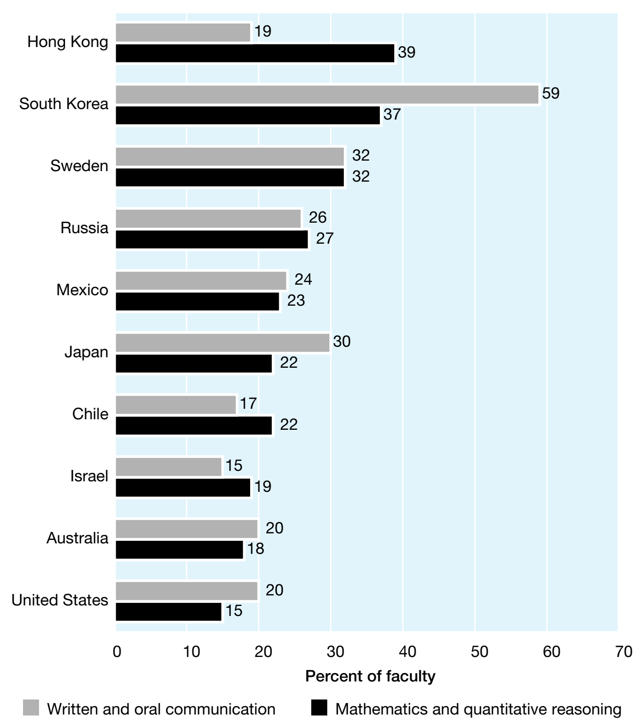
As high school sophomores, about 28 percent of males and 10 percent of females planned to study natural sciences or engineering in college (NCES, 1994a). Almost 57 percent of males and 79 percent of females, throughout high school and college, never expressed the intention to major in the natural sciences or engineering, whereas only 4 percent of males and 1 percent of females expressed consistent interest throughout high school and college in majoring in these fields. (See text table 4-1.)

Are Students Adequately Prepared for Mathematics Classes?

In an international survey performed in 1989 (Carnegie Foundation for the Advancement of Teaching, 1991), just 15 percent of U.S. faculty believed that students had adequate mathematical and quantitative skills, compared with 22 percent of Japanese faculty members, 27 percent of Russians, and 39 percent of faculty members from Hong Kong. (See figure 4-12 and appendix table 4-11.) These perceptions correspond closely with the results of the 1991 International Assessment of Educational Progress, which tested 9- and 13-year-olds on their science and mathematics abilities. The nations whose students scored the highest—Russia and South Korea—were the ones with the highest faculty perceptions of student preparation. The nation whose students scored the lowest—the United States—was the one with the lowest faculty perceptions. ■

FIGURE 4–12

Percent of faculty agreeing with statements that undergraduates in their country are adequately prepared in select skills, by type of skill and country: 1992



SOURCE: Mooney, C.J. (1994, June 22). The shared concerns of scholars. *The Chronicle of Higher Education,* XL (42), pp. A34-A38.
See appendix table 4–11.

TEXT TABLE 4-1

Percent of students identifying natural science or engineering as intended or actual field of study at various points in education system, by sex: 1980 to 1986

	1980: High school sophomores (intended field) Male	Female		1982: High school seniors (intended field) Male	Female		1984: College sophomores (actual or intended field of study) Male	Female		1986: College seniors (actual or intended field of study) Male	Female
NS&E	27.8%	10.3%	NS&E	11.9%	3.1%	NS&E	6.5%	1.3%	NS&E	4.3%	0.8%
									Non-NS&E	2.2%	0.5%
						Non-NS&E	5.4%	1.8%	NS&E	0.6%	0.1%
									Non-NS&E	4.8%	1.7%
			Non-NS&E	15.9%	7.3%	NS&E	1.6%	0.6%	NS&E	0.6%	0.2%
									Non-NS&E	1.1%	0.4%
						Non-NS&E	14.3%	6.7%	NS&E	0.5%	0.1%
									Non-NS&E	13.8%	6.6%
Non-NS&E	72.2%	89.7%	NS&E	11.1%	6.9%	NS&E	3.9%	1.8%	NS&E	2.4%	0.8%
									Non-NS&E	1.5%	1.0%
						Non-NS&E	7.2%	5.1%	NS&E	0.7%	0.5%
									Non-NS&E	6.5%	4.6%
			Non-NS&E	61.1%	82.8%	NS&E	2.3%	2.8%	NS&E	0.6%	1.0%
									Non-NS&E	1.7%	1.8%
						Non-NS&E	58.8%	80.0%	NS&E	1.4%	0.7%
									Non-NS&E	57.4%	79.2%

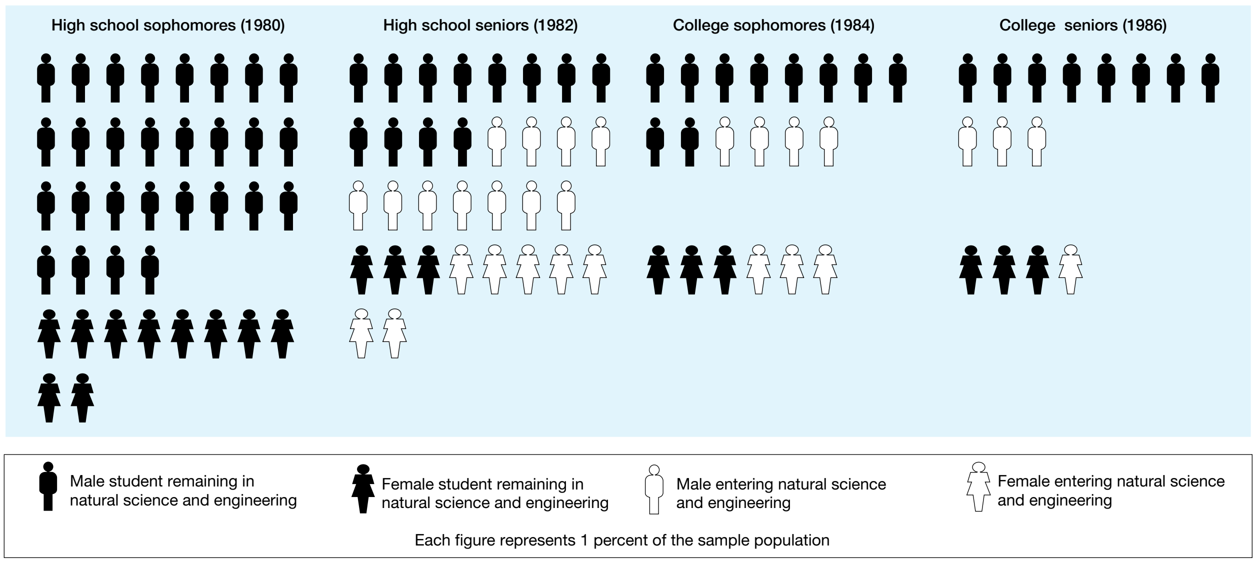
Natural science and engineering (NS&E)

Non-natural-science and -engineering discipline (Non-NS&E)

NOTES: Percent selecting natural sciences or engineering in high school is percent indicating these fields when asked to "indicate the field that seems closest to what you would most likely study in college." In college, percent selecting natural sciences or engineering are those that indicated these fields when asked, "During the last month you attended, what was your actual or intended field of study or training?" The data used in this table are drawn from the first four cycles (1980 base year, through the 1986 third follow-up) of the *High school and beyond 1980 sophomore cohort.* The sample began in 1980 with a national sample of 1,015 high schools. As a result of rounding, totals may not add to 100 percent.
SOURCE: National Center for Education Statistics. (1994a). *High school and beyond study, 1980 to 1992.* Unpublished tablulations.

FIGURE 4–13

Percent of 1980 high school sophomores identifying natural science and engineering as intended or actual field of study at various points in the educational system, by sex: 1980 to 1986



NOTES: Percent selecting natural sciences and engineering in high school is percent indicating these fields when asked to "indicate the field that seems closest to what you would most likely study in college." In college, percent selecting natural sciences and engineering are those that indicated these fields when asked, "During the last month you attended, what was your actual or intended field of study or training?" The data used in this table are drawn from the first four cycles (1980 base year, through the 1986 third follow-up) of the *High school and beyond sophomore cohort*. The sample began in 1980 with a national sample base of 1,015 high schools.
SOURCE: National Center for Education Statistics. (1994a). *High school and beyond study, 1980 to 1992.* Unpublished tabulations.
See text table 4–1.

Indicators of Science and Mathematics Education 1995

For many years, educators believed that students who eventually became science or engineering majors in college made up their minds early, in elementary or secondary school, about their career intentions. Thus, analysts assumed that, although many students dropped out of the science and engineering "pipeline" as their educational careers progressed, few new entrants replaced them along the way. However, the High School and Beyond study (NCES, 1994a) indicates that the system is more open. (See figure 4-13.) Many students drop out of science and engineering majors, some enter, and some students change their intentions several times before choosing a major.[4]

Quite a few students who major in science or engineering in college decide to do so relatively late in their undergraduate careers. The High School and Beyond study (NCES, 1994a) found that about 30 percent of students who were high school sophomores in 1980, and who ultimately became natural science or engineering majors in college, chose this direction sometime after 1984—probably after their second year of college. (See text table 4-1.) This suggests that, if policy makers' objective is to increase the number of majors and degrees, in addition to emphasizing retention strategies, they should consider ways of attracting students who are further along in their postsecondary careers.

Overall, many more students drop out of natural sciences and engineering than enter. Of course, all college departments face attrition, as their students switch to other majors, but not all face net attrition. However, the natural sciences—and, to a lesser extent, engineering—are particularly susceptible to attrition.[5] According to the High School and Beyond study, only 40 percent of students who intended to major in natural sciences or engineering as high school sophomores were actually in a natural science or engineering major as college seniors.(See text table 4-2.)

Indeed, a 1991 study by the Higher Education Research Institute found that only about half of students who, in their first year of college, had declared or intended a major in the natural sciences followed through with their plans by the time they were in or approaching their senior year. (See figure 4-14 and appendix table 4-12.) About 62 percent of engineering students, and more than 65 percent of students who intended to major in English, the social sciences, fine arts, education, or history, followed through with their original plans.

The High School and Beyond study data indicate that the pool of students interested in natural science and engineering shrank most after the senior year in high school and before the sophomore year in college. Just over half of the net decrease in the number of students with an actual or intended major in natural sciences or engineering occurred during this period.[6] (See text table 4-2.)

TEXT TABLE 4-2

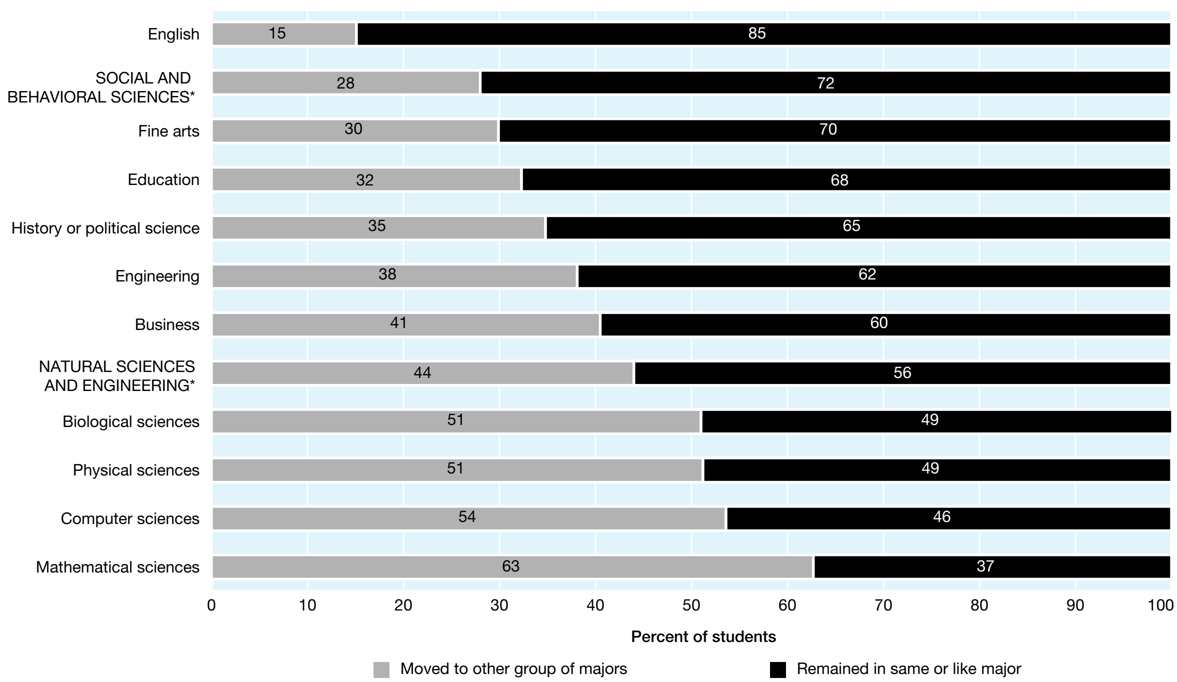
Percent of students whose actual or intended field of study is natural sciences or engineering, by education level and sex: 1980 to 1986

	High school (intended field)		College (actual or intended field)	
Sex	Sophomores (1980)	Seniors (1982)	Sophomores (1984)	Seniors (1986)
Male	27.8	23.0	14.3	11.1
Female	10.3	10.0	6.5	4.0

SOURCE: National Center for Education Statistics. (1994a). *High school and beyond study, 1980 to 1992.* Unpublished tabulations.

FIGURE 4–14

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



*The social and behavioral sciences category includes social sciences and psychology; the natural sciences and engineering category includes biological sciences, physical sciences, computer sciences, mathematical sciences, and engineering.
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.
See appendix table 4–12.

Indicators of Science and Mathematics Education 1995

In a study of seven institutions conducted by Seymour and Hewitt (1994), students who switched from natural sciences and engineering majors to other fields most often attributed their decision to a loss of interest in natural science and engineering coupled with increased interest in other fields, poor quality of teaching, an inflexible curriculum, fast course pace, and a sense that the career options and rewards in natural sciences and engineering were not worth the effort.

Similarly, Tinto (1988) argued that students who leave a particular college or college major before completing their studies often do so because they feel alienated from other students or faculty or because they are unable to make the transition from their old peer group to a new one. This inability to make necessary peer connections may be a particular problem for students from groups historically underrepresented in science and engineering, including blacks, Hispanics, Native Americans, and females.

Attrition among minority students in science and engineering may also be due to a variety of other social and academic obstacles. (For example, see Holden, 1992; Culotta, 1992.) Among these obstacles are financial difficulties, poor precollege preparation, low expectations from instructors, negative peer pressure, difficulty bridging the gap between their cultural identity and the world of science, and poor access to information on postsecondary educational opportunities.

Reasons for high attrition among female science and engineering students may include a lack of, or damaged sense of, self-confidence or self-esteem; stereotyping of science and engineering as "male" fields; experiences of gender bias; distaste for the competitive nature of science and engineering education; psychological alienation; an inability to get adequate academic guidance or advice; and low faculty expectations (Frazier-Kouassi et al., 1992; Seymour & Hewitt, 1994).

To encourage retention of females and students from underrepresented racial and ethnic groups, some postsecondary institutions have sponsored campus-based efforts to provide social and academic support to these groups. These were originally designed as stop-gap measures to provide students with the necessary skills to succeed in the existing undergraduate educational system; however, they are increasingly being implemented on a broader scale. Some are even working with employers and elementary and secondary school systems (National Research Council, 1992; Matyas & Malcom, 1991).

Financial Support

In the late 1980s and early 1990s, private and public 2- and 4-year institutions raised tuition and fees significantly in response to increasing costs and, for public institutions, declining or flat state appropriations levels. Between 1985 and 1993, tuition and fees in 4-year institutions increased by about 40 percent, in real 1993 dollars. (See appendix table 4-13.) The percentage increase was slightly more in public 4-year institutions and slightly less in private 4-year institutions. Public 2-year college tuition and fees increased by about 30 percent.

Between 1981 and 1993, the buying power of Federal student aid grants eroded rapidly. In 1981, the maximum Pell grant (the main Federal grant program for low-income students) covered 31 percent of the average educational expenses at a private 4-year institution. By 1993, the maximum grant covered just 16 percent of that cost. In its place have come student loans (Blanchette, 1994).

Originally conceived as a mechanism of support for middle-income students, loans have now become the major student aid program for low-income students. As a result, just under half of all bachelor's degree recipients in 1993 graduated from college in debt, compared with about one-third of graduates in 1980. The median debt of these students in constant 1990 dollars increased from about $4,000 in 1980 to about $7,000 by 1990 (U.S. Department of Education, 1993).

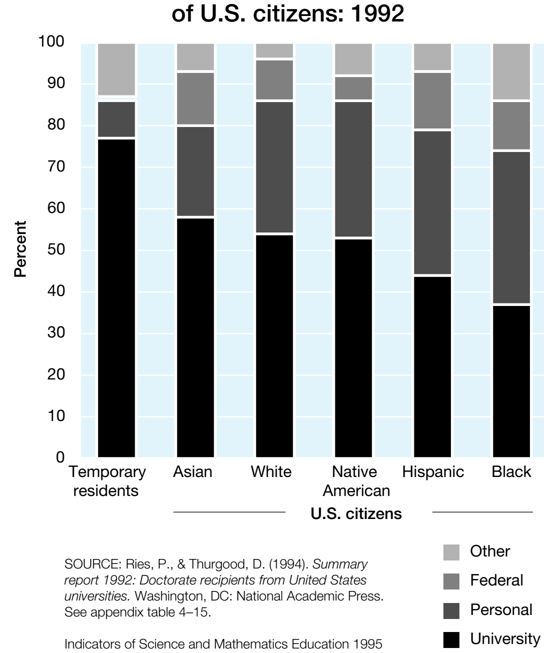
Roughly half of 1990 bachelor's degree recipients who hold postgraduation occupations in the science and technology labor market had college debt. (See appendix table 4-14.) Graduates employed as elementary and secondary teachers and engineers were most likely to have accumulated debt during their college years. Graduates working in computer science were least likely to have graduated with debt. This debt accounted for a large fraction of some graduates' median first-year income—from about 40 percent for social scientists to about 20 percent for science technicians (U.S. Department of Education, 1993).

About 24 percent of science and engineering doctoral students finance their education through personal sources such as loans. About 62 percent of science and engineering doctoral students obtain their primary financial support from university sources, mostly in the form of graduate assistantships funded by research grants awarded by the Federal Government. About 7 percent of recipients receive direct Federal support in the form of competitively selected fellowships or traineeships. (See figure 4-15 and appendix table 4-15.)

Of all U.S. citizens, 54 percent of white students and 58 percent of Asian students are supported by university sources, mostly in the form of assistantships. Only 37 per-

FIGURE 4–15

Primary source of support of science and engineering doctorate recipients, by residency status and race or ethnic origin of U.S. citizens: 1992



SOURCE: Ries, P., & Thurgood, D. (1994). *Summary report 1992: Doctorate recipients from United States universities.* Washington, DC: National Academic Press. See appendix table 4–15.

cent of black students and 44 percent of Hispanic students are supported by university sources. (See figure 4-15 and appendix table 4-15.) A comparatively high proportion (about 77 percent) of foreign students are supported by university sources. This is due, in part, to their high concentrations in fields such as engineering, where assistantships are prevalent, and their ineligibility for Federal graduate student fellowship programs.

Blacks are more likely than other racial and ethnic groups to finance their graduate education from personal sources, such as loans, or other sources, such as nationally competitive fellowships, business or employer funds, and state governments.

Degree Production

Bachelor's degrees account for the vast majority of all science and engineering degrees awarded in any given year. (See sidebar for international comparisons and figure 4-16.) For every 14 science and engineering bachelor's degrees awarded in 1991, 1 science and engineering doctorate was awarded. (See figure 4-17 and appendix table 4-17.)

Between 1971 and 1991, the number of science and engineering degrees increased at all levels, except the associate degree level. Bachelor's degrees awarded in science and engineering increased by 15 percent, master's degrees increased by 39 percent, and doctorates increased by 23 percent. By broad field, the following trends emerged between 1971 and 1991[7] :

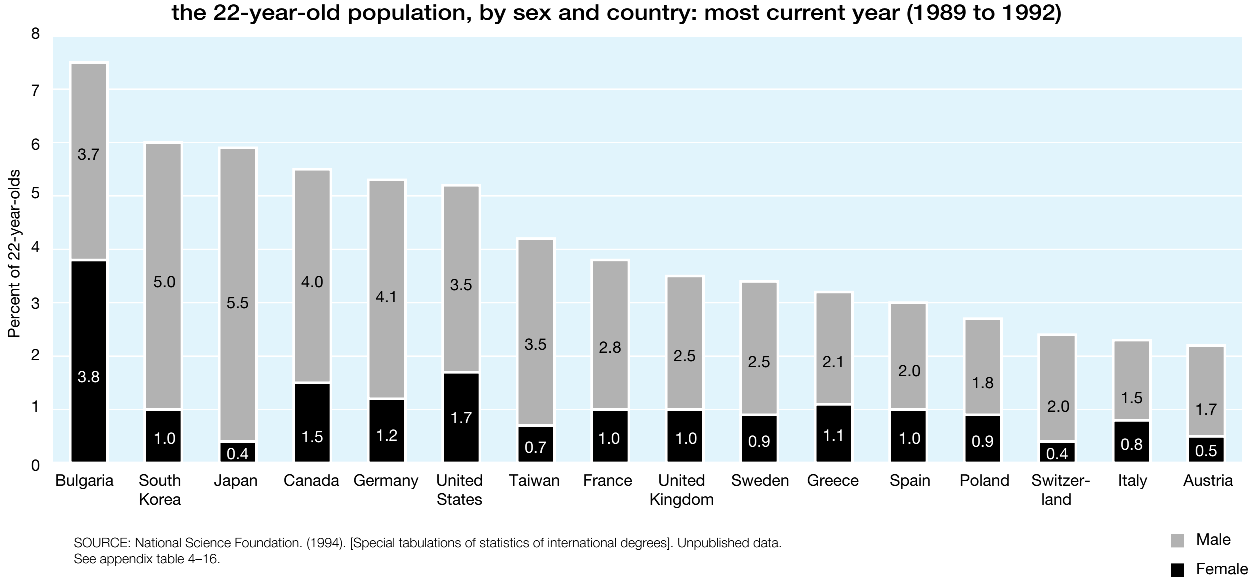
- Engineering degree production increased at the bachelor's, master's, and doctoral levels. The increases ranged from about one-third at the bachelor's level to almost one-half at the doctoral level.
- Natural science degrees increased by 11 percent at the bachelor's level, 24 percent at the master's level, and 17 percent at the doctoral level.
- Social and behavioral sciences degrees increased by 10 percent at the bachelor's level, 48 percent at the mas-

International Comparisons

A greater proportion of 22-year-olds in the United States and Canada complete college than in any of the 14 other countries from which comparable data are available. However, the proportion of individuals who earn natural science and engineering bachelor's degrees is lower in the United States and Canada than in Bulgaria, Japan, and South Korea. (See figure 4-16 and appendix table 4-16.) The proportion of males who earn natural science and engineering degrees ranges from a high of about 11 percent of male 22-year-olds in Japan to a low of about 3 percent in Italy. In the United States, about 7 percent of the male college-age population earns bachelor's degrees in these fields. The countries with the highest proportion of females who earn natural science and engineering degrees are Bulgaria, the United States, and Canada. In Bulgaria, the proportion of females earning degrees in these fields is more than double that of the United States or Canada. ■

FIGURE 4–16

First university natural science and engineering degrees awarded as a percent of the 22-year-old population, by sex and country: most current year (1989 to 1992)



SOURCE: National Science Foundation. (1994). [Special tabulations of statistics of international degrees]. Unpublished data. See appendix table 4–16.

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ter's level, and 19 percent at the doctoral level. (See appendix tables 4-18, 4-19, and 4-20.)

Even though the absolute number of science and engineering degrees awarded rose substantially between 1971 and 1991, science and engineering bachelor's degrees decreased as a proportion of total baccalaureates; they accounted for 35 percent of all baccalaureates awarded in 1971, but only 31 percent in 1991. (See figure 4-18.)

The proportion of science and engineering master's degrees stayed about the same—almost one-quarter of all master's degrees. On the other hand, science and engineering doctorates increased as a percentage of all doctoral awards; science and engineering doctorates accounted for 61 percent of all doctoral degrees awarded in 1971 and about 64 percent in 1991.

Sex. Although females earned the majority of bachelor's degrees awarded in all academic fields in 1991, they earned only about 44 percent of science and engineering bachelor's degrees (NSF, 1994a). Females earned 56 percent of social and behavioral sciences bachelor's degrees, 41 percent of the bachelor's degrees awarded in the natural sciences, and just 16 percent of engineering bachelor's degrees.(See appendix table 4-18.)

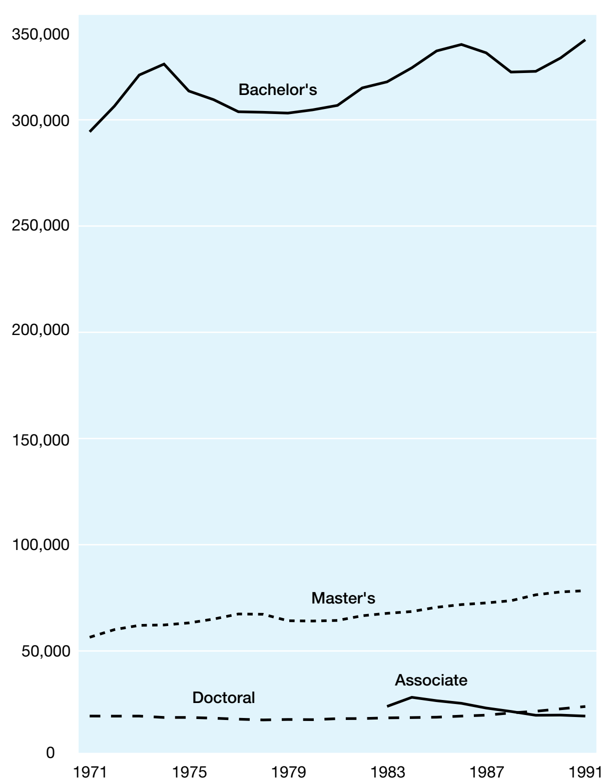
Females also earned the majority of master's degrees awarded in all fields; however, they earned just 36 percent of science and engineering master's degrees (NSF, 1994a). Females earned 54 percent of the master's degrees awarded in the social and behavioral sciences, 36 percent of natural sciences master's degrees, and 14 percent of engineering master's degrees.(See appendix table 4-19.)

Although females earned 37 percent of all doctorates, they earned just 28 percent of doctorates in science and engineering (NSF, 1994a). Females earned 48 percent of doctorates in the social and behavioral sciences, 26 percent of doctorates within the natural sciences, and 9 percent of engineering doctorates. (See appendix table 4-20.)

The gap between the number of science and engineering degrees awarded to females versus males at all degree levels has narrowed over the past 20 years—mostly because the proportion of males who earned degrees in these fields

FIGURE 4–17

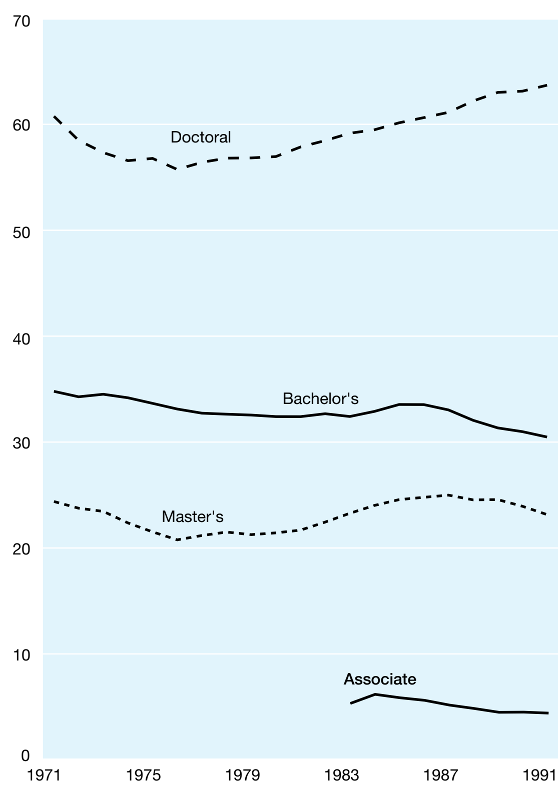
Science and engineering degrees awarded, by degree level: 1971 to 1991



NOTE: Associate degree data available beginning in 1983.
SOURCE: National Science Foundation. (1994a). *Science and engineering degrees: 1966-91* (NSF 94-305). Arlington, VA: NSF.
See appendix table 4–17.

FIGURE 4–18

Science and engineering degrees awarded as a percent of degrees awarded in all fields, by degree level: 1971 to 1991



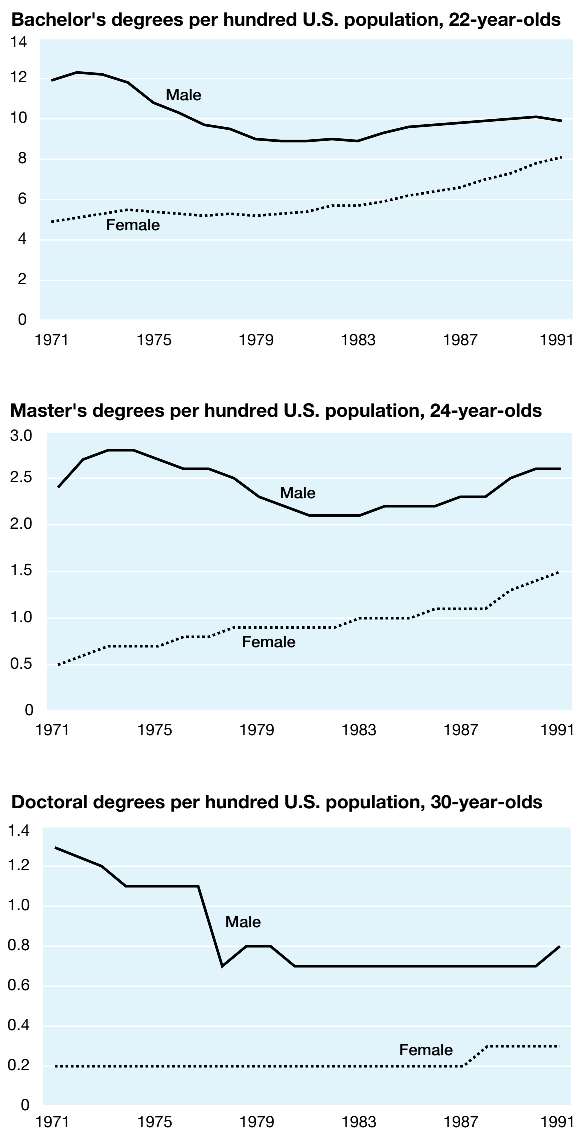
NOTE: Associate degree data available beginning in 1983.
SOURCE: National Science Foundation. (1994a). *Science and engineering degrees: 1966-91* (NSF 94-305). Arlington, VA: NSF.
See appendix table 4–17.

declined, while the proportion of females increased. (See figure 4-19 and appendix table 4-21.)

The gap between the proportion of males and females who earned science and engineering degrees narrowed most at the bachelor's degree level. In 1971, 12 males versus 5 females per hundred 22-year-olds received a bachelor's degree in science and engineering. By 1991, 10 males versus 8 females per hundred 22-year-olds received a bachelor's degree in science and engineering.

FIGURE 4-19

Science and engineering degrees awarded per hundred U.S. population, by degree level and sex: 1971 to 1991



SOURCE: National Science Foundation. (1994a). *Science and engineering degrees: 1966-91* (NSF 94-305). Arlington, VA: NSF.
See appendix table 4–21.

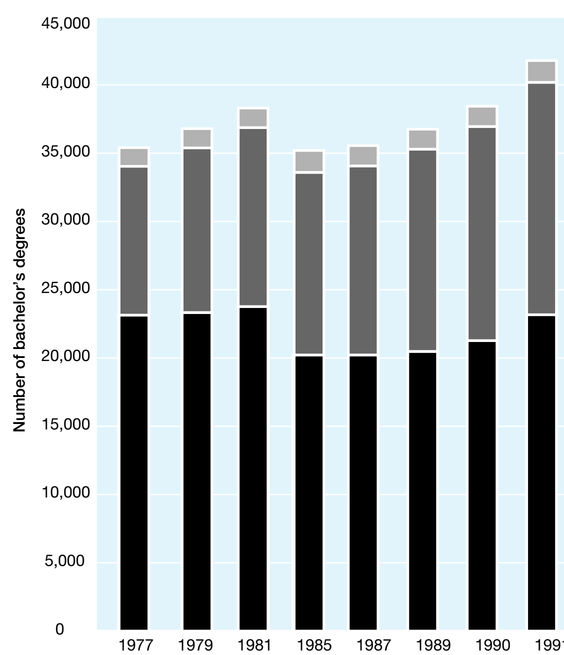
At the doctoral level, a large decline in the number of males enrolled in science and engineering—rather than an increase in the number of females enrolled in science and engineering—narrowed the gap. In fact, the proportion of the females who earned science and engineering doctorates remained flat for most of the period between 1971 and 1991.

RACE AND ETHNIC ORIGIN. Blacks and Hispanics remain underrepresented in science and engineering.[8] In 1991, although blacks made up about 14 percent of the college-age population, they earned just over 6 percent of the science and engineering bachelor's degrees conferred to U.S. citizens. (See figure 4-20 and appendix table 4-22.) After a decline in the 1980s, the number of science and engineering bachelor's degrees awarded to blacks in 1991 returned to 1977 levels. Blacks received a total of just 36 more science and engineering bachelor's degrees in 1991 than in 1977. (See appendix table 4-22.)

Similarly, Hispanics made up 11 percent of the college-age population, but earned not quite 5 percent of science and engineering degrees; however, their representation has increased markedly. (See sidebar on concentration of engineering degrees and figures 4-21 and 4-

FIGURE 4-20

Number of science and engineering bachelor's degrees awarded to students in underrepresented racial and ethnic groups: 1977 to 1991



NOTE: Persons of Hispanic origin may be of any race.
SOURCE: National Science Foundation. (1994b). *Science and engineering degrees, by race/ethnicity of recipients: 1977-91* (NSF 94-306). Arlington, VA: NSF.
See appendix table 4–22.

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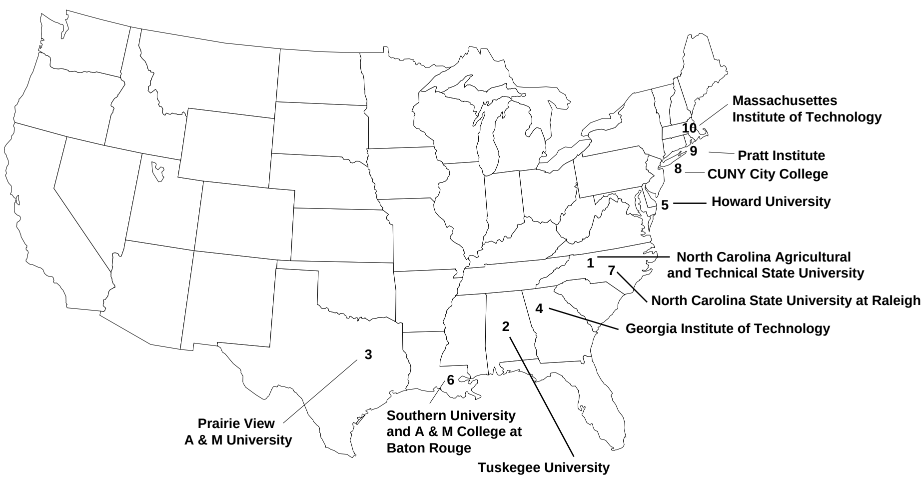
A Few Schools Award Most Engineering Degrees to Minorities

In 1993, blacks and Hispanics each earned about 4 percent of engineering bachelor's degrees (NSF, 1994e). Roughly one-third of these degrees earned by blacks were granted by just 10 colleges and universities. (See figure 4-21 and appendix table 4-23.) Five of these institutions are historically black colleges and universities, and two offer a doctorate in engineering. Similarly, in 1993, just 10 postsecondary institutions conferred 41 percent of the engineering bachelor's degrees awarded to Hispanics. Nine of these institutions are located in states or territories with large Hispanic populations. (See figure 4-22 and appendix table 4-23.) ■

FIGURE 4-21

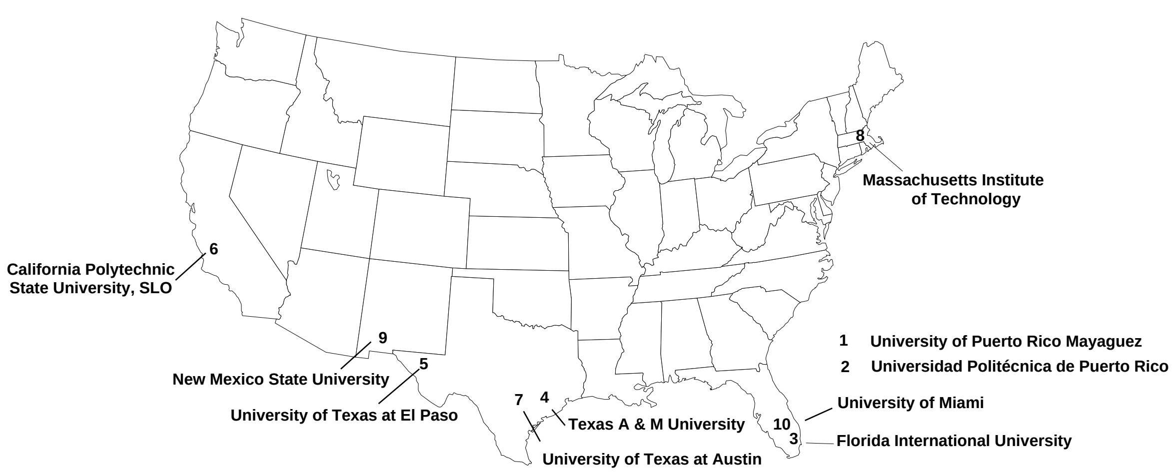
Ten colleges and universities that award the highest number of bachelor's degrees in engineering to blacks: 1993



SOURCE: National Center for Education Statistics. Integrated Postsecondary Education Data System. Special tabulations by Science Resources Studies Division, National Science Foundation. See appendix table 4–23.

FIGURE 4-22

Ten colleges and universities that award the highest number of bachelor's degrees in engineering to Hispanics: 1993



SOURCE: National Center for Education Statistics. Integrated Postsecondary Education Data System. Special tabulations by Science Resources Studies Division, National Science Foundation. See appendix table 4–23.

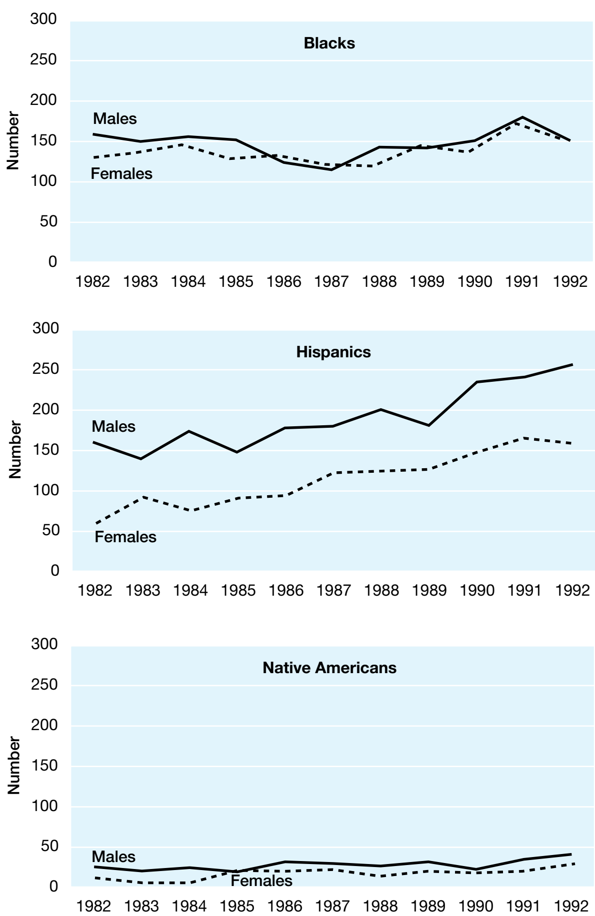
22.) Hispanics earned 55 percent more bachelor's degrees in science and engineering in 1991 than in 1977.

Over this same period of time, the number of science and engineering bachelor's degrees awarded to groups not underrepresented in science and engineering remained relatively constant overall. Although the number of science and engineering bachelor's degrees awarded to Asians more than tripled, the number of degrees awarded to whites decreased by 6 percent. (See appendix table 4-22.)

Blacks and Hispanics are even more underrepresented at the master's degree level than at the bachelor's and still more underrepresented at the doctoral level. In 1992, blacks earned just 2 percent of the science and engineering doctorates awarded to U.S. citizens, and Hispanics earned about 3 percent. (See appendix table 4-24.)

FIGURE 4–23

Science and engineering doctorates awarded to blacks, Hispanics, and Native Americans, by sex: 1982 to 1992



NOTE: Numbers refer to U.S. citizens only.
SOURCE: National Science Foundation (1993b). *Selected data on science and engineering doctorate awards: 1992* (NSF 93-315). Washington, DC: NSF.
See appendix table 4–25.

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Black females earned about the same number of science and engineering doctorates as black males in 1992—the number of black females earning doctorates increased slightly and the number of black males earning doctorates decreased slightly between 1982 and 1992. (See figure 4-23 and appendix table 4-25.) Although Hispanic females were earning increasingly more engineering doctorates, the total number of doctorates they earned still lagged behind the total number of doctorates Hispanic males earned. (See sidebar on diversity and figure 4-24.)

Foreign Students

Between 1972 and 1992, the number of science and engineering doctorates awarded to foreign students by U.S. postsecondary institutions more than doubled, although the number awarded to U.S. citizens declined slightly. (See figures 4-25 and 4-26 and appendix table 4-26.) In 1972, foreign students earned 20 percent of science and engineering doctorates; by 1992, they earned 38 percent.

The science and engineering field with the highest proportion of foreign graduates is engineering. Foreign

Are Postsecondary Institutions Doing Enough About Diversity?

Despite a large postsecondary educational infrastructure and perhaps 20 years of effort to diversify the science and engineering workforce, few institutions are producing large enough numbers of black and Hispanic doctorates to achieve true diversity. In 1992, universities awarded only 5 percent of science and engineering doctorates to blacks and Hispanics, collectively (NSF, 1993b). That year, although 366 postsecondary institutions awarded one or more science and engineering doctorates, nearly two-thirds of these institutions awarded no doctorates to blacks, and fewer than half of these institutions awarded even one science and engineering doctorate to a Hispanic. (See figure 4-24.)

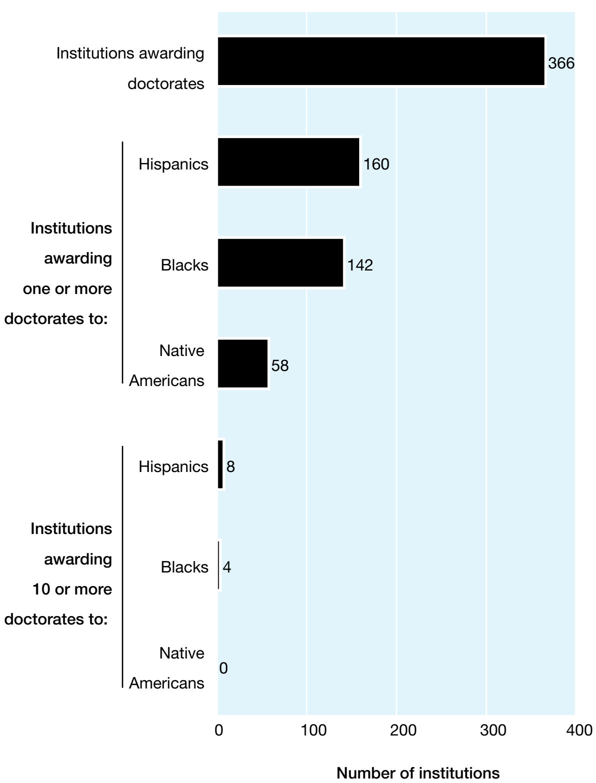
Diversifying the science and engineering workforce may be possible only if postsecondary institutions increase access to science and engineering study. Blacks and Hispanics come from backgrounds historically overrepresented at the lower socioeconomic strata, at lower household income levels, and among families living in poverty. Students from low-income family backgrounds of all races and ethnic origins complete college at lower rates than those from higher income families. For example, 25 percent of blacks who graduated from high school in 1980 and who are from families in the top socioeconomic quartile have since obtained bachelor's degrees. Only 8 percent of blacks from the bottom quartile have completed college. ■

students earned about 61 percent of all engineering doctorates in 1992. In the natural sciences, foreign students earned 41 percent of the doctorates, and in the social and behavioral sciences, they earned 28 percent. In non-science and -engineering fields, foreign students earned only 17 percent of the doctorates. The majority of foreign students studying science and engineering in the United States are from Asia.

The opportunities at home for many foreign science and engineering doctoral recipients have increased during the past 20 years as the economies of many countries, particularly those in Asia, have expanded. As a result, more of these students are returning home than in previous years. In 1970, about 54 percent of the foreign science and engineering doctorate recipients planned to stay in the United States after graduation, mostly to work in academia or industry. In 1992, about 44 percent planned to stay in the United States (NSF, 1993c).

FIGURE 4–24

Number of institutions awarding science and engineering doctorates, by race or ethnic origin of recipient: 1992



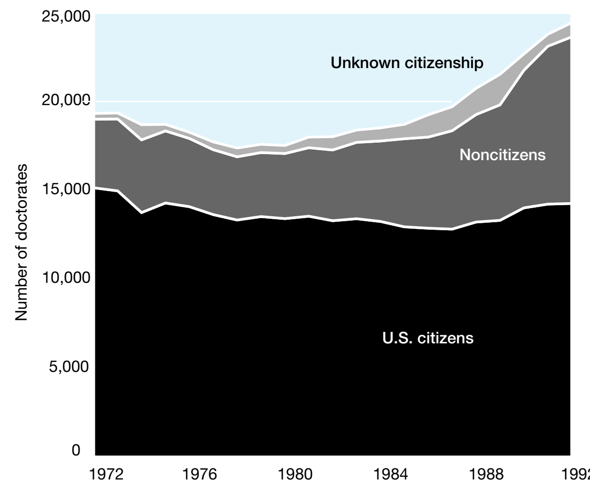
NOTE: Persons of Hispanic origin may be of any race.
SOURCE: National Science Foundation (1994d). [Special tabulations from the National Science Foundation survey of earned doctorates]. Unpublished data.

Technical Students

Individuals with technical[9] training play an important role in the ability of the United States to maintain and advance its economic position in the world (Collins, Gentry, & Crawley, 1993). The most common types of

FIGURE 4–25

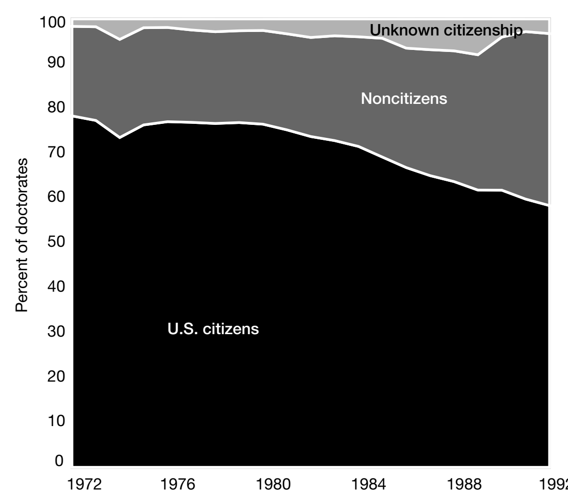
Science and engineering doctorates awarded, by citizenship of recipient: 1972 to 1992



SOURCES: National Science Foundation. (1993a). *Science and engineering doctorates: 1960-91* (NSF 93-301). Washington, DC: NSF; National Science Foundation. (1993b). *Selected data on science and engineering doctorate awards: 1992* (NSF 93-315). Washington, DC: NSF.
See appendix table 4–26.

FIGURE 4–26

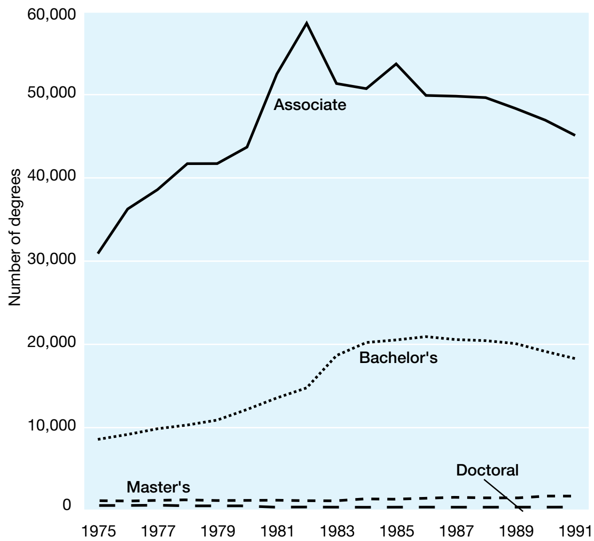
Proportional distribution of science and engineering doctorates awarded, by citizenship of recipient: 1972 to 1992



SOURCES: National Science Foundation. (1993a). *Science and engineering doctorates: 1960-91* (NSF 93-301). Washington, DC: NSF; National Science Foundation. (1993b). *Selected data on science and engineering doctorate awards: 1992* (NSF 93-315). Washington, DC: NSF.
See appendix table 4–26.

FIGURE 4–27

Total number of engineering technology degrees awarded, by degree level: 1975 to 1991



SOURCE: National Science Foundation. (1994a). *Science and engineering degrees: 1966-91* (NSF 94-305). Arlington, VA: NSF.
See appendix table 4–27.

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technical degree awarded are in engineering technologies. (See figure 4-27 and appendix table 4-27.) Other types of technical degree include science technologies, communications technologies, and health technologies. During the past 15 years, the number of students who earned technical degrees and certificates increased at all degree levels (NSF, 1994a).

In 1991, most students who studied engineering technologies received associate degrees, as opposed to any other type of degree. Between 1975 and 1991, the number of engineering technology associate degrees increased by 46 percent, although the 1991 level is a drop from its peak level in 1982. Bachelor's and master's degrees in this field have doubled and tripled, respectively. (See sidebar on technicians.)

Technicians Are Not Just Junior Scientists

In a 1993 study of science technicians, Barley and Bechky found that, while technicians often work with scientists and engineers, they are not junior scientists and engineers, nor do they perform routine tasks. Instead, their work emphasizes skilled technical applications, which require a significant understanding of the fundamental science and engineering underpinning of their trade. Because scientists and engineers, on one hand, and technicians, on the other, employ complementary sets of skills, the division of labor between the two occupational groups is more collaborative than hierarchical (Barley & Bechky, 1993). ■

The Carnegie Classification

The Carnegie Classification, developed by the Carnegie Foundation for the Advancement of Teaching (1991), groups the 3,600 postsecondary institutions into 11 categories, based largely on their academic missions. The classification includes all colleges and universities in the United States that are degree-granting and accredited by an agency recognized by the U.S. Secretary of Education. Used as a key resource for academe, it aids in assessing the changing state of postsecondary education and as a way for campus officials at the respective colleges and universities to define a niche in relation to other postsecondary institutions.

Colleges and universities are divided into the following categories: research universities, doctoral universities, master's (comprehensive) universities and colleges, baccalaureate (liberal arts) colleges, associate of arts colleges, professional schools and specialized institutions, and other specific groupings. Institutions are classified according to the highest level of degree they award, the number of degrees conferred by the discipline, and, in some cases, the amount of Federal research support they receive and the selectivity of their admissions. ■

Postsecondary Learning Environment

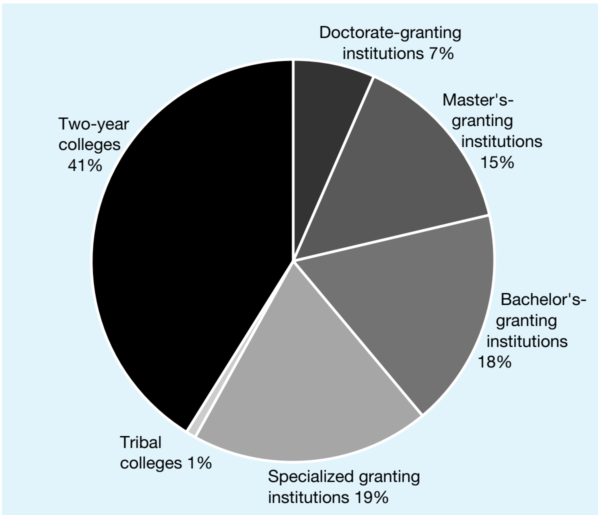
In 1994, there were 3,600 postsecondary institutions in the United States. (See sidebar for definition of Carnegie Classification.) This was a net increase of about 200 institutions since 1987.[10] (See appendix table 4-28.) The greatest increase was among 2-year colleges, with a net increase of more than 100 institutions. In 1994, 2-year institutions accounted for a full 40 percent of all postsecondary institutions; this was the largest single institutional category.[11] (See figure 4-28.) Doctoral-granting institutions, which make up only 7 percent of the postsecondary schools, award the largest share of bachelor's, master's, and doctoral science and engineering degrees (NSB, 1993).[12]

Faculty

The representation of blacks and Hispanics is lower within the natural sciences and engineering fields than in either the social and behavioral sciences or non-science and -engineering fields. (See figure 4-29 and appendix table 4-29.) For example, blacks make up about 5 percent of all postsecondary faculty, but only about 3 percent of natural sciences faculty and less than 3 percent of faculty in engineering. Females are most underrepresented in

FIGURE 4–28

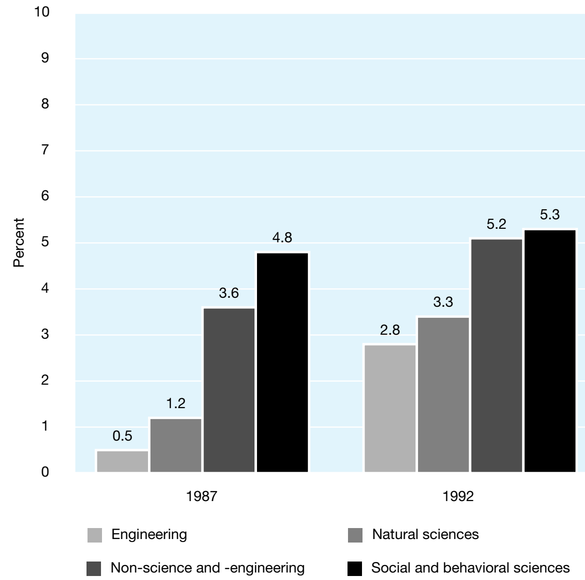
Institutions of higher education, by institutional type: 1994



NOTE: Percents have been rounded to the nearest whole number.
SOURCE: Carnegie Foundation for the Advancement of Teaching. (1991, May/June). Research-intensive vs. teaching-intensive institutions. *Change,* 23-26.
See appendix table 4–28.

FIGURE 4–29

Percent of full-time faculty who are black, 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.
See appendix table 4-29.

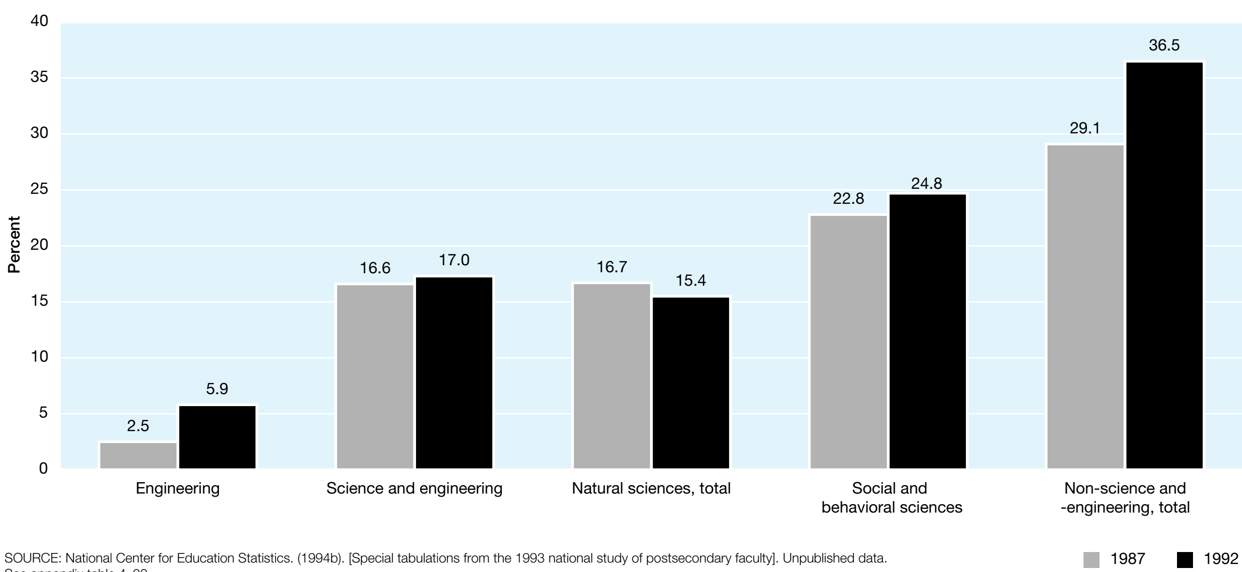
engineering. Although they make up about one-third of all postsecondary faculty, they account for about 15 percent of faculty in the natural sciences and only about 6 percent of engineering faculty. (See figure 4-30 and appendix table 4-30.)

One difficulty that postsecondary institutions have in diversifying their workforce is the small pool of job applicants who are female, members of racial and ethnic minority groups, or disabled. For example, blacks and Hispanics collectively account for a small percentage of all science and engineering doctoral recipients. (See the section on degree production on page 86.)

The difficulty raised by underrepresentation does not end with successful recruitment of a satisfactory candidate. Instead, the burden is transferred to the shoulders of the new recruit. Many young faculty members from

FIGURE 4–30

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.
See appendix table 4–30.

underrepresented groups frequently find themselves overwhelmed with committee assignments, extracurricular activities, and other responsibilities reflecting their position as role models. In addition, limited expectations and alienation experienced during college years sometimes reemerges, persists, or grows worse at the faculty level (Barinaga, 1992, and Etzkowitz et al., 1994). Many experts believe that these problems will exist until a critical mass of faculty from underrepresented groups is achieved (Culotta, 1993).

Teaching and Research

The struggle to prioritize time and resources between teaching and research continues in postsecondary institutions today. In a 1992 study, about two-thirds of U.S. faculty in all fields favored teaching over research, compared with less than half of British faculty, about one-third of German faculty, and about one-quarter of Japan's faculty. (See figure 4-31.)

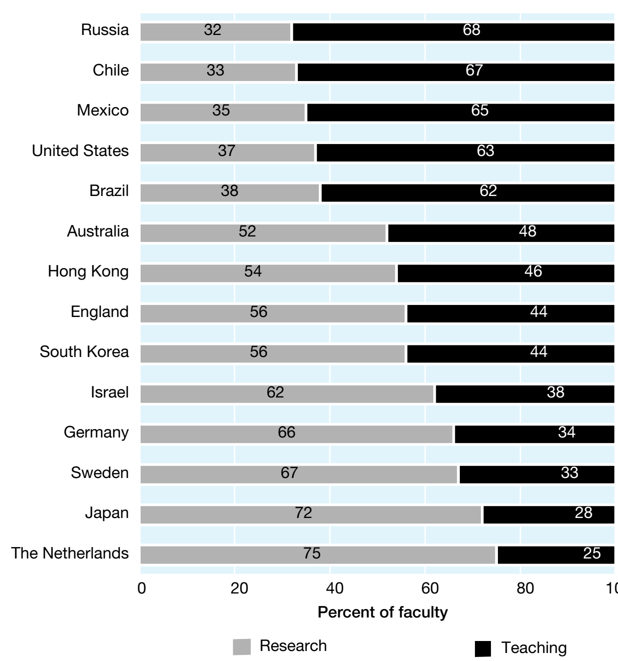
Most postsecondary faculty in the United States, in all fields, cited teaching as their principal job activity. The proportions of faculty who indicated teaching as their primary responsibility varied among the science fields by only about 10 percentage points—from about 63 percent in the natural sciences to about 73 percent in the social and behavioral sciences. (See appendix table 4-31.) However, within natural sciences, the proportions of faculty engaged primarily in teaching varied widely, from about 45 percent of life science faculty, to about 84 percent of mathematics. About 24 percent of faculty in the natural sciences cited research as their principal activity, compared with 16 percent in engineering and only 10 percent social and behavioral sciences.

In doctorate-granting institutions, faculty in science and engineering typically teach between one and two courses per semester. In master's- and bachelor's-degree-granting institutions, faculty in these fields teach between two and three courses on average. In 2-year institutions, faculty teach between three and four courses. (See appendix table 4-32.)

Academic research as a primary institutional mission is most commonly found among doctorate-granting institutions, which account for only 7 percent of postsecondary institutions. In 2-year institutions and bachelor's-granting institutions, which account for nearly 60 percent of the 3,600 postsecondary institutions in the United States, faculty interests and the reward and tenure system frequently reflect their greater teaching missions.

FIGURE 4–31

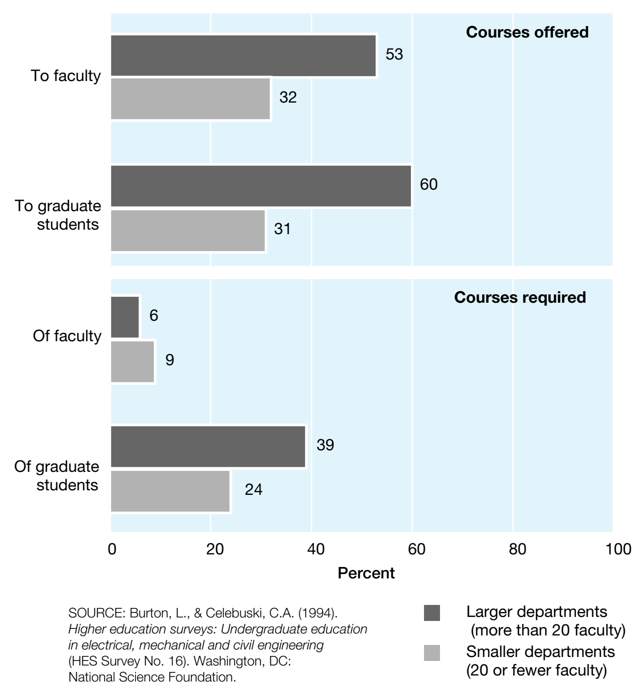
Percent of all faculty whose interest lies primarily in teaching versus research, by country of faculty residence: 1992



NOTE: Includes faculty of all disciplines and departments.
SOURCE: Mooney, C.J. (1994, June 22). The shared concerns of scholars. *The Chronicle of Higher Education,* XL (42), pp. A34-A38.

FIGURE 4–32

Percent of engineering departments (electrical, mechanical, and civil only) requiring or offering courses in communications to faculty and graduate students, by size of department: 1992



SOURCE: Burton, L., & Celebuski, C.A. (1994). *Higher education surveys: Undergraduate education in electrical, mechanical and civil engineering* (HES Survey No. 16). Washington, DC: National Science Foundation.
See appendix table 4–33.

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Project Kaleidoscope Provides New Perspectives

Project Kaleidoscope (1991), which began in 1989, is a collaborative effort to analyze and reform the current structure of undergraduate science and mathematics. Supported by the National Science Foundation and various grants, the project is a consortium of presidents, deans, and faculty in mathematics and the natural sciences from liberal arts colleges and other predominately undergraduate institutions. The consortium recommends revitalizing introductory undergraduate science and mathematics courses, supporting faculty in their role as teachers and scholars within the community of learners, and providing adequate science facilities and equipment. ■

Part-Time Instructors

Some teaching at postsecondary institutions is performed by graduate students and part-time instructors. About 1 in 10 mathematics courses at bachelor's-degree-granting institutions is taught by a graduate student; about 4 in 10 of these courses at 2-year institutions are taught by part-time faculty. Many of these instructors have little or no formal preparation for the classroom; moreover, many graduate teaching assistants are not native English speakers. (See section on foreign students on page 90.)

However, postsecondary institutions are taking steps to enhance teaching by part-time instructors and teaching assistants. Today, 17 states require public colleges and universities to certify that their teaching assistants are competent in English (Chronicle of Higher Education, 1994). Also, some engineering departments are requiring that their faculty and/or graduate students take courses in communications. These courses may cover teaching techniques, academic or career advising, English language skills, and American customs and behavior. About 33 percent of mechanical, electrical, and civil engineering departments require their graduate students to take communications-related classes. (See figure 4-32 and appendix table 4-33.) Large departments, those employing more than 20 faculty members, are more likely than small departments to offer and require these courses.

Instructional Practices

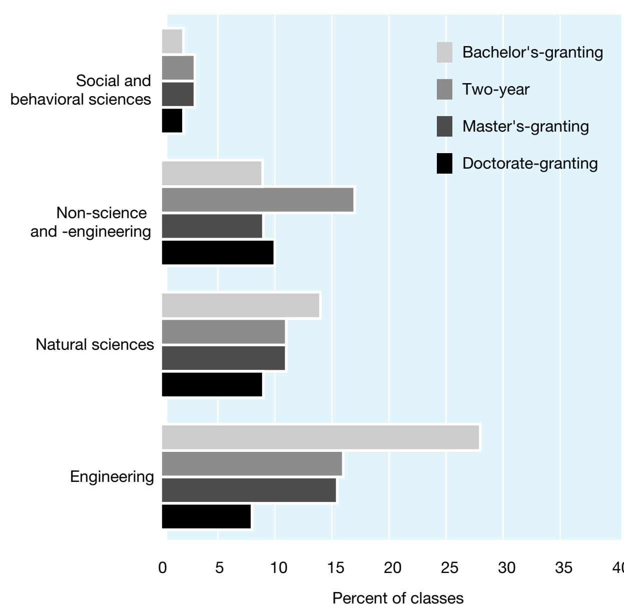
Effective science and engineering education requires that postsecondary institutions enable students to make connections between in-class learning and real-world situations—whether in the laboratory or in the field. Some postsecondary institutions are beginning to put this type of hands-on approach into practice. For instance, at the University of Houston—Downtown, through Project Kaleidoscope (see sidebar on Project Kaleidoscope), students have analyzed blood chemistry and height–weight data in order to establish the equations needed to determine the level of drug delivery for cancer patients undergoing chemotherapy.

However, overall, only a small percentage of science and engineering classes make use of a laboratory or problem-solving format; instead, they rely mostly on lectures. By field, the laboratory or problem-solving format is most likely to be used in engineering and least likely to be used in the social and behavioral sciences. The format's use varies significantly by institution type across fields. For example, although only about 9 percent of all science and engineering classes at bachelor's-granting institutions used laboratories and problem-solving sessions, 28 percent of engineering classes at these institutions used the format. (See figure 4-33 and appendix table 4-34.) In contrast, only about 8 percent of the engineering classes at doctorate-granting institutions used this format.

Still, many undergraduate mathematics majors have opportunities to perform discovery-based activities, including research projects and senior projects or theses. (See figure 4-34 and appendix table 4-35.) Doctorate-granting institutions are more likely than other types of institutions to allow undergraduate mathematics majors

FIGURE 4–33

Percent of classes that use a laboratory or problem-solving format, by type of institution and field of faculty: Fall 1992



SOURCE: National Center for Education Statistics. (1994b). [Special tabulations from the 1993 national study of postsecondary faculty]. Unpublished data.
See appendix table 4–34.

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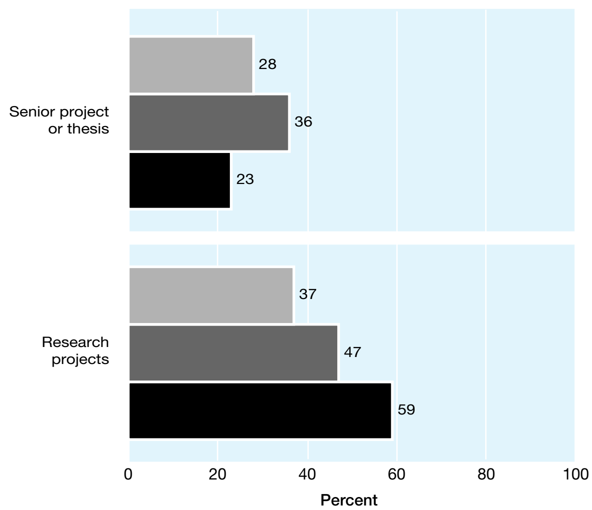
FIGURE 4–34

Percent of mathematics departments offering research opportunities to undergraduate mathematics majors, by type of project and institution: 1990



SOURCE: Albers, D.J., Loftsgaarden, D.O., Rung, D.C., & Watkins, A.E. (1992). *Statistical abstract of undergraduate programs in the mathematical sciences and computer science in the United States: 1990-91 CBMS survey* (MAA Notes No. 23). Washington, DC: Mathematical Association of America.
See appendix table 4–35.

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opportunities to engage in research. Master's-granting institutions are more likely to offer senior projects or theses than are other institutions. Bachelor's-granting institutions are more likely than other institutions to require calculus sections to perform writing activities, group projects, and computer assignments. (See appendix table 4-36 and the sidebar on calculus reform.)

Of course, laboratory or practical problem-solving experience is not, in itself, a guarantee that students will be challenged by and engaged in their science and engineering studies. The scientific research society, Sigma Xi (1990), reports that laboratory experiences—particularly at the introductory levels—lack imagination and are routine and dull. Many laboratory investigations make doing science seem like following a recipe in a cookbook: Students learn that if they repeat the steps outlined in the laboratory manual, they get the proper outcome. Instead, the laboratory format should instill understanding through discovery.

Similarly, Rigden and Tobias (1991) found that classroom atmosphere tends to dampen the spirit of intellectual adventure. They say that interactive, cooperative learning experiences take a distant back seat to passive instructional formats. Introductory classes tend to feature the professor working through a series of problems that students are expected to record in their notebooks and mimic on homework problems. This approach, along with the rapid pace of the courses, large class sizes, and a lack of exchange among students and with faculty, never allows students to see science and engineering as a process of discovery (Simpson & Anderson, 1992).

Resources

Much of the storehouse of research equipment and instrumentation owned by colleges and universities is not used for undergraduate instruction. Of all of the equipment and instrumentation valued at between $10,000 and $1 million owned by doctorate-granting institutions in 1989, just under two-thirds was used only in research. (See figure 4-35 and appendix table 4-37.) Just 8 percent

Reform in Calculus Classes

In 1986, a national calculus reform effort was born at a conference at Tulane University. The conference emphasized three main ideas:

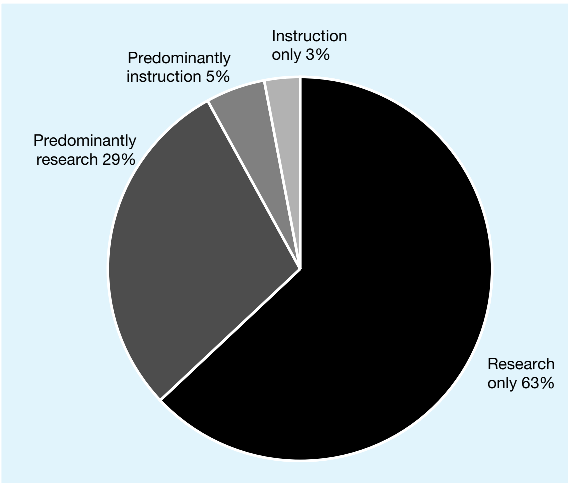
- Courses should promote conceptual understanding and the application of calculus to open-ended problems rather than focus on rote implementation of symbolic algorithms.
- Calculus should be geared to the needs of average students—students for whom some command of calculus is necessary for further learning in their majors.
- Students should be engaged in doing calculus as active learners.

To accomplish these goals, conference participants recommended a change in instructional techniques and the active use of technology—particularly computer technology—in learning (Leitzel & Tucker, 1994). Based on these ideas, in 1988, the National Science Foundation began funding calculus reform efforts across the Nation—efforts that have begun to make an impact. In 1992, just 11 percent of all postsecondary institutions reported that they were engaged in major reform of their calculus courses (Leitzel & Tucker, 1994). By 1994, however, that proportion had doubled.

Yet, as of 1990, few calculus courses embodied the activities advanced by the calculus reform movement. Of all calculus course sections offered in 4-year institutions, about 10 percent had some writing component, about 8 percent of sections used computer-based projects, and just 3 percent used group projects. ■

FIGURE 4–35

Percent of college and university equipment and instrumentation at doctorate-granting institutions used for instruction or research: 1988 to 1989



NOTE: Includes only movable instrumentation and equipment originally costing $10,000 to $999,999 owned by research-performing colleges and universities for use in the natural sciences and engineering, from 1988 to 1989.
SOURCE: National Science Foundation. (1991). *Characteristics of science/engineering equipment in academic settings: 1989-90* (NSF 91-315). Washington, DC: NSF.
See appendix table 4–37.

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of the equipment and instrumentation (such as computers, spectrometers, microscopes, and bioanalytical instruments) were used either solely or predominantly for instruction.[13]

Conclusion

Science, engineering, and technical education remains vital in the United States. An analysis of median earnings of full-time workers with at least a bachelor's degree shows that society places high value on those in natural science and engineering occupations. In 1990, engineers earned 26 percent more than the median income of those holding bachelor's or higher degrees in any field, physical scientists made 8 percent more, and computer scientists earned 5 percent more than the median income. However, those with degrees in education and the social sciences made 32 and 23 percent less, respectively, than the median (U.S. Department of Education, 1994).The ranking of median income by occupation was virtually the same in 1970.

Only one of the occupations that the Bureau of Labor Statistics projected to grow fastest in absolute numerical terms between 1992 and 2000 clearly required postsecondary science or technical educations: systems analysis. About half of the top 25 fastest growing occupations—which are expected to account for half of the total employment growth in the United States over the period—are in retail, clerical, and maintenance areas, requiring little or no advanced preparation in science and technology. However, occupations requiring training in natural sciences and engineering are expected to experience favorable growth between 1992 and 2000. Of course, projections must be interpreted with caution, because they are based on models that assume previous trends will continue.

Reviews and studies on the skills requirements of current and future jobs reveal little overall change in the skills required for particular occupations and no dramatic shifts in demand for skilled labor for the workforce of 2000 (Levin, 1993). However, some experts believe that, in order to remain competitive, employers will need workers with a greater depth and breadth of skills who can rethink and reorganize the way that goods and services are produced (Levin, 1993; Commission on the Skills of the American Workforce, 1990).

U.S. postsecondary science, engineering, and technical education should be able to fulfill future demands for skilled workers. Despite some problems, the condition of postsecondary science, engineering, and technical education in the United States is strong and is continuing to adapt to meet new pressures and needs. High school graduates have higher aspirations, and are better prepared, for postgraduate study. Total enrollment and the diversity of enrollment, in terms of sex, race, and ethnic origin, have increased, although somewhat slowly for blacks.

Very high proportions of students are taking at least one college course in mathematical or computer sciences, physical or life sciences, and social and behavioral sciences. Mathematics college course enrollments have increased, although a substantial part of that increase is due to increases in remedial math enrollments.

Ongoing reforms are changing the way science and engineering are taught and learned at the undergraduate level; however, very few college science and engineering courses are taught in a laboratory or problem-solving format, and seldom do mathematics courses require, for example, writing assignments, group projects, or computer assignments. Policy makers and educators continue to look for ways to reduce the high levels of student attrition from majors in the natural sciences and engineering.

Although the numbers of bachelor's, master's, and doctorate degrees earned by females and underrepresented racial and ethnic groups have increased, these groups remain underrepresented in science and engineering, particularly within the natural sciences and engineering, at the graduate level and among science and engineering faculty. Of particular concern are degree trends for blacks. The number of undergraduate- and graduate-level science and engineering degrees earned by blacks have remained relatively flat over the past 10 years. Moreover, the number of science and engineering doctorates earned by black males has actually declined.

More systematic research is needed on the quality of education received by students in college and universities, how curricula are being reformed, and ways of reducing student attrition. Research is particularly needed on the proper education of students who will become elementary and secondary schoolteachers of science and mathematics. In addition, research ought to consider more fully the contributions that science, engineering, and technical education make to the economy and national well-being. ■

Endnotes

[1] The report was based on the findings from 30 roundtable sessions that brought together senior officers from hundreds of colleges and universities across the United States.

[2] Because these students provide diverse perspectives that can potentially benefit science and technology fields, science and engineering education must change to accommodate new learning styles and fulfill new needs (Wineke & Certain, 1990).

[3] This is the first year for which complete enrollment data by race and ethnicity exist.

[4] The extent to which this finding applies to various subpopulations—including those who have historically been underrepresented in science and engineering—is unknown because of sample size.

[5] The problem of student retention in science and engineering is not confined to the undergraduate level. At the graduate level, as many as half of science and engineering graduate students fail to complete their studies (U.S. Department of Education, 1988).

[6] Some of this decrease can be attributed to students who graduate from high school and do not to pursue postsecondary education of any kind.

[7] For more information on trends in science and engineering degrees, see NSB (1993).

[8] People with disabilities are also considered to be underrepresented in science and engineering, although no data on degrees by disability status exist.

[9] Technicians apply science- and engineering-based techniques using complex technologies in order to transform materials into useful products. Technicians may also be called upon to modify or repair equipment that is used in the production of goods and services.

[10] The Carnegie Foundation for the Advancement of Teaching last classified U.S. postsecondary institutions in 1987.

[11] Two-year institutions provide educational access for local residents to job-related courses, adult education, technically based programs, and preparation for study at 4-year institutions. Tuition is generally lower at 2-year institutions than at 4-year colleges, and campuses are community-based, allowing students to pursue postsecondary education more easily while holding full- or part-time jobs.

[12] One reason may be that these institutions draw students from a wider geographic area than other schools and combine an educational mission with a strong mission in fundamental research and discovery.

[13] The proportion of this fraction that was available for undergraduate, rather than graduate, instruction is unknown.

Chapter 4 References

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Chapter 5

Appendix Tables

List of Appendix Tables

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Chapter 3—The Elementary and Secondary Learning Environment

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Appendix table 1-1

Summary of NSF funding for the Directorate for Education and Human Resources (EHR): 1956 to 1994 (dollars in millions)

		EHR		K-12		Undergraduate		Graduate		Informal		Other	
Fiscal Year	Total NSF	Total	Percent of NSF	Total	Percent of EHR	Total	Percent of EHR	Total	Percent of EHR	Total	Percent of EHR	Total	Percent of EHR
1956	16.0	3.5	22.0	0.9	24.1	0.6	15.9	2.1	59.1	0.0	0.0	--	--
1957	38.6	14.3	37.0	10.2	71.0	1.1	8.0	3.0	21.0	0.0	0.0	--	--
1958	50.0	19.2	38.4	12.7	66.0	2.5	13.0	4.2	22.0	0.0	0.0	--	--
1959	132.9	61.3	46.1	41.1	67.0	10.4	17.0	9.8	16.0	0.0	0.0	--	--
1960	158.6	63.7	40.2	41.4	65.0	11.5	18.0	10.2	16.0	0.3	0.5	--	--
1961	175.0	63.4	36.3	38.7	61.0	14.0	22.0	10.8	17.0	0.3	0.5	--	--
1962	260.8	83.6	32.1	52.7	63.0	15.9	19.0	14.2	17.0	0.3	0.4	--	--
1963	320.8	98.7	30.8	56.3	57.0	22.7	23.0	18.8	19.0	0.4	0.4	--	--
1964	354.6	111.2	31.4	60.1	54.0	23.4	21.0	26.7	24.0	0.4	0.4	--	--
1965	416.0	120.4	28.9	53.0	44.0	31.3	26.0	36.1	30.0	0.4	0.3	--	--
1966	466.4	124.3	26.6	52.2	42.0	32.3	26.0	39.8	32.0	0.1	0.1	--	--
1967	465.1	125.8	27.1	50.3	40.0	30.2	24.0	45.3	36.0	0.4	0.3	--	--
1968	500.3	134.5	26.9	53.8	40.0	35.0	26.0	44.4	33.0	0.3	0.2	--	--
1969	432.6	115.3	26.7	45.0	39.0	30.0	26.0	40.4	35.0	0.2	0.2	--	--
1970	462.5	120.4	26.0	50.5	41.9	27.6	23.0	42.1	34.9	0.2	0.2	--	--
1971	496.1	98.8	19.9	36.6	37.0	21.7	22.0	39.5	40.0	0.4	0.4	--	--
1972	600.7	86.1	14.3	35.3	41.0	27.6	32.0	23.3	27.0	0.7	0.8	--	--
1973	610.3	62.2	10.2	24.3	39.0	17.4	28.0	19.3	31.0	0.6	1.0	--	--
1974	645.7	80.7	12.5	30.7	38.0	29.1	36.0	19.4	24.0	2.4	3.0	--	--
1975	693.1	74.0	10.7	28.1	38.0	21.5	29.0	22.2	30.0	1.5	2.0	--	--
1976	724.4	62.5	8.6	7.5	12.0	35.0	56.0	17.5	28.0	2.5	4.0	--	--
1977	791.8	74.3	9.4	9.7	13.0	43.1	58.0	17.8	24.0	3.7	5.0	--	--
1978	857.3	74.0	8.6	14.1	19.0	35.5	48.0	18.5	25.0	5.2	7.0	--	--
1979	926.9	80.0	8.6	16.0	20.0	36.8	46.0	20.8	26.0	6.4	8.0	--	--
1980	975.1	77.2	7.9	16.9	21.9	32.3	41.8	20.3	26.3	7.6	9.9	--	--
1981	1,035.3	70.7	6.8	26.1	36.9	26.0	36.8	14.8	21.0	3.8	5.3	--	--
1982	999.1	20.9	2.1	3.8	18.3	0.0	0.0	15.0	71.8	2.1	10.0	--	--
1983	1,101.7	30.0	2.7	12.8	42.7	0.0	0.0	15.0	50.0	2.2	7.3	--	--
1984	1,306.9	75.0	5.7	52.5	70.0	0.0	0.0	20.3	27.1	2.2	2.9	--	--
1985	1,507.1	82.0	5.4	42.5	51.8	5.0	6.1	27.3	33.3	7.2	8.8	--	--
1986	1,493.2	84.6	5.7	44.7	52.9	5.4	6.3	26.5	31.4	8.0	9.4	--	--
1987	1,627.6	99.0	6.1	50.8	51.3	9.5	9.6	27.3	27.6	11.4	11.5	--	--
1988	1,722.6	139.2	8.1	76.4	54.9	19.0	13.6	30.3	21.8	13.5	9.7	--	--
1989	1,885.9	171.0	9.1	104.0	60.8	28.0	16.4	24.0	14.0	15.0	8.8	--	--
1990	2,026.1	204.3	10.1	125.0	61.2	34.0	16.6	29.9	14.6	15.4	7.5	--	--
1991	2,343.5	322.0	13.7	194.3	60.3	47.6	14.8	38.8	12.0	23.1	7.2	18.2	5.7
1992	2,571.3	441.5	17.2	269.9	61.1	68.7	15.6	50.2	11.4	34.5	7.8	18.1	4.1
1993	2,749.7	505.1	18.4	273.5	54.2	74.5	14.8	77.4	15.3	34.6	6.9	45.1	8.9
1994	3,017.8	569.0	18.9	323.6	56.9	98.2	17.3	59.9	10.5	34.6	6.1	52.6	9.2

-- Not applicable (not in EHR budget).
NOTES: "K-12" excludes informal science, and includes the public science portion of Research on Teaching and Learning. "Other" includes activities such as EPSCoR, Faculty Awards for Women, Visiting Professorships for Women, and Minority Research Centers.
SOURCES: National Science Foundation. (1992). *EHR Directory of awards: Fiscal year 1990* (NSF 92-75). Washington, DC: NSF; National Science Foundation. (1994). [Budget figures]. Unpublished tabulations.

Appendix table 1-2

Total budget obligations in fiscal year 1994 for mathematics, science, engineering, and technological education of 11 Federal agencies (dollars in millions): 1995

Level of school	Total enacted	Federal agency: National Science Foundation	Dept. of Education	Dept. of Health & Human Services	Dept. of Defense	Other seven agencies
Grand total	$2,612	$610	$524	$712	$540	$226
Kindergarten to 12th	771	339	333	21	26	52
Undergraduate	426	176	10	37	145	58
Graduate	999	88	27	449	369	66
Public understanding of science (informal science)	416	7	154	205	--	50

-- Not available.
NOTES: Other Federal agencies include the Departments of Agriculture, Commerce, Energy, and Interior; Smithsonian Institution, National Aeronautics and Space Administration, and Environmental Protection Agency. Because of definitional changes, these figures may not be compatible with previous analyses of this topic. Agency figures may be different as result of evolving priorities for uses of funding.
SOURCE: National Science and Technology Council (NSTC) Committee on Education and Training (CET) Budget Working Group. (1995). [Budget figures from departmental budget offices]. Unpublished tabulations.

Appendix table 1-3

Number and percent of students enrolled in grades 1-12 and college, by race or ethnic origin: 1970 to 1993

Level of school	Race or ethnic origin	1970	1975	1980	1985	1990	1993
		Number (in thousands)					
Grades 1-12	All races	48,665	46,129	42,005	40,845	41,984	44,126
	White	41,361	38,636	34,566	32,971	33,520	34,900
	Black	6,702	6,708	6,459	6,438	6,602	7,109
	Hispanic	NA	3,010	3,411	3,959	4,738	5,090
	Other races	602	785	980	1,436	1,862	2,117
College	All races	7,413	9,697	10,180	10,863	11,303	11,409
	White	6,759	8,516	8,875	9,334	9,465	9,366
	Black	522	948	1,007	1,049	1,187	1,261
	Hispanic	NA	411	443	579	617	867
	Other races	132	233	298	480	651	782
		Percent					
Grades 1-12	All races	100	100	100	100	100	100
	White	85	84	82	81	80	79
	Black	14	15	15	16	16	16
	Hispanic	NA	7	8	10	12	12
	Other races	1	1	2	4	4	5
College	All races	100	100	100	100	100	100
	White	91	88	87	86	84	82
	Black	7	10	10	10	11	11
	Hispanic	NA	4	4	5	5	8
	Other races	2	2	3	4	6	7

NA: Not available.
NOTES: Persons of Hispanic origin may be of any race. Totals may not equal 100 percent as a result of rounding.
SOURCES: U.S. Bureau of the Census. (1990). *School enrollment—social and economic characteristics of students: 1989* (Current Population Reports, Population Characteristics Series P-20, No. 443). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1991). *School enrollment—social and economic characteristics of students: October 1990* (Current Population Reports, Population Characteristics Series P-20, No. 460). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1994). *School enrollment—social and economic characteristics of students: October 1993* (Current Population Reports, Population Characteristics Series P-20, No. 479). Washington, DC: U.S. Government Printing Office.

Appendix table 1-4

Children ages 5-17 speaking a language other than English at home, by English proficiency level: 1980 and 1990

Language proficiency level	Number 1980	Number 1990	Percent 1980	Percent 1990
			All children ages 5–17	
All children ages 5-17	47,493,975	45,342,448	100	100
Children who speak a language other than English	4,568,329	6,322,934	10	14
			Children who speak a language other than English	
English proficiency level				
Very well	2,670,957	3,934,691	59	62
Well	1,235,088	1,480,680	27	23
Not well	509,665	761,778	11	12
Not at all	125,161	145,785	3	2

NOTES: Includes only children in households and excludes children in group quarters. Proficiency level reported by the householder completing the census form.
SOURCES: U.S. Department of Commerce. (1980). *1980 Census of population, detailed population characteristics: United States summary* (PC 80-1-D1-A). Washington, DC: U.S. Bureau of the Census; U.S. Department of Commerce. (1990). *1990 Census of population* (CPH-L-96). Washington, DC: U.S. Bureau of the Census.

Appendix table 1-5

Education level of parents of elementary or secondary school students, by student race or ethnic origin: 1970 to 1993

Education level	Number (in thousands) 1970	1980	1990	1993	Percent 1970	1980	1990	1993
	Students of all races							
Total	48,016	41,369	39,923	41,707	99.9	100.0	100.1	100.0
0-8 years of school	9,812	5,921	3,518	2,653	20.4	14.3	8.8	6.4
9-11 years of school	9,079	6,232	4,691	4,553	18.9	15.1	11.8	10.9
High school graduate	16,871	15,743	14,894	14,094	35.1	38.0	37.3	33.8
College 1-3 years	5,107	6,127	7,930	10,813	10.6	14.8	19.9	25.9
College graduate or more	7,147	7,346	8,890	9,593	14.9	17.8	22.3	23.0
	White students							
Total	40,825	34,050	32,021	33,124	100.0	100.0	100.0	100.0
0-8 years of school	7,258	4,412	2,628	2,049	17.8	13.0	8.2	6.2
9-11 years of school	7,094	4,358	3,238	3,030	17.4	12.8	10.1	9.1
High school graduate	15,262	13,277	11,905	11,090	37.4	39.0	37.2	33.5
College 1-3 years	4,655	5,260	6,479	8,704	11.4	15.4	20.2	26.3
College graduate or more	6,556	6,743	7,771	8,250	16.0	19.8	24.3	24.9
	Black students							
Total	6,602	6,358	6,155	6,598	100.1	100.0	100.0	100.0
0-8 years of school	2,401	1,326	645	360	36.4	20.9	10.5	5.5
9-11 years of school	1,910	1,769	1,335	1,301	28.9	27.8	21.7	19.7
High school graduate	1,411	2,175	2,492	2,522	21.4	34.2	40.5	38.2
College 1-3 years	421	744	1,090	1,768	6.4	11.7	17.7	26.8
College graduate or more	459	344	593	650	7.0	5.4	9.6	9.9
	Hispanic students							
Total	NA	3,347	4,420	4,704	NA	100.0	99.9	100.0
0-8 years of school	NA	1,634	1,677	1,438	NA	48.8	37.9	30.6
9-11 years of school	NA	493	735	943	NA	14.7	16.6	20.0
High school graduate	NA	774	1,184	1,280	NA	23.1	26.8	27.2
College 1-3 years	NA	293	539	728	NA	8.8	12.2	15.5
College graduate or more	NA	153	285	315	NA	4.6	6.4	6.7

NA: Not available.
NOTES: Data not available for Hispanics before 1980. Persons of Hispanic origin may be of any race. Numbers may not equal totals as a result of rounding.
SOURCES: U.S. Bureau of the Census. (1971). *School enrollment: October 1970* (Current Population Reports, Population Characteristics Series P-20, No. 222). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1981). *School enrollment—social and economic characteristics of students: October 1981 and 1980* (Current Population Reports, Population Characteristics Series P-20, No. 400). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1991). *School enrollment—social and economic characteristics of students: October 1990* (Current Population Reports, Population Characteristics Series P-20, No. 460). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1993). *School enrollment—social and economic characteristics of students: October 1992* (Current Population Reports, Population Characteristics Series P-20, No. 474). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1994). *School enrollment—social and economic characteristics of students: October 1993* (Current Population Reports, Current Population Series P-20, No. 479). Washington, DC: U.S. Government Printing Office.

Appendix table 1-6

Number and percent of one- or two-parent families with children under age 18, by race or ethnic origin: 1970 to 1993

	Number (in thousands)				Percent			
Family characteristic	1970	1980	1990	1993	1970	1980	1990	1993
All families, total	29,631	32,150	34,670	36,058	100	100	100	100
White	26,115	27,294	28,294	29,225	100	100	100	100
Black	3,219	4,705	5,087	5,364	100	100	100	100
Hispanic	NA	2,194	3,429	3,838	100	100	100	100
One-parent families, total	3,808	6,920	9,749	10,901	13	22	28	30
White	2,638	4,664	6,389	7,167	10	17	23	25
Black	1,148	2,114	3,081	3,377	36	52	61	63
Hispanic	NA	568	1,140	1,344	NA	26	33	35
Two-parent families, total	25,823	25,231	24,921	25,157	87	78	72	70
White	23,477	22,628	21,905	22,058	90	83	77	76
Black	2,071	1,961	2,006	1,987	64	48	39	37
Hispanic	NA	1,626	2,289	2,494	NA	74	67	65

NA: Not available.
NOTES: Persons of Hispanic origin may be of any race. Numbers may not equal totals as a result of rounding.
SOURCES: U.S. Bureau of the Census. (1992). *Household and family characteristics: March 1991* (Current Population Reports, Population Characteristics Series P-20, No. 458). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1993). *Household and family characteristics: March 1992* (Current Population Reports, Population Characteristics Series P-20, No. 467). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1994). *Household and family characteristics: March 1993* (Current Population Reports, Population Characteristics Series P-20, No. 477). Washington, DC: U.S. Government Printing Office.

Appendix table 1-7

Number and percent of white, black, and Hispanic children ages 6-17 below the poverty level: 1970 to 1993

Race or	Number (in thousands)				Percent below poverty level			
ethnic origin	1970	1980	1990	1993	1970	1980	1990	1993
Total	6,932	7,128	6,848	8,865	14.3	16.8	17.6	20.1
White	4,101	4,336	4,254	5,369	9.9	12.4	13.4	15.4
Black	2,708	2,544	2,206	2,999	41.3	40.4	39.8	42.6
Hispanic	NA	NA	1,545	2,117	NA	NA	36.7	37.7

NA: Not available.
NOTES: Poverty status of 1970, 1980, 1990, and 1993 as surveyed on a sample in March of 1971, 1981, 1991, and 1994, respectively. Persons of Hispanic origin may be of any race.
SOURCES: U.S. Bureau of the Census. (1971). *Characteristics of the low-income population: 1970* (Current Population Reports, Population Characteristics Series P-60, No. 18). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1981). *Characteristics of the population below the poverty level: 1980* (Current Population Reports, Population Characteristics Series P-60, No. 133). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1991). *Poverty in the United States: 1990* (Current Population Reports, Population Characteristics Series P-60, No. 175). Washington, DC: U.S. Government Printing Office; U.S. Bureau of the Census. (1994). *Official poverty statistics: 1993* (Current Population Reports, Population Characteristics Series P-60, No. 188). Washington, DC: Government Printing Office.

Appendix table 2-1

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

Age and race or ethnic origin		Anchor point	1977		1982		1986		1990		1992		Difference 1977-1992		Difference 1982-1992	
Age 17	Total	300	41.7	(0.9)	37.3	(0.9)	41.3	(1.4)	43.3	(1.3)	46.6	(1.5)	4.9	(1.7)	9.3	(1.7)
	White		47.5	(0.7)	43.9	(1.2)	48.7	(1.7)	51.2	(1.5)	55.4	(1.7)	7.9	(1.8)	11.5	(2.1)
	Black		7.7	(1.0)	6.5	(1.1)	12.5	(2.2)	15.7	(4.0)	14.1	(2.5)	6.4	(2.7)	7.6	(2.7)
	Hispanic		18.5	(2.1)	11.1	(2.0)	14.8	(2.9)	21.1	(3.3)	23.0	(3.8)	4.5	(4.3)	11.9	(4.3)
	Total	250	81.6	(0.7)	76.6	(1.0)	80.7	(1.3)	81.2	(0.9)	83.3	(1.2)	1.7	(1.4)	6.7	(1.6)
	White		88.2	(0.4)	84.9	(0.9)	87.8	(1.4)	89.6	(0.8)	90.5	(1.0)	2.3	(1.1)	5.6	(1.3)
	Black		40.5	(1.5)	35.0	(2.1)	52.2	(3.2)	51.4	(3.7)	55.7	(3.7)	15.2	(4.0)	20.7	(4.3)
	Hispanic		61.5	(1.7)	48.0	(2.7)	60.0	(7.2)	59.9	(5.0)	68.3	(6.6)	6.8	(6.8)	20.3	(7.1)
	Total	200	97.1	(0.2)	95.7	(0.5)	97.1	(0.5)	96.7	(0.3)	97.8	(0.5)	0.7	(0.5)	2.1	(0.7)
	White		99.2	(0.1)	98.6	(0.2)	98.8	(0.3)	99.0	(0.2)	99.3	(0.3)	0.1	(0.3)	0.7	(0.4)
	Black		83.6	(1.3)	79.7	(1.9)	90.9	(2.1)	88.3	(1.9)	92.1	(1.8)	8.5	(2.2)	12.4	(2.6)
	Hispanic		93.1	(1.7)	86.9	(2.9)	93.3	(2.4)	91.9	(2.2)	94.6	(2.6)	1.5	(3.1)	7.7	(3.9)
Age 13	Total	300	11.1	(0.5)	9.6	(0.7)	9.1	(0.9)	11.2	(0.6)	12.0	(0.8)	0.9	(0.9)	2.4	(1.1)
	White		13.4	(0.5)	11.5	(0.8)	11.3	(1.2)	14.2	(0.8)	15.0	(1.0)	1.6	(1.1)	3.5	(1.3)
	Black		1.2	(0.4)	0.8	(0.3)	1.1	(0.4)	1.5	(0.5)	1.8	(0.8)	0.6	(0.9)	1.0	(0.9)
	Hispanic		1.8	(0.8)	2.4	(0.9)	1.5	(0.7)	3.3	(0.8)	3.3	(1.3)	1.5	(1.5)	0.9	(1.6)
	Total	250	48.8	(1.1)	50.9	(1.6)	52.5	(1.6)	56.5	(1.0)	61.3	(1.1)	12.5	(1.6)	10.4	(1.9)
	White		56.5	(0.9)	58.3	(1.4)	61.0	(1.7)	66.5	(1.2)	71.1	(1.3)	14.6	(1.6)	12.8	(1.9)
	Black		14.9	(1.7)	17.1	(1.9)	19.6	(2.8)	24.3	(3.3)	26.2	(2.8)	11.3	(3.3)	9.1	(3.4)
	Hispanic		18.1	(1.8)	24.1	(5.1)	24.9	(4.3)	30.0	(2.8)	36.5	(2.9)	18.4	(3.4)	12.4	(5.9)
	Total	200	86.0	(0.7)	89.8	(0.8)	91.6	(1.0)	92.3	(0.7)	93.1	(0.5)	7.1	(0.9)	3.3	(0.9)
	White		92.2	(0.5)	94.4	(0.6)	96.1	(0.8)	96.9	(0.4)	97.9	(0.4)	5.7	(0.6)	3.5	(0.7)
	Black		57.3	(2.4)	68.6	(2.4)	73.6	(3.0)	77.6	(3.6)	73.8	(2.8)	16.5	(3.7)	5.2	(3.7)
	Hispanic		62.2	(2.4)	75.5	(3.3)	76.7	(3.2)	80.2	(2.9)	86.2	(2.6)	24.0	(3.5)	10.7	(4.2)
Age 9	Total	300	3.2	(0.3)	2.3	(0.7)	3.0	(0.5)	3.1	(0.3)	3.4	(0.3)	0.2	(0.4)	1.1	(0.8)
	White		3.9	(0.3)	2.9	(0.9)	3.8	(0.6)	3.9	(0.4)	4.3	(0.4)	0.4	(0.5)	1.4	(1.0)
	Black		0.2	(0.1)	0.1	(0.4)	0.3	(0.2)	0.1	(0.2)	0.3	(0.3)	0.1	(0.3)	0.2	(0.5)
	Hispanic		0.3	(0.4)	0.0	(0.0)	0.2	(0.2)	0.4	(0.4)	0.4	(0.4)	0.1	(0.6)	0.4	(0.4)
	Total	250	25.7	(0.7)	24.3	(1.8)	27.5	(1.4)	31.1	(0.8)	32.8	(1.0)	7.1	(1.2)	8.5	(2.1)
	White		30.8	(0.7)	29.4	(2.1)	32.7	(1.5)	37.5	(1.1)	39.4	(1.1)	8.6	(1.3)	10.0	(2.4)
	Black		3.5	(0.6)	3.9	(1.3)	8.3	(1.5)	8.5	(1.1)	9.2	(1.4)	5.7	(1.5)	5.3	(1.9)
	Hispanic		8.8	(1.7)	4.2	(2.7)	10.7	(2.4)	11.6	(2.1)	11.7	(1.8)	2.9	(2.5)	7.5	(3.2)
	Total	200	68.0	(1.1)	70.7	(1.9)	72.0	(1.1)	76.4	(0.9)	78.0	(1.2)	10.0	(1.6)	7.3	(2.2)
	White		76.8	(0.7)	78.4	(2.0)	78.9	(1.0)	84.4	(0.7)	85.5	(0.9)	8.7	(1.1)	7.1	(2.2)
	Black		27.2	(1.5)	38.9	(2.7)	46.2	(2.3)	46.4	(3.1)	51.3	(3.5)	24.1	(3.8)	12.4	(4.4)
	Hispanic		42.0	(3.1)	40.2	(6.1)	50.1	(3.7)	56.3	(3.7)	55.5	(4.3)	13.5	(5.3)	15.3	(7.5)

NOTE: Standard errors appear in parentheses.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

Appendix table 2-2

NAEP mathematics proficiency: percent of students at or above selected anchor points, by age and race or ethnic origin, 1978 to 1992

Age and race or ethnic origin		Anchor point	1978		1982		1986		1990		1992		Difference 1978-1992		Difference 1982-1992	
Age 17	Total	300	51.5	(1.1)	48.5	(1.3)	51.7	(1.4)	56.1	(1.4)	59.1	(1.3)	7.6	(1.7)	10.6	(1.8)
	White		57.6	(1.1)	54.7	(1.4)	59.1	(1.7)	63.2	(1.6)	66.4	(1.4)	8.8	(1.8)	11.7	(2.0)
	Black		16.8	(1.6)	17.1	(1.5)	20.8	(2.8)	32.8	(4.5)	29.8	(3.9)	13.0	(4.2)	12.7	(4.2)
	Hispanic		23.4	(2.7)	21.6	(2.2)	26.5	(4.5)	30.1	(3.1)	39.2	(4.9)	15.8	(5.6)	17.6	(5.4)
	Total	250	92.0	(0.5)	93.0	(0.5)	95.6	(0.5)	96.0	(0.5)	96.6	(0.5)	4.6	(0.7)	3.6	(0.7)
	White		95.6	(0.3)	96.2	(0.3)	98.0	(0.4)	97.6	(0.3)	98.3	(0.4)	2.7	(0.5)	2.1	(0.5)
	Black		70.7	(1.7)	76.4	(1.5)	85.6	(2.5)	92.4	(2.2)	89.6	(2.5)	18.9	(3.0)	13.2	(2.9)
	Hispanic		78.3	(2.3)	81.4	(1.9)	89.3	(2.5)	85.8	(4.2)	94.1	(2.2)	15.8	(3.2)	12.7	(2.9)
	Total	200	98.8	(0.1)	99.9	(0.0)	99.9	(0.1)	100.0	(0.1)	100.0	(0.0)	1.2	(0.1)	0.1	(0.0)
	White		100.0	(0.0)	100.0	(0.0)	100.0	(0.1)	100.0	(0.0)	100.0	(0.0)	0.0	(0.0)	0.0	(0.0)
	Black		98.8	(0.3)	99.7	(0.2)	100.0	(0.2)	99.9	(0.2)	100.0	(0.1)	1.2	(0.3)	0.3	(0.2)
	Hispanic		99.3	(0.4)	99.8	(0.3)	99.4	(1.2)	99.6	(0.7)	100.0	(0.0)	0.7	(0.4)	0.2	(0.3)
Age 13	Total	300	18.0	(0.7)	17.4	(0.9)	15.8	(1.0)	17.3	(1.0)	18.9	(1.0)	0.9	(1.2)	1.5	(1.3)
	White		21.4	(0.7)	20.5	(1.0)	18.6	(1.2)	21.0	(1.2)	22.8	(1.3)	1.4	(1.5)	2.3	(1.6)
	Black		2.3	(0.5)	2.9	(1.0)	4.0	(1.4)	3.9	(1.6)	4.0	(0.7)	1.7	(0.9)	1.1	(1.2)
	Hispanic		4.0	(1.0)	6.3	(1.0)	5.5	(1.1)	6.4	(1.7)	7.0	(1.2)	3.0	(1.6)	0.7	(1.6)
	Total	250	64.9	(1.2)	71.4	(1.2)	73.3	(1.6)	74.7	(1.0)	77.9	(1.1)	13.0	(1.6)	6.5	(1.6)
	White		72.9	(0.9)	78.3	(0.9)	78.9	(1.7)	82.0	(1.0)	84.9	(1.1)	12.0	(1.4)	6.6	(1.4)
	Black		28.7	(2.1)	37.9	(2.5)	49.0	(3.7)	48.7	(3.6)	51.0	(2.7)	22.3	(3.4)	13.1	(3.7)
	Hispanic		36.0	(2.9)	52.2	(2.5)	56.0	(5.0)	56.7	(3.3)	63.3	(2.7)	27.3	(4.0)	11.1	(3.7)
	Total	200	94.6	(0.5)	97.7	(0.4)	98.6	(0.2)	98.5	(0.2)	98.7	(0.3)	4.1	(0.6)	1.0	(0.5)
	White		97.6	(0.3)	99.1	(0.1)	99.3	(0.3)	99.4	(0.1)	99.6	(0.2)	2.0	(0.4)	0.5	(0.2)
	Black		79.7	(1.5)	90.2	(1.6)	95.4	(0.9)	95.4	(1.1)	95.0	(1.4)	15.3	(2.1)	4.8	(2.1)
	Hispanic		86.4	(0.9)	95.9	(0.9)	96.9	(1.4)	96.8	(1.1)	98.1	(0.7)	11.7	(1.1)	2.2	(1.1)
Age 9	Total	300	0.8	(0.1)	0.6	(0.1)	0.6	(0.2)	1.2	(0.3)	1.2	(0.3)	0.4	(0.3)	0.6	(0.3)
	White		0.9	(0.2)	0.6	(0.1)	0.8	(0.3)	1.5	(0.4)	1.4	(0.3)	0.5	(0.4)	0.8	(0.3)
	Black		0.0	(0.1)	0.0	(0.1)	0.1	(0.1)	0.1	(0.1)	0.1	(0.1)	0.1	(0.1)	0.1	(0.1)
	Hispanic		0.2	(0.5)	0.0	(0.0)	0.1	(0.2)	0.2	(0.2)	0.1	(0.5)	-0.1	(0.7)	0.1	(0.5)
	Total	250	19.6	(0.7)	18.8	(1.0)	20.7	(0.9)	27.7	(0.9)	27.8	(0.9)	8.2	(1.1)	9.0	(1.3)
	White		22.9	(0.9)	21.8	(1.1)	24.6	(1.0)	32.7	(1.0)	32.4	(1.0)	9.5	(1.3)	10.6	(1.5)
	Black		4.1	(0.6)	4.4	(0.8)	5.6	(0.9)	9.4	(1.7)	9.6	(1.4)	5.5	(1.5)	5.2	(1.6)
	Hispanic		9.2	(2.5)	7.8	(1.7)	7.3	(2.8)	11.3	(3.5)	11.7	(2.5)	2.5	(3.5)	3.9	(3.0)
	Total	200	70.4	(0.9)	71.4	(1.2)	74.1	(1.2)	81.5	(1.0)	81.4	(0.8)	11.0	(1.2)	10.0	(1.4)
	White		76.3	(1.0)	76.8	(1.2)	79.6	(1.3)	86.9	(0.9)	86.9	(0.7)	10.6	(1.2)	10.1	(1.4)
	Black		42.0	(1.4)	46.1	(2.4)	53.4	(2.5)	60.0	(2.8)	59.8	(2.8)	17.8	(3.1)	13.7	(3.7)
	Hispanic		54.2	(2.8)	55.7	(2.3)	57.6	(2.9)	68.4	(3.0)	65.0	(2.9)	10.8	(4.0)	9.3	(3.7)

NOTE: Standard errors appear in parentheses.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

Appendix table 2-3

Percent of eighth-grade mathematics students performing at each proficiency level, by race or ethnic origin and socioeconomic status: 1988

Proficiency level and race or ethnic origin of student	Total		Socioeconomic status: Low		Middle		High	
Percent performing below basic level								
White	15.5	(0.7)	25.8	(2.0)	16.1	(0.9)	8.2	(0.8)
Black	28.9	(1.9)	33.4	(3.1)	26.6	(2.7)	20.1	(4.8)
Hispanic	27.6	(1.8)	32.8	(2.8)	24.8	(2.8)	14.0	(4.3)
Asian	13.4	(2.0)	27.6	(6.0)	13.0	(3.0)	6.4	(2.3)
Percent performing at basic level								
White	37.9	(0.9)	48.1	(2.2)	41.3	(1.3)	25.8	(1.3)
Black	49.4	(2.1)	51.3	(3.3)	50.9	(3.1)	34.7	(5.6)
Hispanic	46.8	(2.0)	49.3	(2.9)	46.6	(3.2)	36.5	(5.9)
Asian	30.7	(2.7)	38.3	(6.5)	39.5	(4.3)	15.9	(3.4)
Percent performing at intermediate level								
White	24.3	(0.8)	19.4	(1.8)	24.8	(1.1)	26.3	(1.3)
Black	16.5	(1.6)	13.0	(2.2)	18.0	(2.4)	24.2	(5.1)
Hispanic	16.9	(1.5)	13.5	(2.0)	18.9	(2.5)	24.2	(5.3)
Asian	21.2	(2.4)	15.7	(4.9)	21.4	(3.6)	23.8	(4.0)
Percent performing at advanced level								
White	22.4	(0.7)	6.8	(1.1)	17.9	(1.0)	39.8	(1.5)
Black	5.3	(0.9)	2.3	(1.0)	4.6	(1.3)	21.0	(4.8)
Hispanic	8.7	(1.2)	4.3	(1.2)	9.7	(1.9)	25.4	(5.3)
Asian	34.7	(2.8)	18.5	(5.2)	26.0	(3.9)	53.9	(4.7)

NOTES: Persons of Hispanic origin may be of any race. Standard errors appear in parentheses.
SOURCE: Rock, D.A., Pollack, J.M., & Hafner, A. (1991). *The tested achievement of the national education longitudinal study of the 1988 eighth grade class* (NCES 91-460). Washington, DC: U.S. Department of Education.

Appendix table 2-4

Average percent of questions answered correctly on the NAEP mathematics exam, by type of question, race or ethnic origin, and age: 1992

Type of question and race or ethnic origin	Age 9	Age 13	Age 17
Extended constructed response			
White	20 (0.8)	10 (0.6)	10 (0.5)
Black	5 (0.7)	2 (0.3)	4 (0.7)
Hispanic	7 (1.0)	3 (0.5)	4 (0.6)
Short constructed response			
White	47 (0.6)	59 (0.6)	44 (0.6)
Black	24 (0.8)	36 (0.9)	26 (0.9)
Hispanic	31 (0.7)	42 (0.7)	32 (0.9)
Multiple choice			
White	53 (0.5)	60 (0.5)	59 (0.4)
Black	38 (0.6)	42 (0.6)	46 (0.9)
Hispanic	42 (0.7)	46 (0.7)	49 (1.0)

NOTES: Standard errors appear in parentheses. Persons of Hispanic origin may be of any race.
SOURCE: Dossey, J.A., Mullis, I.V.S., & Jones, C.O. (1993). *Can students do mathematical problem solving? Results from constructed-response questions in NAEP's 1992 mathematics assessment.* Washington, DC: U.S. Department of Education.

Indicators for Science and Mathematics Education 1995

Appendix table 2-5

NAEP science proficiency, by percent of students at or above selected anchor points, sex, and age: 1977 to 1992

Sex and age	Anchor point	1977	1982	1986	1990	1992	Difference 1977 to 1992
Age 17							
Male	300	48.8 (1.1)	45.2 (1.2)	48.8 (2.1)	48.2 (1.6)	50.9 (2.0)	2.1 (2.3)
Female		34.8 (1.0)	29.9 (1.2)	34.1 (1.5)	38.7 (1.7)	42.0 (1.7)	7.2 (2.0)
Male	250	85.2 (0.7)	81.2 (1.2)	82.4 (1.4)	82.5 (1.2)	85.0 (1.4)	-0.2 (1.6)
Female		78.0 (1.0)	72.2 (1.3)	79.1 (1.7)	79.9 (1.4)	81.6 (1.4)	3.6 (1.7)
Age 13							
Male	250	52.3 (1.3)	56.2 (1.8)	57.3 (2.1)	59.8 (1.3)	62.9 (1.4)	10.6 (1.9)
Female		45.4 (1.2)	46.0 (1.6)	47.7 (1.7)	53.3 (1.4)	59.6 (1.4)	14.2 (1.8)
Age 9							
Male	200	69.5 (1.2)	69.7 (2.0)	74.1 (1.4)	76.3 (1.2)	80.4 (1.4)	10.9 (1.8)
Female		66.5 (1.1)	71.8 (2.2)	70.0 (1.3)	76.4 (1.1)	75.7 (1.2)	9.2 (1.6)

NOTE: Standard errors appear in parentheses.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

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Appendix table 2-6

NAEP mathematics proficiency, by percent of students at or above selected anchor points, sex, and age: 1978 to 1992

Sex and age	Anchor point	1978	1982	1986	1990	1992	Difference 1978-1992
Age 17							
Male	300	55.1 (1.2)	51.9 (1.5)	54.6 (1.8)	57.6 (1.4)	60.5 (1.8)	5.4 (2.2)
Female		48.2 (1.3)	45.3 (1.4)	48.9 (1.7)	54.7 (1.8)	57.7 (1.6)	9.5 (2.1)
Male	250	93.0 (0.5)	93.9 (0.6)	96.1 (0.6)	95.8 (0.8)	96.9 (0.6)	3.9 (0.8)
Female		91.0 (0.6)	92.1 (0.6)	95.1 (0.7)	96.2 (0.8)	96.3 (0.8)	5.3 (1.0)
Age 13							
Male	250	63.9 (1.3)	71.3 (1.4)	73.8 (1.8)	75.1 (1.8)	78.1 (1.6)	14.2 (2.1)
Female		65.9 (1.2)	71.4 (1.3)	72.7 (1.9)	74.4 (1.3)	77.7 (1.1)	11.8 (1.6)
Age 9							
Male	200	68.9 (1.0)	68.8 (1.3)	74.0 (1.4)	80.6 (1.0)	81.9 (1.0)	13.0 (1.4)
Female		72.0 (1.1)	74.0 (1.3)	74.3 (1.3)	82.3 (1.3)	80.9 (1.1)	8.9 (1.6)

NOTE: Standard errors appear in parentheses.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

Appendix table 2-7

IAEP science scores for selected countries at 5th percentile, mean, and 95th percentile, by age: 1991

Age and country	5th Percentile	Mean (average)	95th Percentile
Age 13			
Ireland	36.1 (0.8)	63.3 (0.6)	88.9 (0.0)
United States	40.3 (4.9)	67.0 (1.0)	91.7 (0.0)
Spain	43.5 (0.7)	67.5 (0.6)	88.9 (0.0)
Scotland	38.9 (1.2)	67.9 (0.6)	91.7 (0.0)
France	40.3 (1.4)	68.6 (0.6)	91.7 (0.0)
Canada	43.1 (0.0)	68.8 (0.4)	90.3 (1.0)
Israel	42.4 (2.8)	69.7 (0.7)	91.7 (0.0)
Italy	44.4 (0.0)	69.9 (0.7)	91.7 (0.0)
Slovenia	44.4 (0.0)	70.3 (0.5)	91.7 (0.0)
Soviet Union	44.4 (2.2)	71.3 (1.0)	93.1 (3.1)
Hungary	45.8 (1.6)	73.4 (0.5)	94.4 (0.0)
Switzerland	50.0 (0.7)	73.7 (0.9)	94.4 (0.0)
Taiwan	43.1 (1.4)	75.6 (0.4)	95.8 (0.0)
Korea	50.0 (4.8)	77.5 (0.5)	95.8 (0.0)
Age 9			
Ireland	29.3 (1.6)	56.5 (0.7)	81.0 (1.8)
Slovenia	35.1 (0.2)	57.7 (0.5)	79.0 (0.0)
Israel	36.2 (1.4)	61.2 (0.7)	86.2 (0.0)
Soviet Union	39.7 (1.5)	61.5 (1.2)	86.2 (2.4)
Spain	36.2 (0.0)	61.7 (0.7)	84.5 (0.0)
Hungary	38.5 (0.7)	62.5 (0.5)	84.2 (2.9)
Canada	37.9 (1.1)	62.8 (0.4)	84.5 (0.0)
United States	36.2 (1.7)	64.7 (0.9)	87.9 (0.0)
Taiwan	39.7 (0.0)	66.7 (0.5)	89.7 (0.0)
Korea	44.8 (0.4)	67.9 (0.5)	87.9 (0.0)

NOTE: Standard errors appear in parentheses.
SOURCE: Bybee, R.W., et al. (1994). *Science: Measuring U.S. students' success.* Princeton, NJ: Educational Testing Service.

Appendix table 2-8

IAEP mathematics scores for selected countries at 5th percentile, mean, and 95th percentile, by age: 1991

Age and country	5th Percentile	Mean (average)	95th Percentile
Age 13			
United States	24.0 (0.6)	55.3 (1.0)	90.7 (0.1)
Spain	28.6 (0.5)	55.4 (0.8)	84.7 (1.3)
Slovenia	27.1 (4.4)	57.1 (0.8)	88.0 (2.6)
Ireland	26.8 (1.7)	60.5 (0.9)	90.7 (0.0)
Scotland	29.0 (3.9)	60.6 (0.9)	90.7 (0.0)
Canada	32.0 (0.0)	62.0 (0.6)	91.8 (4.3)
Israel	30.7 (0.9)	63.1 (0.8)	90.7 (0.0)
Italy	32.4 (1.5)	64.0 (0.9)	91.8 (0.5)
France	30.7 (0.8)	64.2 (0.8)	92.0 (5.3)
Hungary	32.4 (2.3)	68.4 (0.8)	96.0 (0.0)
Soviet Union	35.2 (1.4)	70.2 (1.0)	94.7 (0.0)
Switzerland	42.7 (0.8)	70.8 (1.3)	94.7 (0.0)
Taiwan	26.7 (0.6)	72.7 (0.7)	98.7 (0.0)
Korea	33.3 (2.8)	73.4 (0.6)	97.3 (1.9)
Age 9			
Slovenia	27.7 (1.8)	55.8 (0.6)	84.5 (0.0)
United States	24.6 (0.0)	58.4 (1.0)	90.2 (2.3)
Canada	28.3 (2.5)	59.5 (0.5)	88.5 (0.0)
Ireland	24.6 (0.4)	60.0 (0.8)	90.2 (0.0)
Spain	26.8 (1.8)	61.9 (1.0)	90.2 (2.4)
Israel	30.4 (2.8)	64.4 (0.7)	91.8 (0.0)
Soviet Union	30.8 (1.0)	65.9 (1.3)	93.4 (2.3)
Taiwan	32.1 (4.6)	68.1 (0.8)	95.1 (0.0)
Hungary	33.3 (1.5)	68.2 (0.6)	93.4 (0.0)
Korea	41.0 (2.8)	74.8 (0.6)	95.1 (0.0)

NOTE: Standard errors appear in parentheses.
SOURCE: Dossey, J.A., et al. (1994). *Mathematics: How do U.S. students measure up?* Princeton, NJ: Educational Testing Service.

Appendix table 3-1

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

Years required	1974	1980	1983	1985	1987	1989	1990	1992
Total	100	100	100	100	100	100	100	100
None	29	27	24	12	12	10	12	14
0.5–0.9	0	0	0	0	0	0	0	0
1.0–1.9	55	55	18	4	4	2	2	0
2.0–2.9	14	16	51	67	65	65	65	61
3.0–3.9	2	2	8	18	20	22	22	25
4.0	0	0	0	0	0	0	0	0

NOTES: All 50 states and the District of Columbia are included in this table. Totals may not equal 100 percent as a result of rounding. Some states required an additional year of coursework in either science or mathematics. This table counts such a requirement as one-half year in each subject.
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.

Indicators of Science and Mathematics Education 1995

Appendix table 3-2

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

Grade range	Year	Reading	Mathematics	Science
Grades 1-3	1977*	95 (1.6)	41 (0.6)	17 (0.2)
	1986	84 (1.6)	46 (0.6)	20 (0.4)
	1993	85 (2.1)	50 (0.7)	24 (0.7)
Grades 4-6	1977	66 (1.3)	51 (0.4)	28 (0.6)
	1986	63 (1.3)	52 (0.6)	29 (1.0)
	1993	61 (1.8)	53 (1.1)	36 (2.1)

* The survey used estimates for teachers of grades K-3.
NOTES: Self-contained refers to teachers who are responsible for teaching most or all of their academic subjects in one class. Standard errors appear in parentheses.
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.

Indicators of Science and Mathematics Education 1995

Appendix table 3-3

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

Subject	1982	1987	1990	1992
English	3.8 (0.03)	4.0 (0.02)	4.1 (0.04)	4.2 (0.02)
History or social studies	3.1 (0.02)	3.3 (0.04)	3.5 (0.03)	3.5 (0.02)
Mathematics	2.6 (0.02)	3.0 (0.03)	3.1 (0.03)	3.3 (0.02)
Science	2.2 (0.02)	2.6 (0.05)	2.9 (0.03)	3.0 (0.03)
Foreign language	1.1 (0.03)	1.5 (0.05)	1.6 (0.04)	1.8 (0.04)
Computer science	0.1 (0.01)	0.0 (0.02)	0.0 (0.02)	0.6 (0.01)

NOTES: Standard errors appear in parentheses. 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 graduate* (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.

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Appendix table 3-4

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

Course	Year	Total	Male	Female	White	Black	Hispanic
Any science	1982	97.6	97.5	97.7	97.7	98.6	95.9
	1987	98.7	98.4 (0.4)	99.0 (0.3)	98.7 (0.4)	98.7 (0.4)	98.5 (0.6)
	1990	99.4	99.2 (0.3)	99.7 (0.1)	99.5 (0.2)	99.0 (0.7)	99.3 (0.3)
	1992	99.6	99.5	99.7	99.5	100.0	99.7
Biology	1982	78.7	76.5	80.6	80.1	75.3	73.2
	1987	88.3 (0.9)	87.0 (1.2)	89.7 (0.7)	89.2 (1.0)	86.2 (1.7)	85.4 (1.7)
	1990	91.6 (0.9)	90.4 (1.0)	92.7 (0.9)	92.0 (1.0)	91.0 (2.3)	90.3 (1.4)
	1992	93.0	91.9	94.2	93.5	92.2	91.2
Chemistry	1982	31.6	32.4	30.9	34.7	22.5	16.7
	1987	44.8 (1.1)	45.9 (1.3)	43.7 (1.2)	47.7 (1.2)	29.8 (1.7)	29.4 (1.5)
	1990	49.6 (1.3)	48.8 (1.4)	50.4 (1.4)	52.3 (1.4)	40.3 (2.2)	38.8 (2.8)
	1992	55.5	54.2	56.8	58.0	45.9	42.6
Physics	1982	13.5	17.9	9.4	15.3	6.8	5.5
	1987	19.5 (0.9)	24.6 (1.0)	14.8 (0.9)	20.9 (1.0)	10.1 (1.1)	9.8 (1.1)
	1990	21.5 (0.8)	25.5 (0.9)	17.8 (0.9)	23.1 (0.9)	14.5 (1.9)	13.0 (1.3)
	1992	24.7	28.2	21.4	25.9	17.6	15.7

NOTES: Standard errors appear in parentheses. Standard errors are not available for 1982 and 1992. Because of the use of a different editing procedure, the statistics shown for 1982 differ slightly from previously published figures. 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.

Indicators of Science and Mathematics Education 1995

Appendix table 3-5

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

Course	Year	Total	Male	Female	White	Black	Hispanic
Any mathematics	1982	99.0	99.4	98.7	99.1	99.6	98.6
	1987	99.4	99.3 (0.2)	99.4 (0.1)	99.3 (0.2)	99.5 (0.2)	99.4 (0.2)
	1990	99.6	99.4 (0.2)	99.7 (0.1)	99.7 (0.1)	98.7 (0.7)	99.8 (0.2)
	1992	99.6	99.3	99.9	99.7	99.1	99.8
Algebra I	1982	68.4	66.4	70.4	71.1	61.1	59.9
	1987	76.3 (0.8)	75.3 (0.9)	77.2 (0.9)	77.7 (1.1)	70.7 (1.2)	73.1 (1.6)
	1990	77.3 (1.2)	75.6 (1.2)	78.8 (1.4)	77.2 (1.4)	77.6 (2.1)	81.4 (2.1)
	1992	79.4	80.0	78.9	79.6	78.0	84.4
Geometry	1982	48.4	48.3	48.5	53.9	30.3	29.0
	1987	61.5 (0.9)	61.2 (1.2)	61.7 (1.0)	65.1 (1.2)	44.0 (1.9)	40.2 (1.7)
	1990	64.7 (1.3)	63.9 (1.5)	65.4 (1.3)	67.2 (1.4)	56.3 (2.7)	54.4 (2.8)
	1992	70.4	69.0	71.7	72.6	60.4	62.9
Algebra II	1982	36.9	37.5	36.3	40.5	26.2	22.5
	1987	47.1 (1.8)	45.8 (1.9)	48.4 (1.9)	51.9 (1.9)	32.4 (1.5)	30.2 (2.0)
	1990	49.2 (1.4)	47.8 (1.5)	50.5 (1.5)	52.4 (1.7)	39.0 (2.9)	38.6 (2.7)
	1992	56.1	54.0	58.1	59.2	40.9	46.9
Trigonometry	1982	12.2	13.3	11.2	13.8	6.3	6.8
	1987	19.0 (1.5)	20.3 (1.8)	17.8 (1.4)	20.9 (1.8)	10.9 (1.1)	9.9 (0.9)
	1990	18.4 (1.3)	18.4 (1.4)	18.3 (1.3)	19.6 (1.4)	14.1 (1.9)	11.0 (1.5)
	1992	21.1	21.4	20.8	22.5	13.0	15.2
Calculus	1982	4.3	4.7	4.0	5.0	1.4	1.6
	1987	6.2 (0.4)	7.7 (0.6)	4.7 (0.4)	5.9 (0.4)	2.3 (0.4)	3.6 (0.7)
	1990	6.6 (0.5)	7.7 (0.6)	5.6 (0.4)	7.0 (0.5)	2.8 (0.5)	3.9 (0.7)
	1992	10.1	10.3	9.8	10.7	6.9	4.7

NOTES: Standard errors appear in parentheses. Standard errors are not available for 1982 and 1992. Because of the use of a different editing procedure, the statistics shown for 1982 differ slightly from previously published figures. 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.

Appendix table 3-6

Percent of high school classes perceived as low and high ability, by percent minority in class: 1993

Percent minority	Low ability: Science	Low ability: Mathematics	High ability: Science	High ability: Mathematics
Less than 10%	9 (3.1)	6 (1.6)	31 (4.6)	28 (4.1)
10% to 39%	10 (1.9)	11 (2.4)	28 (3.4)	24 (2.9)
40% or more	15 (1.4)	24 (4.2)	14 (2.3)	11 (2.5)

NOTE: Standard errors appear in parentheses.
SOURCE: Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.

Indicators of Science and Mathematics Education 1995

Appendix table 3-7

Percent of grades 10-12 science and mathematics classes where teachers report ability grouping: 1986 and 1993

Ability grouping	Science: 1986	Science: 1993	Mathematics: 1986	Mathematics: 1993
Total	100	100	100	100
Homogeneous, low ability	10 (1.3)	7 (1.3)	19 (2.2)	10 (1.5)
Homogeneous, average ability	33 (1.9)	28 (2.8)	29 (2.5)	31 (1.9)
Homogeneous, high ability	35 (1.9)	29 (2.0)	34 (2.6)	25 (3.2)
Heterogeneous	22 (1.7)	36 (2.2)	18 (2.1)	34 (2.6)

NOTES: Standard errors appear in parentheses. Totals may not equal 100 percent as a result of rounding.
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.

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Appendix table 3-8

Number of full-time and part-time teachers in science and mathematics in the United States, by sex, race or ethnic origin, and teaching assignment: 1988 and 1991

Year and grade range	Total	Male	Female	White	Black	Hispanic	Other
1988							
Total	2,592,673	742,710	1,839,119	2,244,888	189,849	75,142	49,589
Elementary grades K-6	1,256,132	145,529	1,105,024	1,076,667	99,102	41,188	24,472
Secondary grades 7-12							
All secondary teachers	1,336,541	597,185	734,095	1,168,222	90,747	33,954	25,118
Science and mathematics specialists	476,600	230,016	245,021	415,865	33,485	10,280	10,265
Primary or secondary assignment:							
Biology	52,231	30,086	21,984	47,150	2,149	866	1,189
Chemistry	19,683	12,708	6,930	17,728	753	297	598
Earth science	21,143	12,671	8,413	18,210	1,892	442	338
Physics	8,908	6,817	2,091	8,343	161	95	220
General science	52,772	28,718	23,963	46,812	3,682	1,050	647
Mathematics	180,954	89,289	90,800	158,199	12,449	4,240	3,877
Other fields	140,908	49,726	90,840	119,423	12,399	3,291	3,396
Other teachers	859,941	362,558	481,444	742,467	55,744	23,241	14,637
1991							
Total	2,882,547	797,836	2,084,712	2,516,238	216,132	97,491	52,686
Elementary grades K-6	1,418,958	163,643	1,255,315	1,218,898	116,602	53,076	30,383
Secondary grades 7-12							
All secondary teachers	1,463,589	634,193	829,396	1,297,340	99,530	44,416	22,304
Science and mathematics specialists	461,120	225,986	235,134	411,135	29,989	12,101	7,896
Primary or secondary assignment:							
Biology	67,151	36,919	30,231	60,186	3,639	2,303	1,022
Chemistry	23,618	14,643	8,975	21,900	1,004	521	192
Earth science	19,074	10,935	8,139	17,221	1,090	601	162
Physics	10,022	8,105	1,917	9,635	102	53	233
General science	56,572	29,663	26,908	50,276	4,021	1,354	920
Mathematics	200,959	98,168	102,791	176,183	15,155	5,584	4,037
Other fields	83,724	27,552	56,172	75,734	4,977	1,683	1,330
Other teachers	1,002,469	408,207	594,262	886,205	69,541	32,315	14,408

SOURCE: National Center for Education Statistics. (1994). *1990-91 Schools and staffing survey (SASS).* Unpublished tabulations.

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Appendix table 3-9

Percent of public school grades 9-12 science and mathematics teachers who are female or minority, by state: 1991

State	Percent female science teachers		Percent minority science teachers		Percent female mathematics teachers		Percent minority mathematics teache	
Total	35	(1.5)	10	(0.9)	45	(1.5)	13	(1.7)
Alabama	71	(4.8)	16	(4.7)	71	(5.9)	14	(4.7)
Alaska	15	(7.6)	8	(4.5)	27	(6.9)	4	(1.8)
Arizona	37	(7.6)	7	(3.5)	47	(7.3)	14	(4.1)
Arkansas	51	(8.6)	19	(6.7)	56	(9.0)	8	(3.0)
California	25	(7.3)	28	(6.1)	32	(6.8)	36	(8.2)
Colorado	33	(5.3)	5	(2.7)	27	(5.5)	2	(1.3)
Connecticut	40	(8.9)	9	(2.8)	59	(8.2)	*	
Delaware	--		--		--		--	
District of Columbia	--		--		--		--	
Florida	42	(8.4)	24	(7.3)	64	(7.4)	9	(3.8)
Georgia	58	(9.1)	18	(5.5)	68	(7.2)	17	(5.2)
Hawaii	--		--		--		--	
Idaho	24	(5.5)	*		35	(4.3)	5	(1.9)
Illinois	41	(7.8)	4	(0.7)	36	(6.6)	13	(3.4)
Indiana	13	(4.0)	4	(2.3)	45	(6.3)	6	(2.1)
Iowa	25	(8.6)	*		36	(7.0)	*	
Kansas	29	(8.0)	*		44	(6.7)		(0.0)
Kentucky	51	(7.3)	*		65	(4.8)	3	(1.9)
Louisiana	41	(6.7)	24	(7.1)	51	(6.2)	27	(7.4)
Maine	22	(5.6)	0	(0.0)	31	(3.8)	*	
Maryland	53	(11.2)	10	(5.8)	51	(8.3)	14	(5.5)
Massachusetts	27	(6.0)	1	(1.0)	40	(6.3)	5	(2.5)
Michigan	27	(5.6)	*		17	(5.5)	*	
Minnesota	17	(4.8)	0	(0.0)	31	(5.4)	*	
Mississippi	48	(6.1)	34	(6.7)	61	(5.9)	32	(5.9)
Missouri	30	(7.0)	*		47	(6.8)	*	
Montana	19	(4.0)	*		21	(6.1)	*	
Nebraska	18	(5.1)	*		33	(8.7)		(0.0)
Nevada	--		--		60	(11.8)	15	(9.5)
New Hampshire	--		--		--		--	
New Jersey	32	(7.0)	5	(3.6)	47	(8.0)	5	(3.3)
New Mexico	40	(6.4)	33	(10.7)	48	(9.9)	28	(6.8)
New York	31	(7.4)	3	(1.9)	49	(7.1)	8	(3.4)
North Carolina	57	(6.3)	14	(5.4)	59	(7.1)	17	(5.0)
North Dakota	21	(4.4)	0	(0.0)	37	(4.9)	*	
Ohio	32	(7.9)	0	(0.0)	31	(7.2)		(0.0)
Oklahoma	25	(5.1)	6	(2.6)	50	(6.5)	13	(4.8)
Oregon	25	(6.0)	*		29	(5.6)	4	(1.9)
Pennsylvania	29	(5.6)	*		48	(7.9)	*	
Rhode Island	--		--		--		--	
South Carolina	47	(4.5)	29	(6.9)	70	(6.2)	11	(3.6)
South Dakota	25	(5.2)	*		43	(4.4)		(0.0)
Tennessee	48	(6.9)	14	(3.8)	62	(7.5)	9	(2.9)
Texas	43	(4.7)	17	(4.2)	54	(5.6)	17	(4.2)
Utah	27	(6.7)	*		32	(5.0)	6	(2.4)
Vermont	--		--		--		--	
Virginia	46	(9.3)	*		63	(6.6)	18	(5.9)
Washington	25	(5.1)	4	(3.1)	24	(6.8)	6	(1.8)
West Virginia	55	(8.2)	*		56	(6.5)	*	
Wisconsin	16	(4.5)	*		30	(8.3)	*	
Wyoming	19	(6.1)	*		28	(7.4)	*	

* Less than 0.5 percent.
-- Too few sample cases for a reliable estimate.
NOTE: Standard errors appear in parentheses.
SOURCE: Blank, R.K., Matti, M.C., Weiss, I.R., Broughman, S., & Rollefson, M. (1994). *SASS by state, 1990-91 schools and staffing survey: Selected state results* (NCES 94-343). Washington, DC: National Center for Education Statistics.

Appendix table 3-10

Distribution of science and mathematics teachers, by race or ethnic origin and grade range: 1986 and 1993

Year	Race or ethnic origin	Grade range 1-6	7-9	10-12
1986	Total	100	100	100
	White	86 (1.0)	93 (1.1)	94 (0.8)
	Black	10 (0.8)	6 (1.0)	4 (0.6)
	Hispanic	3 (0.5)	1 (0.4)	1 (0.3)
	Other	1 (0.3)	1 (0.4)	1 (0.3)
1993	Total	100	100	100
	White	89 (1.3)	91 (1.2)	93 (0.7)
	Black	5 (0.8)	6 (0.6)	3 (0.5)
	Hispanic	4 (1.1)	2 (0.4)	1 (0.3)
	Other	1 (0.3)	2 (0.7)	2 (0.5)

NOTES: Standard errors appear in parentheses. Totals may not equal 100 percent as a result of rounding.
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.

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Appendix table 3-11

Percent of science and mathematics teachers with master's degrees, by years of teaching experience and by grade range: 1993

Years of teaching experience	Grade range 1-4	5-8	9-12
0 to 2	8 (1.9)	11 (2.7)	21 (4.4)
3 to 5	19 (3.5)	17 (4.2)	31 (3.7)
6 to 10	39 (4.4)	34 (5.8)	45 (4.7)
11 to 20	40 (3.9)	50 (4.3)	62 (2.4)
21 or more	47 (4.3)	58 (3.9)	72 (2.4)

NOTE: Standard errors appear in parentheses.
SOURCE: Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.

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Appendix table 3-12

Percent of science and mathematics classes about which teachers report having strong control over various curriculum and instructional decisions, by grade range: 1993

	Grade range		
Field and decision	1–4	5–8	9–12
Science			
Selecting teaching techniques	66 (2.1)	72 (3.0)	79 (3.0)
Determining amount of homework to be assigned	72 (2.1)	75 (3.1)	81 (2.5)
Setting pace for covering topics	56 (2.5)	63 (2.8)	71 (2.6)
Choosing criteria for grading students	60 (3.4)	66 (3.1)	69 (2.5)
Selecting sequence in which topics are covered	56 (2.0)	62 (3.0)	68 (2.7)
Selecting other instructional materials	30 (2.0)	42 (2.8)	55 (3.8)
Determining goals and objectives	32 (1.9)	40 (3.0)	53 (3.7)
Selecting content, topics, and skills to be taught	27 (2.5)	36 (2.6)	50 (3.3)
Selecting textbooks	11 (1.5)	25 (2.3)	45 (4.2)
Mathematics			
Selecting teaching techniques	69 (2.7)	71 (2.7)	76 (1.4)
Determining amount of homework to be assigned	68 (3.1)	72 (2.9)	79 (1.8)
Setting pace for covering topics	60 (3.3)	55 (3.1)	56 (2.4)
Choosing criteria for grading students	53 (2.7)	63 (2.7)	66 (2.3)
Selecting sequence in which topics are covered	52 (2.1)	52 (2.9)	54 (2.4)
Selecting other instructional materials	36 (2.3)	40 (2.1)	52 (2.2)
Determining goals and objectives	29 (3.1)	33 (1.8)	41 (2.4)
Selecting content, topics, and skills to be taught	22 (2.0)	27 (2.2)	39 (2.4)
Selecting textbooks	12 (1.4)	20 (2.0)	35 (2.6)

NOTES: Teachers were given a five-point scale for each decision, with 1 labeled as “no control” and 5 labeled “strong control.” Standard errors appear in parentheses.
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.

Appendix table 3-13

Percent of 12th-grade science and mathematics students whose teachers report having “complete control” over particular decisions, by subject: 1992

Decision	Science	Mathematics	All science and mathematics
Determining amount of homework	70	71	71
Selecting teaching techniques	68	69	69
Selecting content, topics, and skills to be taught	45	24	32
Disciplining students	37	41	40
Selecting textbooks and other instructional materials	37	19	27

SOURCE: National Center for Education Statistics. (1992). *National education longitudinal study of 1988: Second teacher follow-up study.* Unpublished tabulations.

Indicators of Science and Mathematics Education 1995

Appendix table 3-14

Percent of 12th-grade science and mathematics students whose teachers report having “complete control” over particular decisions, by region: 1992

Area	Midwest	Northeast	South	West
Determining amount of homework	69	72	71	74
Selecting teaching techniques	69	76	64	71
Selecting content, topics, and skills to be taught	39	34	24	37
Disciplining students	38	48	36	41
Selecting textbooks and other instructional materials	32	36	18	27

SOURCE: National Center for Education Statistics. (1992). *National education longitudinal study of 1988: Second teacher follow-up study.* Unpublished tabulations.

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Appendix table 3-15

Percent of 12th-grade science and mathematics students whose teachers report having “complete control” over particular decisions, by overall proficiency level: 1992

	Proficiency level					
Subject and area	Below Level 1	Level 1	Level 2	Level 3	Level 4	Level 5
Science						
Determining amount of homework	73	71	72	70	--	--
Selecting teaching techniques	68	66	68	71	--	--
Selecting content, topics, and skills to be taught	26	29	33	36	--	--
Disciplining students	41	38	40	41	--	--
Selecting textbooks and other instructional materials	20	21	28	32	--	--
Mathematics						
Determining amount of homework	70	74	72	73	70	69
Selecting teaching techniques	64	66	67	69	69	73
Selecting content, topics, and skills to be taught	25	27	29	33	35	36
Disciplining students	35	38	38	42	40	44
Selecting textbooks and other instructional materials	15	20	21	28	30	35

-- Not applicable.
NOTES: Science levels of proficiency as defined by the NELS:88 Second follow-up student component data file user’s manual are as follows:
Science Level 1: Understanding of everyday science concepts, “common knowledge” that can be acquired in everyday life.
Science Level 2: Understanding of fundamental science concepts upon which more complex science knowledge can be built.
Science Level 3: Understanding of relatively complex scientific concepts, typically requiring an additional problem-solving step.
Mathematics levels of proficiency as defined by their NELS:88 Second follow-up student component data file user's manual are as follows:
Math Level 1: Simple arithmetical operations on whole numbers, essentially single-step operations that rely on rote memory.
Math Level 2: Simple operations with decimals, fractions, powers, and roots.
Math Level 3: Simple problem solving, requiring the understanding of low-level mathematical concepts.
Math Level 4: Understanding of intermediate-level mathematical concepts or having the ability to formulate multistep solutions to work problems.
Math Level 5: Proficiency in solving complex multistep word problems or the ability to demonstrate knowledge of mathematics material found in advanced mathematics courses.
SOURCE: National Center for Education Statistics. (1992). *National education longitudinal study of 1988: Second teacher follow-up study.* Unpublished tabulations.

Appendix table 3-16

Percent of mathematics teachers who are familiar with the National Council of Teachers of Mathematics' standards, by level of familiarity and grade range: 1993

Standard and level of familiarity	Grade range		
	1-4	5-8	9-12
Curriculum and evaluation standards			
Total	100	100	100
Well aware of them	18 (1.6)	28 (2.2)	56 (2.6)
Heard about them, but don't know much about them	39 (1.8)	41 (3.0)	33 (2.7)
Not aware of them	30 (2.9)	22 (2.6)	8 (1.4)
Not sure	13 (1.2)	9 (2.1)	3 (0.3)
Professional standards for teaching			
Total	100	100	100
Well aware of them	12 (1.3)	19 (1.7)	40 (2.0)
Heard about them, but don't know much about them	38 (2.0)	48 (3.0)	44 (2.7)
Not aware of them	38 (2.8)	25 (2.8)	13 (1.8)
Not sure	12 (1.3)	8 (1.4)	3 (0.4)

NOTES: Standard errors appear in parentheses. Totals may not equal 100 percent as a result of rounding.
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.

Appendix table 3-17

Percent of science and mathematics teachers agreeing with each of a number of statements related to curriculum and instruction, by grade range: 1993

Field and statement	Grade range 1-4	5-8	9-12
Science			
Students learn best when they study science in the context of a personal or social application	94 (1.4)	94 (2.2)	86 (4.5)
Virtually all students can learn to think scientifically	80 (2.4)	84 (3.3)	76 (2.6)
Laboratory-based science classes are more effective than nonlaboratory classes	78 (2.1)	87 (1.5)	90 (1.2)
It is important for students to learn basic scientific terms and formulas before learning underlying concepts and principles	31 (2.2)	44 (3.7)	55 (2.6)
Students learn best in classes with students of similar abilities	23 (2.3)	33 (3.3)	68 (2.0)
Mathematics			
Students learn best when they study mathematics in the context of a personal or social application	94 (1.3)	91 (1.7)	84 (1.7)
Virtually all students can learn to think mathematically	76 (2.0)	76 (2.6)	72 (2.3)
Students must master arithmetic computation before going on to algebra	70 (2.2)	77 (3.1)	81 (1.7)
Students learn mathematics best in classes with students of similar abilities	41 (1.9)	62 (3.8)	76 (2.9)
Students should be able to use calculators most of the time	24 (1.9)	39 (3.1)	73 (1.7)

NOTES: Includes teachers who indicated “Strongly Agree” and “Agree” to each statement. Standard errors appear in parentheses.
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.

Appendix table 3-18

Percent of mathematics teachers indicating that various strategies definitely should be a part of mathematics instruction, by stategy and grade range: 1993

	Grade range		
Strategy	1-4	5-8	9-12
Hands-on or manipulative activities	82 (2.2)	49 (3.2)	26 (2.2)
Concrete experience before abstract treatments	81 (2.0)	55 (2.7)	33 (2.5)
Applications of mathematics in daily life	81 (1.6)	75 (3.1)	50 (2.8)
Emphasis on solving real problems	80 (1.9)	78 (1.9)	57 (2.9)
Every student studying mathematics each year	76 (2.7)	69 (3.5)	38 (2.5)
Emphasis on mathematical reasoning	69 (2.0)	64 (2.6)	58 (3.0)
Emphasis on connections among concepts	68 (1.7)	62 (2.4)	52 (2.2)
Students working in cooperative learning groups	58 (1.8)	41 (2.8)	27 (2.2)
Use of computers	52 (2.9)	39 (3.3)	34 (2.3)
Emphasis on arithmetic computation	49 (2.4)	36 (2.4)	22 (1.8)
Coordination of mathematics with science	34 (2.1)	27 (3.4)	22 (2.6)
Taking student preconceptions about a topic into account when planning curriculum or instruction	34 (2.9)	26 (2.8)	18 (2.5)
Use of calculators	33 (3.2)	37 (3.7)	50 (2.5)
Inclusion of performance-based assessment	33 (1.9)	29 (2.9)	18 (1.6)
Deeper coverage of fewer mathematics ideas	33 (3.6)	31 (3.4)	16 (2.6)
Emphasis on writing about mathematics	32 (2.0)	23 (2.6)	20 (2.8)
Integration of mathematics subjects all taught together each year	26 (1.7)	25 (3.2)	20 (2.8)
Coordination of mathematics with vocation or technology education	25 (2.5)	23 (2.8)	19 (1.7)

NOTE: Standard errors appear in parentheses.
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.

Appendix table 3-19

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

Year	Grades	Science		Mathematics	
		Lecture	Hands-on	Lecture	Hands-on
1977*	1-3	60 (3.4)	67 (3.3)	58 (3.4)	58 (3.4)
	4-6	69 (3.3)	54 (3.6)	68 (3.3)	38 (3.5)
	7-9	72 (2.3)	59 (2.5)	83 (1.9)	23 (2.1)
	10-12	76 (2.1)	53 (2.4)	89 (1.5)	24 (2.2)
1986					
	1-3	71 (2.3)	52 (2.5)	69 (2.3)	60 (2.5)
	4-6	78 (2.8)	45 (3.3)	82 (2.4)	31 (2.9)
	7-9	83 (2.2)	43 (3.0)	89 (1.9)	18 (2.3)
	10-12	84 (2.0)	39 (2.7)	90 (1.2)	10 (1.2)
1993					
	1-3	75 (4.1)	62 (0.7)	79 (2.6)	79 (1.9)
	4-6	82 (2.5)	50 (3.3)	90 (2.0)	51 (4.1)
	7-9	80 (2.9)	50 (3.9)	93 (1.4)	26 (2.7)
	10-12	88 (1.5)	43 (2.3)	94 (2.1)	26 (3.1)

* The 1977 survey includes kindergarten.
NOTE: Standard errors appear in parentheses.
SOURCES: Weiss, I.R. (1987). *Report of the 1985-86 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institiute; Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.

Appendix table 3-20

Percent of science teachers indicating that various strategies definitely should be a part of science instruction, by strategy and grade range: 1993

	Grade range		
Strategy	1-4	5-8	9-12
Hands-on or laboratory activities	78 (2.3)	78 (2.8)	76 (2.1)
Applications of science in daily life	73 (2.5)	69 (4.3)	60 (3.6)
Concrete experience before abstract treatments	70 (2.6)	51 (4.4)	35 (3.1)
Every student studying science every year	63 (2.0)	61 (2.9)	37 (2.6)
Students working in cooperative learning groups	57 (2.5)	50 (3.0)	30 (2.0)
Emphasis on connections among concepts	52 (2.7)	54 (4.4)	53 (2.5)
Coordination of sciences with mathematics	47 (2.8)	43 (3.5)	47 (3.8)
Coordination of sciences with language arts	46 (2.7)	35 (3.7)	20 (3.0)
Coordination of sciences with social science	43 (2.9)	34 (3.6)	19 (3.8)
Taking student conceptions about a natural phenomenon into account when planning curriculum or instruction	39 (2.2)	34 (4.0)	22 (1.4)
Coordination of sciences with vocational or technology education	37 (2.5)	33 (4.2)	29 (1.7)
Use of computers	30 (3.6)	37 (4.3)	36 (2.3)
Coordination of science disciplines	30 (3.4)	37 (3.3)	35 (2.7)
Revisiting science topics, each time in greater depth	29 (2.6)	21 (2.4)	19 (1.6)
Deeper coverage of fewer science concepts	28 (2.8)	30 (3.1)	20 (1.6)
Applications of scientific methods in addressing societal issues	28 (2.3)	33 (3.3)	35 (3.1)
Inclusion of performance-based assessment	22 (2.4)	26 (3.5)	18 (1.8)

NOTE: Standard errors appear in parentheses.
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.

Appendix table 3-21

Percent of science teachers completing various numbers of science courses, by area, number of science courses completed, grade range, and number of science areas: 1993

Area and number of courses	Grade range 1-4		5-8		9-12	
Number of science areas completed						
Total	100		100		100	
None	1	(0.5)	0	(0.2)	0	(0.1)
1	9	(1.4)	7	(1.9)	4	(1.0)
2	28	(2.2)	25	(3.2)	20	(2.2)
3	63	(2.9)	68	(2.9)	77	(2.3)
Area of study						
Life science						
Total	100		100		100	
None	8	(1.2)	6	(1.6)	6	(1.1)
1 to 3 courses	68	(3.5)	47	(4.6)	17	(2.6)
4 to 7 courses	20	(3.2)	28	(3.2)	20	(3.0)
8 or more courses	4	(1.2)	18	(2.1)	57	(1.9)
Physical science						
Total	100		100		100	
None	25	(2.2)	19	(3.1)	1	(0.2)
1 to 3 courses	58	(3.2)	44	(3.8)	13	(3.0)
4 to 7 courses	14	(1.9)	23	(2.8)	29	(2.3)
8 or more courses	4	(0.9)	14	(2.5)	57	(2.0)
Earth science						
Total	100		100		100	
None	15	(1.6)	14	(2.2)	20	(2.3)
1 to 3 courses	66	(2.8)	53	(3.4)	43	(2.2)
4 to 7 courses	16	(2.0)	24	(2.1)	25	(1.6)
8 or more courses	2	(0.9)	8	(1.8)	11	(1.2)

NOTES: Standard errors appear in parentheses. Totals may not equal 100 percent as a result of rounding.
SOURCE: Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.

Appendix table 3-22

Grades 7-12 science teachers' level of preparation in field taught: 1993

Field of class taught and grade range	Total	Number of courses taken in same field taught: 6 or more courses	Fewer than 6 courses: 6 or more courses in another field	Fewer than 6 courses: Fewer than 6 courses in another field
Life science, 7-12	100	82 (5.6)	3 (1.2)	14 (5.7)
Earth science, 7-12	100	45 (5.3)	34 (8.2)	21 (8.2)
Physical science, 7-12	100	75 (4.2)	11 (2.5)	14 (3.9)
Biology, 9-12	100	94 (1.9)	3 (1.6)	3 (1.1)
Chemistry, 9-12	100	82 (3.4)	18 (3.6)	1 (0.4)
Physics, 9-12	100	74 (6.0)	22 (5.7)	4 (2.9)

NOTES: Standard errors appear in parentheses. Totals may not equal 100 percent as a result of rounding.
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.

Appendix table 3-23

Percent of mathematics teachers completing college courses in mathematics and science, by grades taught: 1993

College course completed	Grade range 1-4	5-8	9-12
Mathematics for elementary school teachers	98 (1.2)	80 (2.2)	20 (2.8)
Mathematics for middle school teachers	14 (1.7)	41 (3.6)	30 (1.9)
Geometry for elementary or middle school teachers	30 (2.2)	35 (3.2)	24 (1.7)
College algebra or trigonometry or elementary functions	42 (2.3)	57 (3.7)	89 (1.0)
Calculus	12 (1.8)	32 (2.2)	95 (1.3)
Advanced calculus	4 (1.3)	17 (2.1)	72 (2.9)
Differential equations	2 (0.7)	12 (1.3)	62 (3.3)
Geometry	22 (2.3)	39 (3.0)	84 (2.6)
Probability and statistics	27 (3.0)	44 (3.1)	81 (2.7)
Abstract algebra or number theory	10 (1.5)	22 (2.2)	75 (2.9)
Linear algebra	6 (1.4)	20 (2.0)	78 (2.6)
Applications of mathematics or problem solving	24 (1.8)	28 (2.5)	45 (2.7)
History of mathematics	8 (1.5)	13 (1.6)	42 (2.6)
Discrete mathematics	2 (1.2)	6 (1.2)	26 (2.0)
Other upper-division mathematics	6 (1.7)	18 (1.9)	57 (3.3)
Biological sciences	74 (2.8)	72 (2.9)	55 (2.9)
Chemistry	28 (2.2)	37 (2.4)	51 (2.8)
Physics	17 (1.6)	27 (1.9)	59 (3.0)
Physical science	49 (2.8)	48 (3.6)	31 (2.6)
Earth or space science	45 (2.8)	45 (2.4)	28 (2.8)
Engineering	2 (1.1)	3 (0.9)	10 (0.8)
Computer programming	21 (1.9)	30 (2.4)	65 (2.5)
Other computer science	21 (2.2)	24 (2.6)	33 (2.6)
Supervised student teaching in mathematics	50 (2.6)	41 (3.3)	65 (2.9)
Methods of teaching mathematics	99 (0.4)	91 (2.1)	84 (2.7)
Instructional use of computers or other technologies	35 (3.4)	32 (2.7)	43 (2.3)

NOTE: Standard errors appear in parentheses.
SOURCES: 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.; Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.

Appendix table 3-24

Percent of mathematics teachers completing college coursework recommended by the National Council of Teachers of Mathematics: 1986 and 1993

Grade range and course	1986	1993
Grades 7-9		
Calculus	71 (2.7)	73 (3.8)
College geometry	69 (2.8)	70 (3.8)
Probability or statistics	61 (2.0)	69 (3.9)
Abstract algebra or number theory	49 (3.0)	55 (5.1)
Applications of mathematics or problem solving	36 (2.9)	40 (2.1)
Grades 10-12		
Calculus	89 (1.3)	95 (1.5)
College geometry	80 (1.6)	84 (3.1)
Probability and statistics	76 (1.7)	85 (1.8)
Abstract algebra or number theory	69 (1.9)	80 (2.5)
Linear algebra	69 (1.9)	82 (1.6)
Advanced calculus	63 (1.9)	73 (3.3)
Other upper-division mathematics	63 (1.9)	62 (3.8)
Differential equations	61 (2.0)	66 (3.1)
Applications of mathematics or problem solving	39 (2.0)	49 (2.7)
History of mathematics	37 (1.9)	46 (2.8)

NOTE: Standard errors appear in parentheses.
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.

Appendix table 3-25

Preparation of teachers of grades 7-12 science and mathematics classes with low, medium, and high proportions of minority students, by percent of classes: 1993

Field of class taught and field of study	Proportion of minority students		
	Low	Medium	High
Science or science education			
Undergraduate major in science	60 (3.9)	61 (2.7)	62 (3.2)
Undergraduate or graduate major in science or science education	72 (3.7)	72 (3.0)	68 (3.7)
Undergraduate or graduate major or minor in science or science education	94 (1.7)	89 (2.8)	85 (2.7)
Mathematics or mathematics education			
Undergraduate major in mathematics	37 (3.1)	37 (2.8)	31 (2.3)
Undergraduate or graduate major in mathematics or mathematics education	62 (3.7)	54 (3.3)	47 (2.7)
Undergraduate or graduate major or minor in mathematics or mathematics education	78 (3.7)	73 (3.7)	67 (2.6)

NOTES: Low indicates a proportion of less than 10 percent minority. Medium indicates a proportion between 10 percent and 39 percent minority. High indicates a proportion of at least 40 percent minority. Standard errors appear in parentheses.
SOURCE: Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.

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Appendix table 3-26

Percent of self-contained elementary teachers feeling very well qualified to teach each subject: 1977 to 1993

Subject	1977*	1986	1993
Reading or language arts	63 (1.7)	86 (1.0)	76 (1.9)
Mathematics	49 (1.8)	69 (1.3)	60 (2.4)
Social studies	39 (1.7)	51 (1.4)	61 (1.7)
Life sciences	--	27 (1.2)	26 (2.0)
Science	22 (1.5)	--	--

-- Not applicable.
* The survey used estimates for teachers of grades K-3.
NOTES: Self-contained refers to teachers who are responsible for teaching most or all of their academic subjects in one class. Standard errors appear in parentheses.
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.

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Appendix table 3-27

Percent of mathematics teachers considering themselves well qualified to teach specific topics, by grade range: 1993

Topic	Grade range 1-4		5-8		9-12	
Estimation	50	(2.7)	64	(3.3)	72	(2.2)
Number sense and numeration	66	(2.6)	71	(3.0)	78	(2.3)
Number systems and number theory	44	(2.3)	58	(2.8)	67	(2.9)
Measurement	54	(2.6)	60	(3.2)	79	(2.2)
Fractions and decimals	47	(2.1)	81	(3.0)	93	(1.6)
Geometry and spatial sense	42	(2.3)	50	(3.0)	69	(3.3)
Functions	36	(2.1)	49	(2.5)	75	(2.2)
Patterns and relationships	58	(3.1)	52	(3.3)	71	(2.8)
Algebra	17	(2.0)	44	(3.1)	95	(0.8)
Trigonometry	5	(1.3)	13	(1.6)	60	(2.7)
Probability and statistics	11	(1.6)	28	(3.0)	33	(2.3)
Discrete mathematics	5	(0.8)	10	(2.0)	20	(1.7)
Conceptual foundations of calculus	2	(0.5)	4	(0.8)	29	(1.8)
Mathematical structure	7	(1.8)	14	(2.1)	30	(2.0)

NOTE: Standard errors appear in parentheses.
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.

Appendix table 3-28

Percent of mathematics teachers considering themselves well prepared to do specific tasks, by grade range: 1993

Task	Grade range 1-4	Grade range 5-8	Grade range 9-12
Present the applications of mathematics concepts	93 (1.6)	93 (2.0)	87 (2.7)
Use cooperative learning groups	87 (1.7)	82 (2.6)	66 (2.9)
Take into account student preconceptions about mathematics when planning curriculum and instruction	81 (2.6)	76 (3.3)	66 (2.3)
Use computers as an integral part of mathematics instruction	51 (2.7)	48 (3.7)	43 (2.2)
Use calculators as an integral part of mathematics instruction	55 (2.8)	71 (2.2)	81 (2.4)
Integrate mathematics with other subject areas	78 (2.8)	70 (2.9)	50 (2.9)
Manage a class of students who are using manipulatives	90 (1.5)	79 (2.5)	62 (2.8)
Use a variety of assessment strategies	77 (2.5)	73 (3.2)	67 (2.1)
Use the textbook as a resource rather than as the primary instructional tool	79 (1.1)	67 (3.8)	62 (3.0)
Use performance-based assessment	61 (2.8)	63 (2.6)	58 (2.4)
Teach groups that are heterogeneous in ability	89 (1.8)	85 (2.5)	71 (2.3)
Teach students from a variety of cultural backgrounds	70 (2.5)	73 (2.7)	63 (3.0)
Teach students who have limited English proficiency	28 (3.1)	33 (3.3)	25 (2.4)
Teach students who have learning disabilities	52 (3.6)	43 (3.6)	28 (2.8)
Encourage participation of females in mathematics	95 (1.6)	95 (1.1)	92 (1.5)
Encourage participation of minorities in mathematics	84 (2.9)	84 (2.6)	83 (1.6)
Involve parents in the mathematics education of their children	67 (2.6)	57 (2.6)	49 (2.3)

NOTE: Standard errors appear in parentheses.
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.

Appendix table 3-29

Percent of science teachers considering themselves well prepared to do specific tasks, by grade range: 1993

	Grade range		
Task	1-4	5-8	9-12
Present the applications of science concepts	74 (2.3)	80 (3.5)	92 (3.1)
Use cooperative learning techniques	83 (2.2)	83 (2.5)	64 (3.4)
Take into account student preconceptions about natural phenomena when planning curriculum and instruction	70 (2.2)	63 (3.8)	62 (3.0)
Use computers as an integral part of science instruction	30 (3.4)	31 (2.7)	40 (2.4)
Integrate science with other subject areas	76 (2.3)	67 (3.0)	62 (2.5)
Manage a class of students who are using hands-on or laboratory activities	78 (2.6)	83 (2.1)	91 (3.1)
Use a variety of assessment strategies	70 (3.0)	78 (3.2)	85 (1.5)
Use the textbook as a resource rather than as the primary instructional tool	77 (3.1)	70 (3.0)	80 (3.0)
Use performance-based assessment	60 (2.9)	65 (3.3)	64 (2.7)
Teach groups that are heterogeneous in ability	89 (2.3)	90 (1.9)	71 (2.9)
Teach students from a variety of cultural backgrounds	73 (2.7)	69 (3.7)	62 (2.3)
Teach students who have limited English proficiency	32 (2.7)	25 (3.4)	23 (2.1)
Teach students who have learning disabilities	50 (3.5)	46 (3.1)	27 (1.8)
Encourage participation of females in science	92 (2.0)	94 (1.7)	90 (3.0)
Encourage participation of minorities in science	87 (2.3)	86 (2.4)	80 (3.3)
Involve parents in the science education of their children	57 (3.6)	56 (3.1)	43 (3.0)

NOTE: Standard errors appear in parentheses.
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.

Appendix table 3-30

Percent of 12th-grade students whose science and mathematics teachers discuss curriculum issues, by type of person or group with whom they discuss: 1992

Person or group	Science students	Mathematics students	Science and mathematics students
Teachers in the department	95	97	96
Department chair	82	86	86
Principals	60	59	59
Teachers outside the department	58	59	58
Other teachers outside the school	57	60	59
Other school administrators	45	49	47
Parents	41	42	42
Others in the community (business leaders, university staff, etc.)	36	32	33

SOURCE: National Center for Education Statistics. (1992). *National education longitudinal study of 1988: Second teacher follow-up study.* Washington, DC: NCES.

Appendix table 3-31

Percent of science and mathematics teachers agreeing with each of a number of statements related to teacher collegiality, by grade range: 1993

	Grade range		
Field and statement	**1-4**	**5-8**	**9-12**
Science			
I feel supported by colleagues to try out new ideas in teaching science	74 (2.3)	76 (3.1)	87 (1.6)
I feel that I have many opportunities to learn new things in my present job	74 (2.2)	68 (3.9)	66 (2.0)
Science teachers in this school regularly share ideas and materials	55 (2.5)	56 (3.1)	72 (2.1)
Most science teachers in this school contribute actively to making decisions about the science curriculum	44 (2.8)	47 (3.8)	66 (2.3)
I receive little support from the school administration for teaching science	21 (2.3)	23 (3.5)	23 (2.6)
I have time during the regular school week to work with my peers on science curriculum and instruction	14 (1.6)	14 (2.4)	16 (3.6)
Science teachers in this school regularly observe each other teaching classes as part of sharing and improving instructional strategies	11 (1.8)	11 (1.8)	14 (3.1)
Mathematics			
I feel supported by colleagues to try out new ideas in teaching mathematics	84 (2.0)	83 (3.3)	80 (2.3)
I feel that I have many opportunities to learn new things in my present job	76 (2.3)	72 (2.5)	57 (3.0)
Mathematics teachers in this school regularly share ideas and materials	65 (2.3)	52 (3.2)	67 (2.8)
The testing program in my state or district dictates what mathematics I teach	60 (3.0)	52 (3.3)	40 (2.6)
Most mathematics teachers in this school contribute actively to making decisions about the mathematics curriculum	47 (1.8)	46 (2.8)	69 (2.6)
I receive little support from the school administration for teaching mathematics	14 (1.5)	19 (3.1)	20 (2.6)
I have time during the regular school week to work with my peers on mathematics curriculum and instruction	21 (1.9)	17 (1.8)	16 (1.6)
Mathematics teachers in this school regularly observe each other teaching classes as part of sharing and improving instructional strategies	12 (1.8)	10 (2.1)	11 (1.8)

NOTES: Includes teachers indicating “Strongly Agree” and “Agree” to each statement. Standard errors appear in parentheses.
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.

Appendix table 3-32

Amount of time science and mathematics teachers spent on science or mathemathics in-service education in the past 3 years, by subject of class taught and grade range: 1993

Subject of class taught	Amount of time	Grade range 1-4	5-8	9-12
Science	None	26 (2.8)	17 (1.9)	12 (1.5)
	Fewer than 6 hours	30 (1.8)	22 (2.6)	14 (1.8)
	6 -15 hours	22 (2.1)	27 (4.2)	18 (3.0)
	16 - 35 hours	14 (1.9)	14 (2.8)	19 (1.4)
	More than 35 hours	9 (1.8)	20 (2.4)	38 (3.1)
Mathematics	None	17 (1.5)	15 (1.5)	10 (1.8)
	Fewer than 6 hours	22 (2.0)	22 (3.5)	14 (2.8)
	6 -15 hours	29 (2.4)	23 (2.5)	21 (1.8)
	16 - 35 hours	18 (2.4)	24 (2.5)	24 (2.6)
	More than 35 hours	15 (2.0)	17 (2.0)	31 (2.5)

NOTE: Standard errors appear in parentheses.
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.

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Appendix table 3-33

Year of most recent college coursework in field for science and mathematics teachers, by grade range: 1993

Field and year of most recent course	Grade range 1-4	5-8	9-12
Science, total	100	100	100
Before 1983	53 (2.5)	41 (3.0)	24 (3.8)
1983 - 1988	20 (2.1)	18 (1.6)	21 (1.5)
1989 - 1993	26 (3.0)	41 (2.8)	55 (3.2)
Mathematics, total	100	100	100
Before 1983	41 (2.3)	39 (3.8)	31 (1.8)
1983 - 1988	22 (1.9)	22 (3.1)	26 (2.7)
1989 - 1993	37 (2.6)	40 (3.3)	43 (2.2)

NOTES: Standard errors appear in parentheses. Totals may not equal 100 percent as a result of rounding.
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.

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Appendix table 3-34

Percent of science and mathematics teachers participating in various professional activities in the past 12 months, by subject and grade range: 1993

Field and activity	Grade range: 1-4		5-8		9-12	
Science						
Served on a school or district curriculum committee	17	(3.4)	26	(2.3)	40	(2.7)
Served on a school or district textbook selection committee	14	(2.0)	19	(2.1)	37	(2.9)
Attended any national or state teacher association meetings	7	(1.0)	20	(3.0)	37	(3.3)
Taught any in-service workshops or courses in science or science teaching	5	(1.1)	9	(1.2)	16	(2.0)
Received any local, state, or national grants or awards for teaching	3	(0.7)	8	(1.3)	17	(1.9)
Mathematics						
Served on a school or district curriculum committee	18	(1.9)	25	(2.6)	51	(2.5)
Served on a school or district textbook selection committee	16	(2.0)	31	(2.7)	47	(2.9)
Attended any national or state teacher association meetings	9	(1.4)	19	(2.1)	39	(2.6)
Taught any in-service workshops or courses in mathematics or mathematics teaching	6	(1.4)	6	(0.8)	13	(1.2)
Received any local, state, or national grants or awards for teaching	3	(0.7)	3	(0.8)	8	(0.6)

NOTE: Standard errors appear in parentheses.
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.

Appendix table 3-35

Percent of mathematics classes never taking part in various activities, by grade range: 1993

Activity	Grade range 1-4		5-8		9-12	
Work at home on mathematics projects that take a week or more	72	(2.3)	53	(2.8)	66	(2.0)
Listen and take notes during presentation by teacher	63	(3.2)	12	(2.7)	1	(0.2)
Watch films, filmstrips, or videotapes	51	(2.2)	51	(2.4)	54	(2.4)
Work in class on mathematics projects that take a week or more	48	(1.8)	41	(2.7)	58	(2.1)
Write their reasoning about how to solve a problem	31	(1.9)	14	(1.5)	20	(1.6)
Use computers or calculators to develop an understanding of mathematics concepts	21	(1.6)	14	(2.3)	19	(2.2)
Use computers or calculators to do computations	17	(1.3)	8	(3.1)	7	(1.4)
Use computers or calculators to explore problems	17	(1.3)	10	(3.0)	15	(1.5)
Make conjectures and explore possible methods to solve a mathematics problem	16	(2.1)	8	(1.3)	14	(1.9)
Do mathematics problems from textbooks	11	(2.1)	1	(0.4)	1	(0.3)
Participate in dialogue with the teacher to develop an idea	8	(1.7)	5	(1.3)	4	(0.7)
Learn about mathematics through real-life applications	3	(1.2)	3	(1.1)	8	(1.2)
Do mathematics problems from worksheets	2	(0.7)	2	(0.4)	3	(0.6)
Use manipulative materials or models	1	(0.3)	7	(1.3)	19	(1.6)
Work in small groups	1	(0.3)	2	(0.6)	4	(0.6)

NOTE: Standard errors appear in parentheses.
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.

Appendix table 3-36

Percent of science classes never taking part in various activities, by grade range: 1993

Activity	Grade range 1-4		5-8		9-12	
Listen and take notes during presentation by teacher	52	(1.8)	6	(1.0)	0	(0.2)
Work at home on science projects that take a week or more	51	(1.9)	27	(2.3)	49	(2.3)
Use a computer	38	(3.0)	44	(3.0)	54	(3.2)
Prepare written science reports	36	(2.1)	10	(1.1)	12	(2.3)
Work in class on science projects that take a week or more	28	(2.5)	22	(2.1)	43	(3.4)
Read a science textbook in class	23	(2.4)	9	(1.4)	21	(1.2)
Take field trips	23	(2.7)	35	(2.9)	62	(2.3)
Watch films, filmstrips, or videotapes	6	(1.9)	2	(0.5)	8	(1.5)
Watch the teacher demonstrate a scientific principle	3	(0.8)	4	(1.6)	1	(0.4)
Participate in dialogue with the teacher to develop an idea	3	(1.0)	1	(0.5)	1	(0.4)
Do hands-on or laboratory science activities	2	(0.7)	2	(0.6)	1	(0.3)
Work in small groups	2	(1.0)	1	(0.2)	1	(0.1)

NOTE: Standard errors appear in parentheses.
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.

Appendix table 3-37

Percent of science and mathematics classes “covering” various proportions of their textbooks, by grade range: 1986 and 1993

Subject and textbook coverage	1986 Grades 1-6		1986 Grades 7-9		1986 Grades 10-12		1993 Grades 1-6		1993 Grades 7-9		1993 Grades 10-12	
Science, total	100		100		100		100		100		100	
Less than 25%	4	(0.8)	2	(0.8)	1	(0.5)	11	(1.7)	4	(0.7)	4	(1.2)
25% to 49%	11	(1.3)	11	(1.9)	12	(1.8)	18	(1.9)	16	(1.9)	18	(2.3)
50% to 74%	24	(1.2)	27	(2.8)	38	(3.7)	23	(1.8)	32	(3.0)	37	(2.6)
75% to 90%	30	(1.8)	41	(2.9)	34	(2.6)	29	(1.7)	40	(4.5)	34	(2.2)
Greater than 90%	31	(1.9)	20	(3.4)	15	(2.0)	19	(2.0)	8	(1.6)	8	(1.0)
Mathematics, total	100		100		100		100		100		100	
Less than 25%	0	(0.0)	1	(0.6)	3	(0.7)	1	(0.4)	0	(0.1)	1	(0.2)
25% to 49%	2	(0.6)	7	(1.5)	6	(1.0)	4	(0.7)	5	(1.1)	6	(0.7)
50% to 74%	8	(1.1)	17	(2.3)	23	(1.7)	22	(1.6)	20	(2.0)	24	(2.3)
75% to 90%	41	(1.9)	50	(3.0)	45	(2.0)	47	(2.1)	47	(2.5)	49	(3.2)
Greater than 90%	48	(3.0)	26	(2.6)	23	(1.7)	26	(2.0)	27	(2.2)	20	(1.7)

NOTES: Standard errors appear in parentheses. Totals may not equal 100 percent as a result of rounding.
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.

Appendix table 3-38

Percent of 12th-grade science teachers responding to availability and condition of science equipment and facilities: 1992

Description	Availability of consumable supplies	Condition of science equipment used	Availability of facilities (lab equipment)
Total	100.0	100.0	100.0
None	3.3	2.7	4.7
Poor	11.8	12.4	12.7
Fair	26.4	32.0	24.9
Good	40.8	41.3	36.7
Excellent	17.7	11.7	21.0

NOTE: Totals may not equal 100 percent as a result of rounding.
SOURCE: National Center for Education Statistics. (1992). *National education longitudinal study of 1988: Second teacher follow-up study.* Washington, DC: NCES.

Indicators of Science and Mathematics Education 1995

Appendix table 3-39

Median and mean student–computer ratios for computer-using schools, by country and school level: 1992

		Student–computer ratio*		
Education level	Country	Total schools	Median	Mean
Elementary	Japan	82	24	110 (16.7)
	Netherlands	175	16	24 (1.7)
	United States	171	6	7 (0.5)
Lower secondary	Austria	261	11	11 (0.3)
	Germany	134	15	17 (0.8)
	Japan	129	31	88 (14.4)
	Netherlands	285	14	15 (0.5)
	United States	148	5	7 (0.7)
Upper secondary	Austria	162	4	5 (0.4)
	Japan	136	23	38 (4.5)
	United States	130	5	8 (1.1)

* Student–computer ratio is calculated using grade-specific enrollment for three grades at each school level (rather than full school enrollment): the target grade, the grade immediately before the target grade, and the grade immediately after it.
NOTE: Standard errors appear in parentheses.
SOURCE: Pelgrum, W.J., Janssen Reinen, I.A.M., & Plomp, T. (Eds.). (1993). *Schools, teachers, students and computers: A cross-national perspective* (IEA COMPED Study Stage 2). Netherlands: IEA.

Indicators of Science and Mathematics Education 1995

Appendix table 3-40

Mean percent of 16+ bit computers (80286 and higher processors) in computer-using schools: 1989 and 1992

Education level	Nation	1989	1992
Lower secondary	Japan	77	92
	Austria	23	67
	Germany	12	38
	Netherlands	1	22
	United States	1	17
Upper secondary	Japan	72	85
	Austria	19	77
	Slovenia	17	76
	United States	3	29

NOTE: Standard errors are not available.
SOURCE: Pelgrum, W.J., Janssen Reinen, I.A.M., & Plomp, T. (Eds.). (1993). *Schools, teachers, students and computers: A cross-national perspective* (IEA COMPED Study Stage 2). Netherlands: IEA.

Appendix table 3-41

Percent of external network use by type of external network: 1992

Education level and type of network	Percent of all schools	Percent of schools that use external networks
Elementary, total number of schools	163	37
AT&T ID Learning	3	13
Dialog or other databases	5	24
National Geographic Kids Network	6	24
CompuServe or other e-mail	11	46
Other	11	43
Lower secondary, total number of schools	142	33
AT&T ID Learning	3	12
Dialog or other databases	3	15
National Geographic Kids Network	3	15
CompuServe or other e-mail	12	52
Other	8	36
Upper secondary, total number of schools	141	61
AT&T ID Learning	5	11
Dialog or other databases	13	30
National Geographic Kids Network	1	3
CompuServe or other e-mail	15	34
Other	15	34

NOTE: Standard errors are not available.
SOURCE: Anderson, R.E. (Ed.). (1993). *Computers in American schools, 1992: An overview.* Minneapolis, MN: University of Minnesota.

Indicators of Science and Mathematics Education 1995

Appendix table 3-42

Average percentage of mathematics problems correct on test items requiring the use of a calculator, ages 9, 13, and 17: 1978 to 1992

Tested age	Items on test	1978	1982	1986	1990	1992
9 years	8	74 (1.0)	75 (0.8)	75 (0.7)	78 (0.9)	80 (0.5)
13 years	8	55 (1.4)	52 (1.4)	55 (1.4)	60 (1.0)	62 (1.3)
17 years	11	63 (1.0)	59 (1.2)	65 (1.2)	66 (1.0)	67 (0.8)

NOTE: Standard errors appear in parentheses.
SOURCE: Mullis, I.V.S., et al. (1994). *NAEP 1992 trends in academic progress* (Report No. 23-TR01). Washington, DC: National Center for Education Statistics.

Indicators of Science and Mathematics Education 1995

Appendix table 4-1

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

Sex, race, or ethnic origin	High school diploma or less		Two years or fewer of college or vocational school		College graduate		Graduate degree	
	1980	1990	1980	1990	1980	1990	1980	1990
All sophomores	26.5	10.2	32.9	30.3	22.7	32.1	17.9	27.4
Male	28.0	11.0	31.7	32.3	22.4	32.9	18.0	23.8
Female	23.4	9.4	34.2	28.3	23.8	31.4	18.7	30.9
Asian	11.7	8.2	21.5	21.7	32.4	31.4	34.3	38.7
Hispanic	33.7	14.3	33.7	38.5	17.0	25.5	15.6	21.7
Black	26.3	11.1	32.7	30.2	21.8	28.2	19.2	30.5
White	25.9	9.4	33.1	29.5	23.4	33.9	17.7	27.3
Native American	35.7	18.8	32.9	43.0	17.2	21.8	14.2	16.5

NOTES: Persons of Hispanic origin may be of any race. Totals may not add to 100 percent as a result of rounding.
SOURCE: National Center for Education Statistics. (1992). *High school and beyond study, 1980 to 1992.* Washington, DC: NCES.

Appendix table 4-2

College enrollment rates of recent high school graduates, by race or ethnic origin: 1976 to 1992

Year	Recent high school graduates[1] (numbers in thousands)				Enrolled in college[2] (numbers in thousands)				Percent of high school graduates enrolled in college			
	Total	White	Black[3]	Hispanic[3]	Total	White	Black[3]	Hispanic[3]	Total	White	Black[3]	Hispanic[3]
1976	2,987	2,640	320	152	1,458	1,291	134	80	48.8	48.9	41.9	52.6
1977	3,140	2,768	335	156	1,590	1,403	166	80	50.6	50.7	49.6	51.3
1978	3,161	2,750	352	133	1,584	1,378	161	57	50.1	50.1	45.7	42.9
1979	3,160	2,776	324	154	1,559	1,376	147	69	49.3	49.6	45.4	44.8
1980	3,089	2,682	361	129	1,524	1,339	151	68	49.3	49.9	41.8	52.7
1981	3,053	2,626	359	146	1,646	1,434	154	76	53.9	54.6	42.9	52.1
1982	3,100	2,644	384	174	1,568	1,376	140	75	50.6	52.0	36.5	43.1
1983	2,964	2,496	392	138	1,562	1,372	151	75	52.7	55.0	38.5	54.3
1984	3,012	2,514	438	185	1,662	1,455	176	82	55.2	57.9	40.2	44.3
1985	2,666	2,241	333	141	1,539	1,332	141	72	57.7	59.4	42.3	51.1
1986	2,786	2,307	386	169	1,499	1,292	141	75	53.8	56.0	36.5	44.4
1987	2,647	2,207	337	176	1,503	1,249	175	59	56.8	56.6	51.9	33.5
1988	2,673	2,187	382	179	1,575	1,328	172	102	58.9	60.7	45.0	57.0
1989	2,454	2,051	337	168	1,463	1,238	178	93	59.6	60.4	52.8	55.4
1990	2,355	1,921	341	112	1,410	1,182	158	53	59.9	61.5	46.3	47.3
1991	2,276	1,867	320	154	1,420	1,207	146	88	62.4	64.6	45.6	57.1
1992	2,398	1,900	353	199	1,479	1,204	169	109	61.7	63.4	47.9	54.8

NOTES: Persons of Hispanic origin may be of any race. Data are based upon sample surveys of the civilian population.

[1] Individuals aged 16 to 24 who graduated from high school during the preceding 12 months.

[2] Enrollment in college as of October of each year for individuals aged 16 to 24 who graduated from high school or received the GED during the preceding 12 months.

[3] As a result of the small sample size, black and Hispanic data are subject to relatively large sampling errors.

SOURCE: National Center for Education Statistics. (1994). *Digest of educational statistics 1994* (NCES 94-115). Washington, DC: U.S. Government Printing Office.

Appendix table 4-3

Total fall enrollment in postsecondary institutions, by attendance status and age: 1970 to 1991

Age	1970	1975	1980	1985	1987	1990	1991
	Full-time students (in thousands)						
Total	5,815	6,841	7,098	7,075	7,231	7,821	8,115
14-17 years	242	242	216	203	142	141	114
18 and 19	2,406	2,510	2,580	2,322	2,488	2,479	2,408
20 and 21	1,647	1,854	2,060	1,975	2,024	2,121	2,299
22-24	881	1,008	1,174	1,227	1,223	1,387	1,496
25-29	407	692	610	695	693	802	868
30-34	100	279	264	310	293	403	401
35 and older	134	256	193	345	367	487	528
Percent 21 years and younger	73.9	67.3	68.4	63.6	64.4	60.6	59.4
	Part-time students (in thousands)						
Total	2,766	4,344	4,999	5,172	5,536	5,998	6,244
14-17 years	17	36	31	32	95	26	7
18 and 19	194	276	320	278	359	321	305
20 and 21	233	390	364	408	480	498	469
22-24	576	746	815	705	766	779	790
25-29	668	1,082	1,261	1,258	1,237	1,261	1,266
30-34	388	687	979	951	972	957	1,067
35 and older	689	1,127	1,229	1,540	1,626	2,157	2,339
Percent 21 years and younger	16.1	16.2	14.3	13.9	16.9	14.1	12.5

NOTES: Distribution by age is based on samples of the civilian noninstitutional population. Numbers may not add to totals as a result of rounding.
SOURCE: National Center for Education Statistics. (1994). *Digest of educational statistics 1994* (NCES 94-115). Washington, DC: U.S. Government Printing Office.

Appendix table 4-4

Total fall enrollment in postsecondary institutions, by sex: 1970 to 1998 (projected)

Year	Enrollment (in thousands)			Percent female
	Total	Men	Women	
1970	8,581	5,044	3,537	41.2
1975	11,185	6,149	5,036	45.0
1980	12,097	5,874	6,223	51.4
1985	12,247	5,818	6,429	52.5
1987	12,767	5,932	6,835	53.5
1990	13,820	6,284	7,535	54.5
1991	14,359	6,502	7,857	54.7
1998*	15,111	6,811	8,300	54.9

* Projected

SOURCE: National Center for Education Statistics. (1994). *Digest of educational statistics 1994* (NCES 94-115). Washington, DC: U.S. Government Printing Office.

Appendix table 4-5

Total fall enrollment in postsecondary institutions, by race or ethnic origin of student, all institutions, and 2-year institutions: 1976 to 1993

Race or ethnic origin	1976	1980	1984	1988	1990	1991	1993
				All institutions			
				Students (in thousands)			
Total	10,986	12,087	12,233	13,043	13,820	14,359	14,306
White	9,076	9,833	9,815	10,283	10,723	10,990	10,604
Black	1,033	1,107	1,076	1,130	1,247	1,335	1,410
Hispanic	384	472	535	680	783	867	989
Asian	198	286	390	497	573	637	724
Native American	76	84	84	93	103	114	122
Nonresident alien	219	305	335	361	392	416	457
				Percent (U.S. citizens only)			
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
White	84.3	83.5	82.5	81.1	79.9	78.8	76.6
Black	9.6	9.4	9.0	8.9	9.3	9.6	10.2
Hispanic	3.6	4.0	4.5	5.4	5.8	6.2	7.1
Asian	1.8	2.4	3.3	3.9	4.3	4.6	5.2
Native American	0.7	0.7	0.7	0.7	0.8	0.8	0.9
Nonresident alien	--	--	--	--	--	--	--
				Two-year institutions			
				Students (in thousands)			
Total	3,879	4,521	4,527	4,868	5,240	5,652	5,566
White	3,077	3,556	3,514	3,702	3,954	4,199	3,961
Black	429	473	459	473	524	578	599
Hispanic	210	255	289	384	424	484	557
Asian	79	124	167	199	215	256	295
Native American	41	47	46	50	55	74	63
Nonresident alien	42	64	53	60	67	63	91
				Percent (U.S. citizens only)			
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
White	80.2	79.8	78.5	77.0	76.4	75.1	72.3
Black	11.2	10.6	10.3	9.8	10.1	10.3	10.9
Hispanic	5.5	5.7	6.5	8.0	8.2	8.7	10.2
Asian	2.1	2.8	3.7	4.1	4.2	4.6	5.4
Native American	1.1	1.1	1.0	1.0	1.1	1.3	1.2
Nonresident alien	--	--	--	--	--	--	--

–Distribution for U.S. citizens only.
NOTES: Numbers may not add to totals as a result of rounding. Persons of Hispanic origin may be of any race.
SOURCES: National Center for Education Statistics. (1994). *Digest of educational statistics 1994* (NCES 94-115). Washington, DC: U.S. Government Printing Office; National Center for Education Statistics. (1995). *Fall enrollment in colleges and universities.* Unpublished tabulations.

Appendix table 4-6

Number of college courses outside their major that 1991 bachelor's degree recipients took, by field, sex, and race or ethnic origin: 1991

Courses	Total	Male	Female	Race or ethnic origin: Black	Hispanic	Asian	Other race or ethnic origin
	Mathematics and computer science coursetaking by non-mathematics and non-computer-science majors						
Total, nonmajors	1,008,018	449,784	557,512	59,496	40,653	37,019	55,246
None	196,601	75,274	119,952	10,934	6,983	7,684	12,551
1-4	647,586	268,780	376,358	37,311	24,748	21,153	31,319
5 or more	163,831	105,730	61,202	11,251	8,922	8,181	11,376
	Percent						
Total, nonmajors	100.0	100.0	100.0	100.0	100.0	100.0	100.0
None	19.5	16.7	21.5	18.4	17.2	20.8	22.7
1-4	64.2	59.8	67.5	62.7	60.9	57.1	56.7
5 or more	16.3	23.5	11.0	18.9	21.9	22.1	20.6
	Engineering coursetaking by non-engineering majors						
Total, nonmajors	978,503	417,450	558,376	59,214	39,361	33,355	53,151
None	908,211	370,072	533,972	56,113	37,768	28,147	50,918
1-4	57,112	35,436	22,559	2,739	1,362	4,465	1,293
5 or more	13,180	11,942	1,845	362	231	743	940
	Percent						
Total, nonmajors	100.0	100.0	100.0	100.0	100.0	100.0	100.0
None	92.8	88.7	95.6	94.8	96.0	84.4	95.8
1-4	5.8	8.5	4.0	4.6	3.5	13.4	2.4
5 or more	1.3	2.9	0.3	0.6	0.6	2.2	1.8

Continued

Appendix table 4-6

Number of college courses outside their major that 1991 bachelor's degree recipients took, by field, sex, and race or ethnic origin: 1991, continued

Courses	Total	Male	Female	Race or ethnic origin: Black	Hispanic	Asian	Other race or ethnic origin
	Life and physical sciences coursetaking by non-life and non-physical-sciences majors						
Total, nonmajors	984,866	441,116	543,238	57,595	40,175	35,837	54,378
None	211,507	93,301	118,223	11,992	10,807	6,855	13,391
1-4	609,855	263,147	345,009	36,500	21,820	18,792	30,526
5 or more	163,504	84,668	80,006	9,103	7,548	10,190	10,461
	Percent						
Total, nonmajors	100.0	100.0	100.0	100.0	100.0	100.0	100.0
None	21.5	21.2	21.8	20.8	26.9	19.1	24.6
1-4	61.9	59.7	63.5	63.4	54.3	52.4	56.1
5 or more	16.6	19.2	14.7	15.8	18.8	28.4	19.2
	Social sciences coursetaking by non-social-sciences majors						
Total, nonmajors	860,673	386,976	473,240	48,297	34,676	33,293	49,258
None	51,791	22,078	29,340	2,176	2,502	2,028	4,957
1-4	338,265	158,003	180,885	18,284	13,935	13,815	21,656
5 or more	470,617	206,895	263,014	27,837	18,239	17,450	22,645
	Percent						
Total, nonmajors	100.0	100.0	100.0	100.0	100.0	100.0	100.0
None	6.0	5.7	6.2	4.5	7.2	6.1	10.1
1-4	39.3	40.8	38.2	37.9	40.2	41.5	44.0
5 or more	54.7	53.5	55.6	57.6	52.6	52.4	46.0

NOTES: Persons of Hispanic origin may be of any race. Numbers shown are population estimates from a weighted sample.
SOURCE: University of Pennsylvania Institute for Research on Higher Education and the Association of American Colleges and Universities. (1994). *Estimates of student curricular activity from a national survey of colleges and universities.* Philadelphia: University of Pennsylvania.

Appendix table 4-7

Students with a grade point average of 3.0 or higher, by field of major and sex: 1991

Major and sex	Total students	Number of students with GPA 3.0 or higher	Percent of students
All students			
All fields, total	1,044,267	562,741	53.9
Science and engineering, total	345,009	185,907	53.9
Mathematical and computer sciences	36,249	19,751	54.5
Life and physical sciences	59,401	36,659	61.7
Engineering	65,764	34,087	51.8
Social sciences	183,595	95,410	53.9
Males			
All fields, total	473,851	221,271	46.7
Science and engineering, total	200,077	98,532	49.2
Mathematical and computer sciences	24,067	11,693	48.6
Life and physical sciences	32,734	19,500	59.6
Engineering	56,401	27,706	49.1
Social sciences	86,875	39,633	45.6
Females			
All fields, total	570,416	338,047	59.3
Science and engineering, total	149,298	88,610	59.4
Mathematical and computer sciences	12,904	8,373	64.9
Life and physical sciences	27,178	17,364	63.9
Engineering	12,040	7,532	62.6
Social sciences	97,176	55,341	56.9

SOURCE: University of Pennsylvania Institute for Research on Higher Education and the Association of American Colleges and Universities. (1994). *Estimates of student curricular activity from a national survey of colleges and universities.* Philadelphia: University of Pennsylvania.

Appendix table 4-8

Number and percent of high school graduates, college enrollment, and science and engineering degree attainment, by race or ethnic origin: 1990

Race or ethnic origin	U.S. population (18-24 years old)	High school graduates (18-24 years old)	High school graduates enrolled in college (18-24 years old)	Science and engineering earned bachelor's degrees	Science and engineering earned doctorates
	Number				
Total	24,852,000	20,311,000	7,964,000	379,392	14,014
White	20,393,000	16,823,000	6,635,000	296,140	12,560
Black	3,520,000	2,710,000	894,000	21,274	285
Hispanic	2,749,000	1,498,000	435,000	15,680	382
	Percent				
Total	100.0	100.0	100.0	100.0	100.0
White	82.1	82.8	83.3	78.1	89.6
Black	14.2	13.3	11.2	5.6	2.0
Hispanic	11.1	7.4	5.5	4.1	2.7

NOTES: Persons of Hispanic origin may be of any race. Totals may not add to 100 percent because not all races and ethnic groups are shown.
SOURCES: National Science Foundation. (1994). *Science and engineering degrees, by race/ethnicity of recipients: 1977-1991* (NSF 94-306). Arlington, VA: NSF; U.S. Bureau of the Census. (1992). *School enrollment—social and economic characteristics of students: October 1990* (Current Population Reports, Series P-20, No.460). Washington, DC: U.S. Government Printing Office.

Appendix table 4-9

Number and percent of high school graduates, college enrollment, and science and engineering degree attainment, by sex: 1990

Sex	U.S. population (18-24 years old)	High school graduates (18-24 years old)	High school graduates enrolled in college (18-24 years old)	Science and engineering earned bachelor's degrees	Science and engineering earned doctorates
			Number		
Total	24,852,000	20,311,000	7,964,000	329,094	22,763
Male	12,134,000	9,778,000	3,922,000	189,082	16,447
Female	12,718,000	10,533,000	4,042,000	140,012	6,316
			Percent		
Total	100.0	100.0	100.0	100.0	100.0
Male	48.8	48.1	49.2	57.5	72.3
Female	51.2	51.9	50.8	42.5	27.7

SOURCES: National Science Foundation. (1994). *Science and engineering degrees: 1966-1991* (NSF 94-305). Arlington, VA: NSF; U.S. Bureau of the Census. (1992). *School enrollment—social and economic characteristics of students: October 1990* (Current Population Reports, Series P-20, No.460). Washington, DC: U.S. Government Printing Office.

Indicators of Science and Mathematics Education 1995

Appendix table 4-10

Percent of high school seniors taking selected science and mathematics courses, by sex and post-high-school plans: 1990 and 1993

					Post-high-school plans		
Course area	Year	All students	Male	Female	Intended major in the natural sciences or engineering	Other college major	Non-college-bound
Mathematics							
Algebra	1990	89	88	89	98	97	77
	1993	91	91	92	98	98	79
Geometry	1990	71	70	71	93	89	48
	1993	74	73	75	94	89	46
Trigonometry	1990	28	31	27	67	38	6
	1993	36	36	37	74	42	8
Calculus	1990	8	10	6	26	11	*
	1993	11	13	9	33	8	*
Number in sample	1990	2,332	1,107	1,225	276	474	752
	1993	2,046	1,071	975	229	464	579
Science							
Low-level science	1990	75	74	76	62	73	84
	1993	73	74	72	52	73	90
Biology	1990	92	93	92	98	98	86
	1993	91	90	93	96	96	83
Chemistry	1990	53	54	53	84	73	27
	1993	60	59	62	85	75	29
Physics	1990	23	27	19	52	27	6
	1993	32	32	27	64	30	7
Number in sample	1990	2,296	1,096	1,201	276	486	748
	1993	2,016	1,057	959	229	464	578

* Less than 1 percent.
SOURCE: National Science Board. (1993). *Science and engineering indicators - 1993* (NSB 93-1). Washington, DC: U.S. Government Printing Office.

Appendix table 4-11

Percent of all faculty who say that undergraduates in their country are adequately prepared in selected skills, by type of skill and country: 1992

Country	Mathematics and quantitative reasoning	Written and oral communication
Hong Kong	39	19
South Korea	37	59
Sweden	32	32
Russia	27	26
Mexico	23	24
Japan	22	30
Chile	22	17
Israel	19	15
Australia	18	20
United States	15	20

NOTE: Includes faculty of all disciplines and departments.
SOURCE: Mooney, C.J. (1994, June 22). The shared concerns of scholars. *The Chronicle of Higher Education.* XL (42), pp. A37-A38.

Appendix table 4-12

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

Field of major	Remained in same or like major	Moved to other group of majors
All natural sciences and engineering	56.0	44.0
Engineering	61.9	38.1
Natural sciences		
Biological sciences	49.1	51.0
Computer sciences	46.4	53.6
Mathematical sciences	37.3	62.7
Physical sciences	48.8	51.2
Social and behavioral sciences	72.0	28.0
Non-science and -engineering		
Business	59.5	40.5
Education	67.7	32.3
English	84.9	15.1
Fine arts	70.1	29.9
History or political science	65.2	34.8

NOTE: Like majors are defined as follows: Group one—biological sciences, physical sciences, engineering, and mathematical sciences; Group two—history or political science, social and behavioral sciences, fine arts, and English. Computer sciences, business, and education were defined to be separate majors, without other like majors.
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.

Appendix table 4-13

Average undergraduate tuition and fees paid by students, by type and control of institution: 1985 to 1993

	Public institutions		Private institutions	
Year	4-year	2-year	4-year	2-year
1985	$1,657	$788	$7,497	$4,703
1986	1,717	835	7,976	4,785
1987	1,809	844	8,516	4,713
1988	1,897	871	8,782	5,135
1989	1,961	865	9,152	5,709
1990	2,012	854	9,492	5,875
1991	2,025	884	9,743	5,975
1992	2,181	965	10,062	5,921
1993	2,352	1,018	10,393	6,101

NOTES: 1993 data are preliminary. Public institution tuition and fees are shown for in-state residents. Amounts represent real 1993 dollars.
SOURCE: National Center for Education Statistics. (1993). *Digest of educational statistics 1993* (NCES 93-292). Washington, DC: U.S. Government Printing Office.

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Appendix table 4-14

Debt burden of 1990 bachelor's degree recipients, by postgraduation occupation: 1991

Occupation	Percent with debt	Median debt	Median income	Median debt as a percent of median first-year income
Engineers, surveyors, architects	51.5	$6,900	$31,200	22.1
Elementary & secondary teachers	51.0	$6,500	$18,200	35.7
Science technicians	46.9	$4,000	$20,500	19.5
Engineering technicians	46.2	$8,000	$27,900	28.7
Social scientists & urban planners	45.3	$8,000	$20,500	39.0
Natural scientists & mathematicians	44.6	$5,000	$23,900	20.9
Computer scientists	40.2	$8,000	$30,000	26.7

NOTES: Median debt includes only those with debt. Median income includes only those with debt and first-year income.
SOURCE: U.S. Department of Education, Office of Policy and Planning. (1993). *Debt burden: The next generation.* Rockville, MD: Westat, Inc.

Indicators of Science and Mathematics Education 1995

Appendix table 4-15

Number and percent of science and engineering doctorate recipients, by primary source of support, residency status, and race or ethnic origin: 1992

Primary source of support	Total	Noncitizens: Permanent residents	Noncitizens: Temporary residents	U.S. citizens: Total	U.S. citizens: Whites	U.S. citizens: Blacks	U.S. citizens: Hispanics	U.S. citizens: Asians	U.S. citizens: Native Americans
	Number								
Total	17,823	918	5,681	11,199	10,042	205	285	480	51
University	10,976	645	4,347	5,970	5,380	75	126	277	27
Personal	4,320	192	523	3,599	3,271	77	99	109	17
Federal	1,206	26	68	1,113	975	24	39	61	3
Other	1,325	55	744	516	421	29	21	33	4
	Percent								
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
University	61.6	70.2	76.5	53.3	53.6	36.6	44.2	57.8	52.9
Personal	24.2	20.9	9.2	32.1	32.6	37.6	34.8	22.7	33.3
Federal	6.8	2.8	1.2	9.9	9.7	11.7	13.7	12.7	5.9
Other	7.4	6.0	13.1	4.6	4.2	14.1	7.4	6.9	7.8

NOTES: Persons of Hispanic origin may be of any race. University sources include research and teaching assistantships funded under Federal research grants, as well as other sources available to universities. Personal sources include loans (Federal and non-Federal), recipients' own earnings, and contributions from family and spouse. Federal sources include Federal agency fellowship and traineeship programs. Other support includes U.S. nationally competitive fellowships, business or employer funds, foreign government, state government, and other nonspecified sources. Numbers represent only those doctorate recipients with known primary support. Percents are based on these numbers. Data also include health sciences which are not included in other doctoral data in this report.
SOURCE: Ries, P., & Thurgood, D. (1994). *Summary report 1992: Doctorate recipients from United States universities.* Washington, DC: National Academy Press.

Appendix table 4-16

Participation rate of 22-year-olds in first university degrees in the natural sciences and engineering, by sex and country: most current year (1989 to 1992)

Region/ country	All first university degrees	Natural sciences [1]	Social sciences	Engineering [2]	Persons 22-years-old	Percent 22-year-olds: With first univ. degree	Percent 22-year-olds: With NS&E degree[3]	Percent 22-year-olds: NS&E degrees earned as a percent of all 22-year-olds
	Male							
Asia								
Japan [4]	290,253	20,221	138,708	78,705	915,800	31.7	10.8	5.5
South Korea	104,627	15,953	7,579	26,763	447,600	23.4	9.5	5.0
Taiwan	23,556	4,723	1,167	8,110	190,800	12.4	6.7	3.5
Europe								
Austria	5,996	1,071	301	978	62,272	9.6	3.3	1.7
Bulgaria	10,296	1,047	201	3,337	61,046	16.9	7.2	3.7
France	55,637	10,416	3,925	13,394	435,915	12.8	5.5	2.8
Germany [5]	111,894	18,475	20,829	34,634	660,000	16.1	7.6	4.1
Greece	8,600	1,731	969	1,547	78,932	10.9	4.2	2.1
Italy	46,519	6,779	10,447	7,278	465,783	10.0	3.0	1.5
Poland	24,525	3,309	752	6,100	265,441	9.2	3.5	1.8
Spain	51,208	7,390	1,495	5,996	338,000	15.2	4.0	2.0
Sweden	7,203	897	262	2,018	60,871	11.8	4.8	2.5
Switzerland	5,893	1,088	429	751	47,859	11.5	3.6	2.0
United Kingdom [6]	46,888	12,963	6,536	8,647	437,232	10.7	4.9	2.5
North America								
Canada	56,157	8,235	7,929	7,738	205,200	27.4	7.3	4.0
United States	508,952	62,341	74,900	68,851	1,896,959	26.8	6.9	3.5
	Female							
Asia								
Japan [4]	109,750	4,932	18,519	2,650	871,600	12.6	0.9	0.4
South Korea	61,289	7,242	2,632	1,308	411,400	14.9	2.1	1.0
Taiwan	19,396	1,810	2,007	840	180,200	10.8	1.5	0.7
Europe								
Austria	4,673	481	457	70	59,590	7.8	0.9	0.5
Bulgaria	13,590	1,341	259	3,211	57,259	23.7	7.8	3.8
France	48,200	5,484	3,419	3,195	417,947	11.5	2.1	1.0
Germany [5]	69,751	11,425	16,297	4,218	627,400	10.6	2.4	1.2
Greece	9,832	1,228	998	450	73,717	13.3	2.3	1.1
Italy	49,706	6,369	8,864	622	450,470	11.0	1.6	0.8
Poland	30,835	3,551	1,329	1,340	252,900	12.2	1.9	0.9
Spain	70,691	5,912	4,024	648	322,400	21.9	2.0	1.0
Sweden	9,859	595	938	529	57,994	17.0	1.9	0.9
Switzerland	3,272	376	495	26	45,940	7.1	0.9	0.4
United Kingdom [6]	38,005	7,368	6,855	1,398	416,872	9.1	2.1	1.0
North America								
Canada	74,007	5,272	13,811	929	198,200	34.2	3.1	1.5
United States	599,045	50,542	95,205	11,630	1,829,155	32.8	3.4	1.7

NOTES: NS&E = Natural sciences and engineering. Data for Bulgaria, Germany, Italy, Poland, Switzerland, and the United Kingdom are from 1992. Data for Austria, France, Greece, Japan, Sweden, and the United States are for 1991. All other data are from 1990.
[1] Includes degrees in math and computer sciences and agricultural sciences. [2] Includes degrees in engineering technology. [3] Social science degrees are not included in this proportion. [4] Japanese social sciences data are adjusted to delete business. [5] Average age of German degree recipient is 27 years of age. Population given is for all 27-year-olds in united Germany. [6] United Kingdom data do not include open universities.
SOURCE: National Science Foundation. (1994). [Special tabulations of statistics of international degrees]. Unpublished data.

Appendix table 4-17

Degrees awarded in all fields, science and engineering, and science and engineering as a percent of all fields, by degree level: 1971 to 1991

Degree	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
All fields, total												
Associate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bachelor's	846,110	894,110	930,272	954,376	931,663	934,443	928,228	930,201	931,340	940,251	946,877	964,043
Master's	231,486	252,774	264,525	278,259	293,651	313,001	318,241	312,816	302,075	299,095	296,798	296,580
Doctoral	31,867	33,041	33,755	33,047	32,952	32,946	31,716	30,875	31,239	31,020	31,357	31,111
Science and engineering, total												
Associate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bachelor's	294,357	306,459	321,085	326,230	313,555	309,491	303,798	303,555	303,162	304,695	306,792	315,023
Master's	56,454	60,049	62,046	62,239	63,198	65,007	67,397	67,264	64,226	64,089	64,366	66,568
Doctoral	19,363	19,324	19,352	18,694	18,711	18,364	17,892	17,539	17,753	17,668	18,143	18,190
Science and engineering as a percent of all fields												
Associate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bachelor's	34.8	34.3	34.5	34.2	33.7	33.1	32.7	32.6	32.6	32.4	32.4	32.7
Master's	24.4	23.8	23.5	22.4	21.5	20.8	21.2	21.5	21.3	21.4	21.7	22.4
Doctoral	60.8	58.5	57.3	56.6	56.8	55.7	56.4	56.8	56.8	57.0	57.9	58.5

Continued

Appendix table 4-17

Degrees awarded in all fields, science and engineering, and science and engineering as a percent of total, by degree level: 1971 to 1991, continued

Degree	1983	1984	1985	1986	1987	1988	1989	1990	1991
All fields, total									
Associate	461,888	457,851	459,087	451,258	440,816	441,093	440,375	459,048	486,297
Bachelor's	980,679	986,345	990,877	1,000,204	1,003,532	1,006,033	1,030,171	1,062,151	1,107,997
Master's	290,931	285,462	287,213	289,829	290,532	300,091	311,050	324,947	338,498
Doctoral	31,282	31,337	31,297	31,895	32,363	33,490	34,318	36,057	37,451
Science and engineering, total									
Associate	23,901	28,183	26,580	25,359	23,130	21,520	19,733	19,810	19,352
Bachelor's	317,875	324,483	332,422	335,460	331,526	322,482	322,821	329,094	337,675
Master's	67,716	68,564	70,562	71,831	72,603	73,655	76,425	77,788	78,368
Doctoral	18,506	18,641	18,824	19,339	19,784	20,832	21,625	22,763	23,854
Science and engineering as a percent of all fields									
Associate	5.2	6.2	5.8	5.6	5.3	4.9	4.5	4.3	4.0
Bachelor's	32.4	32.9	33.5	33.5	33.0	32.1	31.3	31.0	30.5
Master's	23.3	24.0	24.6	24.8	25.0	24.5	24.6	23.9	23.2
Doctoral	59.2	59.5	60.1	60.6	61.1	62.2	63.0	63.1	63.7

N/A: Not available.
NOTE: Data on science and engineering associate degrees are not available before 1983.
SOURCE: National Science Foundation. (1994). *Science and engineering degrees: 1966-91* (NSF 94-305). Arlington, VA: NSF.

Appendix table 4-18

Number of bachelor's degrees awarded, by major field group and by sex: 1971 to 1991

	Total				Female				
					Total S&E				
Year	Total S&E	Engineering	Natural sciences	Social and behav. sci.	Number	Percent	Engineering	Natural sciences	Social and behav. sci.
1971	294,357	45,248	94,544	154,565	85,039	28.9	361	23,848	60,830
1972	306,459	45,711	96,410	164,338	90,037	29.4	492	24,709	64,836
1973	321,085	46,779	103,004	171,302	95,995	29.9	576	26,885	68,534
1974	326,230	43,248	109,752	173,230	102,578	31.4	698	29,986	71,894
1975	313,555	39,824	110,584	163,147	102,814	32.8	845	31,878	70,091
1976	309,491	38,790	113,296	157,405	103,921	33.6	1,317	33,653	68,951
1977	303,798	41,357	113,908	148,533	104,993	34.6	2,044	35,289	67,660
1978	303,555	47,251	112,286	144,018	107,667	35.5	3,482	36,457	67,728
1979	303,162	53,469	110,790	138,903	109,915	36.3	4,881	37,494	67,540
1980	304,695	58,810	110,253	135,632	113,480	37.2	5,952	38,905	68,623
1981	306,792	63,717	110,468	132,607	115,815	37.8	7,063	40,366	68,386
1982	315,023	67,460	113,998	133,565	121,399	38.5	8,275	42,819	70,305
1983	317,875	72,670	116,554	128,651	123,337	38.8	9,652	45,426	68,259
1984	324,483	76,153	122,252	126,078	125,221	38.6	10,729	47,973	66,519
1985	332,422	77,572	129,817	125,033	128,958	38.8	11,246	51,449	66,263
1986	335,460	76,820	131,082	127,558	130,689	39.0	11,138	51,836	67,715
1987	331,526	74,425	125,166	131,935	131,545	39.7	11,404	49,706	70,435
1988	322,482	70,154	115,611	136,717	130,933	40.6	10,779	46,569	73,585
1989	322,821	66,947	109,137	146,737	133,483	41.3	10,188	43,446	79,849
1990	329,094	64,705	105,021	159,368	140,012	42.5	9,973	42,680	87,359
1991	337,675	62,187	105,383	170,105	148,347	43.9	9,665	43,477	95,205

NOTE: S&E is science and engineering.
SOURCE: National Science Foundation. (1994). *Science and engineering degrees: 1966-91* (NSF 94-305). Arlington, VA: NSF.

Appendix table 4-19

Number of master's degrees awarded, by major field group and by sex: 1971 to 1991

	Total				Female			
Year	Total science and engineering	Engineering	Natural sciences	Social and behavioral sciences	Total science and engineering	Engineering	Natural sciences	Social and behavioral sciences
1971	56,454	16,367	20,735	19,352	10,338	186	4,598	5,554
1972	60,049	16,764	21,658	21,627	11,328	271	4,851	6,206
1973	62,046	16,545	21,899	23,602	11,813	278	4,683	6,852
1974	62,239	15,205	22,040	24,994	12,711	347	4,913	7,451
1975	63,198	15,167	21,468	26,563	13,788	372	4,888	8,528
1976	65,007	16,045	21,150	27,812	15,015	568	4,986	9,461
1977	67,397	16,012	21,856	29,529	16,498	698	5,493	10,307
1978	67,264	16,080	21,967	29,217	17,230	843	5,680	10,707
1979	64,226	15,279	21,544	27,403	17,612	937	5,852	10,823
1980	64,089	15,943	21,347	26,799	18,085	1,123	5,903	11,059
1981	64,366	16,451	21,136	26,779	18,861	1,329	5,975	11,557
1982	66,568	17,557	22,368	26,643	20,011	1,575	6,722	11,714
1983	67,716	18,886	22,540	26,290	20,998	1,755	7,054	12,189
1984	68,564	20,145	23,170	25,249	21,531	2,100	7,483	11,948
1985	70,562	20,972	23,961	25,629	22,320	2,244	7,730	12,356
1986	71,831	21,096	25,151	25,584	23,220	2,400	8,305	12,515
1987	72,603	22,070	25,208	25,325	23,844	2,770	8,545	12,529
1988	73,655	22,726	25,784	25,145	23,835	2,808	8,463	12,564
1989	76,425	23,743	26,047	26,635	25,580	3,082	8,831	13,667
1990	77,788	23,995	26,255	27,538	26,558	3,269	9,027	14,262
1991	78,368	24,013	25,638	28,717	27,927	3,357	9,135	15,435

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

Appendix table 4-20

Number of doctoral degrees awarded, by major field group and by sex: 1971 to 1991

	Total				Female			
Year	Total science and engineering	Engineering	Natural sciences	Social and behavioral sciences	Total science and engineering	Engineering	Natural sciences	Social and behavioral sciences
1971	19,363	3,514	10,280	5,569	1,990	16	1,000	974
1972	19,324	3,509	9,986	5,829	2,142	22	1,040	1,080
1973	19,352	3,374	9,804	6,174	2,510	46	1,171	1,293
1974	18,694	3,161	9,266	6,267	2,662	34	1,163	1,465
1975	18,711	3,011	9,250	6,450	2,905	52	1,252	1,601
1976	18,364	2,838	8,866	6,660	3,060	55	1,272	1,733
1977	17,892	2,648	8,640	6,604	3,185	74	1,273	1,838
1978	17,539	2,425	8,560	6,554	3,410	53	1,397	1,960
1979	17,753	2,494	8,796	6,463	3,703	62	1,527	2,114
1980	17,668	2,479	8,826	6,363	3,915	90	1,652	2,173
1981	18,143	2,528	8,956	6,659	4,143	99	1,724	2,320
1982	18,190	2,646	9,135	6,409	4,307	124	1,868	2,315
1983	18,506	2,781	9,182	6,543	4,650	124	1,983	2,543
1984	18,641	2,913	9,329	6,399	4,739	151	2,005	2,583
1985	18,824	3,166	9,435	6,223	4,840	198	2,123	2,519
1986	19,339	3,376	9,612	6,351	5,114	225	2,316	2,663
1987	19,784	3,712	9,845	6,227	5,253	242	2,361	2,650
1988	20,832	4,188	10,437	6,207	5,606	286	2,570	2,750
1989	21,625	4,544	10,656	6,425	6,044	375	2,799	2,870
1990	22,763	4,893	11,363	6,507	6,316	415	2,932	2,969
1991	23,854	5,212	11,989	6,653	6,789	452	3,122	3,215

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

Appendix table 4-21

Science and engineering degrees awarded per hundred U.S. population, by degree level and sex: 1971 to 1991

Year	Bachelor's degree			Master's degree			Doctoral degree		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
1971	8.4	11.9	4.9	1.5	2.4	0.5	0.7	1.3	0.2
1972	8.7	12.3	5.1	1.7	2.7	0.6	0.7	1.2	0.2
1973	8.8	12.2	5.3	1.7	2.8	0.7	0.6	1.1	0.2
1974	8.7	11.8	5.5	1.7	2.8	0.7	0.6	1.1	0.2
1975	8.1	10.8	5.4	1.7	2.7	0.7	0.6	1.1	0.2
1976	7.8	10.3	5.3	1.7	2.6	0.8	0.6	1.1	0.2
1977	7.5	9.7	5.2	1.7	2.6	0.8	0.5	0.7	0.2
1978	7.4	9.5	5.3	1.7	2.5	0.9	0.5	0.8	0.2
1979	7.1	9.0	5.2	1.6	2.3	0.9	0.5	0.8	0.2
1980	7.1	8.9	5.3	1.5	2.2	0.9	0.5	0.7	0.2
1981	7.2	8.9	5.4	1.5	2.1	0.9	0.5	0.7	0.2
1982	7.4	9.0	5.7	1.5	2.1	0.9	0.5	0.7	0.2
1983	7.3	8.9	5.7	1.6	2.1	1.0	0.5	0.7	0.2
1984	7.6	9.3	5.9	1.6	2.2	1.0	0.4	0.7	0.2
1985	7.9	9.6	6.2	1.6	2.2	1.0	0.4	0.7	0.2
1986	8.1	9.7	6.4	1.7	2.2	1.1	0.4	0.7	0.2
1987	8.3	9.8	6.6	1.7	2.3	1.1	0.4	0.7	0.2
1988	8.4	9.9	7.0	1.7	2.3	1.1	0.5	0.7	0.3
1989	8.7	10.0	7.3	1.9	2.5	1.3	0.5	0.7	0.3
1990	9.0	10.1	7.8	2.0	2.6	1.4	0.5	0.7	0.3
1991	9.0	9.9	8.1	2.1	2.6	1.5	0.5	0.8	0.3

NOTE: Bachelor's degrees, per hundred 22-year-olds; master's, per hundred 24-year-olds; doctorates, per hundred 30-year-olds.
SOURCE: National Science Foundation. (1994). *Science and engineering degrees: 1966-91* (NSF 94-305). Arlington, VA: NSF.

Appendix table 4-22

Number and percent of bachelor's degrees awarded in science and engineering, by citizenship and race or ethnic origin: 1977 to 1991

Citizenship	1977	1979	1981	1985	1987	1989	1990	1991
	Number							
Total, all recipients	374,579	373,431	374,693	375,786	376,450	371,248	379,392	389,952
Total, U.S. citizens and permanent residents	365,907	363,308	361,362	356,256	351,607	350,242	355,032	366,945
White	323,845	318,819	313,486	307,061	298,129	293,262	296,140	303,532
Black	23,134	23,324	23,767	20,223	20,224	20,481	21,274	23,170
Hispanic	11,002	12,163	13,107	13,373	13,846	14,811	15,680	17,021
Asian	6,558	7,591	9,572	13,996	17,921	20,222	20,453	21,628
Native American	1,368	1,411	1,430	1,603	1,487	1,466	1,485	1,594
Nonresident alien	8,486	10,039	13,282	15,526	14,824	13,138	13,216	13,591
Unknown	186	84	49	4,004	10,019	7,868	11,144	9,416
	Percent							
Total, all recipients	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Percent of all recipients, U.S. citizens and permanent residents	97.7	97.3	96.4	94.8	93.4	94.3	93.6	94.1
Total, U.S. citizens and permanent residents	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
White	88.5	87.8	86.8	86.2	84.8	83.7	83.4	82.7
Black	6.3	6.4	6.6	5.7	5.8	5.8	6.0	6.3
Hispanic	3.0	3.3	3.6	3.8	3.9	4.2	4.4	4.6
Asian	1.8	2.1	2.6	3.9	5.1	5.8	5.8	5.9
Native American	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Nonresident alien	--	--	--	--	--	--	--	--
Unknown	--	--	--	--	--	--	--	--

-- Figures are percentages of total U.S. citizens and permanent residents only.
NOTES: Persons of Hispanic origin may be of any race. Percentages may not add to 100 as a result of rounding.
SOURCE: National Science Foundation. (1994). *Science and engineering degrees, by race/ethnicity of recipients: 1977-91* (NSF 94-306). Arlington, VA: NSF.

Appendix table 4-23

Number and percent of engineering bachelor's degrees awarded to blacks and Hispanics, by institution and sex: 1993

Academic institution	State or territory	All engineering bachelor's degrees	Percent awarded to blacks	Blacks All	Blacks Male	Blacks Female
North Carolina A&T State University	NC	173	88.4	153	90	63
Tuskegee University	AL	125	96.0	120	72	48
Prairie View A&M University	TX	138	81.9	113	71	42
Georgia Institute of Technology, Main Campus	GA	1,218	7.8	95	59	36
Howard University	DC	123	71.5	88	53	35
Southern University and A&M College	LA	78	91.0	71	42	29
North Carolina State University at Raleigh	NC	1,041	6.1	64	52	12
CUNY City College	NY	211	25.1	53	44	9
Pratt Institute	NY	90	47.8	43	40	3
Massachusetts Institute of Technology	MA	587	7.0	41	33	8
			Percent awarded to Hispanics	Hispanics All	Hispanics Male	Hispanics Female
University of Puerto Rico Mayaguez	PR	529	100.0	529	379	150
Universidad Politécnica de Puerto Rico	PR	147	100.0	147	118	29
Florida International University	FL	195	53.8	105	80	25
Texas A&M University, Main Campus	TX	938	9.2	86	66	20
University of Texas at El Paso	TX	153	49.7	76	59	17
California Polytechnic State University—SLO	CA	700	9.6	67	59	8
University of Texas at Austin	TX	751	8.5	64	57	7
Massachusetts Institute of Technology	MA	587	9.2	54	41	13
New Mexico State University, All Campuses	NM	229	23.6	54	43	11
University of Miami	FL	144	31.3	45	33	12

NOTES: Persons of Hispanic origin may be of any race. Universities listed are the ones that award the largest number of engineering bachelor's degrees to blacks or Hispanics.
SOURCE: National Center for Education Statistics. Integrated Postsecondary Education Data System. Special tabulations by Science Resources Studies Division, National Science Foundation.

Appendix table 4-24

Number of doctorates awarded to U.S. citizens, by selected racial and ethnic groups: 1982 to 1992

Year	Science and engineering total			Non-science and -engineering total		
	Black	Hispanic	Native American	Black	Hispanic	Native American
1982	285	226	38	762	309	39
1983	283	237	27	639	302	54
1984	299	254	31	654	282	43
1985	278	244	41	634	317	55
1986	254	276	52	569	295	47
1987	234	305	52	534	313	63
1988	260	327	41	554	270	53
1989	284	310	52	537	273	42
1990	285	382	41	613	335	55
1991	349	405	55	652	325	75
1992	300	414	69	651	341	79

NOTE: Persons of Hispanic origin may be of any race.
SOURCE: National Science Foundation. (1993). *Selected data on science and engineering doctorate awards: 1992* (NSF 93-315). Washington, DC: NSF.

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Appendix table 4-25

Number of science and engineering doctorates awarded to U.S. citizens, by selected racial and ethnic groups and sex: 1982 to 1992

Year	Black		Hispanic		Native American	
	Male	Female	Male	Female	Male	Female
1982	159	126	160	66	27	11
1983	150	133	140	97	22	5
1984	156	143	173	81	26	5
1985	152	126	148	96	21	20
1986	124	130	177	99	33	19
1987	115	119	179	126	31	21
1988	143	117	199	128	28	13
1989	142	142	180	130	33	19
1990	151	134	232	150	24	17
1991	180	169	238	167	36	19
1992	151	149	253	161	42	27

NOTE: Persons of Hispanic origin may be of any race.
SOURCE: National Science Foundation. (1993). *Selected data on science and engineering doctorate awards: 1992* (NSF 93-315). Washington, DC: NSF.

Indicators of Science and Mathematics Education 1995

Appendix table 4-26

Science and engineering doctorates awarded, by citizenship: 1972 to 1992

Year	Total	U.S. citizens	Noncitizens	Unknown citizenship	Percent noncitizen
1972	19,324	15,144	3,860	320	20.0
1973	19,352	14,971	4,044	337	20.9
1974	18,694	13,750	4,092	852	21.9
1975	18,710	14,288	4,056	366	21.7
1976	18,268	14,082	3,839	347	21.0
1977	17,723	13,636	3,651	436	20.6
1978	17,383	13,331	3,557	495	20.5
1979	17,589	13,524	3,602	463	20.5
1980	17,523	13,410	3,662	451	20.9
1981	17,996	13,544	3,855	597	21.4
1982	18,017	13,292	3,981	744	22.1
1983	18,393	13,403	4,298	692	23.4
1984	18,514	13,250	4,527	737	24.5
1985	18,712	12,947	4,957	808	26.5
1986	19,251	12,869	5,128	1,254	26.6
1987	19,706	12,819	5,536	1,351	28.1
1988	20,739	13,217	6,047	1,475	29.2
1989	21,528	13,311	6,498	1,719	30.2
1990	22,672	14,014	7,739	919	34.1
1991	23,780	14,225	8,882	673	37.4
1992	24,432	14,262	9,372	798	38.4

SOURCES: National Science Foundation. (1993). *Science and engineering doctorates: 1960-91* (NSF 93-301). Washington, DC: NSF; National Science Foundation. (1993). *Selected data on science and engineering doctorate awards: 1992* (NSF 93-315). Washington, DC: NSF.

Appendix table 4-27

Engineering technology degrees awarded, by degree level: 1975 to 1991

Year	Degree: Associate	Bachelor's	Master's	Doctoral
1975	30,906	8,589	371	5
1976	36,263	9,180	493	10
1977	38,588	9,864	505	12
1978	41,708	10,314	579	15
1979	41,716	10,906	496	16
1980	43,696	12,180	510	16
1981	52,478	13,567	532	21
1982	58,574	14,778	636	33
1983	51,332	18,663	622	18
1984	50,718	20,225	694	6
1985	53,693	20,533	816	15
1986	49,904	20,928	925	21
1987	49,813	20,577	883	13
1988	49,640	20,447	980	14
1989	48,342	20,098	1,135	18
1990	46,931	19,150	1,194	18
1991	45,104	18,294	1,188	25

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

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Appendix table 4-28

Number of institutions of higher education, by Carnegie Institution classification type: 1987 and 1994

Type	1987	1994
Total	3,389	3,600
Doctorate-granting institutions	213	236
Master's-granting institutions	595	532
Bachelor's-granting institutions	572	633
Specialized-degree-granting institutions	642	690
Tribal colleges	—	29
Two-year colleges	1,367	1,480

— Unavailable because the tribal colleges category did not exist in 1987.
NOTE: Data use 1994 Carnegie classification system.
SOURCE: Carnegie Foundation for the Advancement of Teaching. (1991, May/June). Research-intensive vs. teaching-intensive institutions. *Change,* 23-26.

Indicators of Science and Mathematics Education 1995

Appendix table 4-29

Total number and percent of full-time instructional faculty, by field and race or ethnic origin: Fall 1987 and Fall 1992

Field	1987						1992					
	Total	White	Asian	Black	Hispanic	Native American	Total	White	Asian	Black	Hispanic	Native American
	Number											
Total	399,741	354,811	20,814	12,637	8,570	2,909	365,348	319,217	20,092	17,089	7,613	1,337
Science and engineering, total	132,965	118,275	8,262	2,978	2,889	561	142,685	122,161	11,673	5,530	2,903	418
Natural sciences	72,043	64,767	4,591	861	1,484	341	78,016	67,282	6,494	2,606	1,430	204
Social and behavioral sciences	41,974	37,637	1,087	2,018	1,011	221	45,082	40,041	1,493	2,375	1,008	165
Engineering	18,948	15,871	2,584	100	394	0	19,587	14,838	3,686	549	465	49
Non-science and -engineering, total	266,776	236,536	12,552	9,659	5,681	2,347	222,663	197,056	8,418	11,559	4,710	920
Business	25,022	21,530	2,196	690	171	435	28,162	25,195	1,633	944	230	159
Education	25,674	22,720	365	1,606	718	265	28,099	24,775	354	2,209	607	154
Fine arts	26,072	23,675	436	798	1,012	151	25,637	22,613	697	1,526	670	132
Health sciences	85,763	75,079	6,649	2,348	976	711	44,883	39,738	2,359	2,134	528	125
Humanities	49,585	44,862	998	1,200	2,195	330	51,831	46,039	1,724	1,996	1,925	147
Other programs	54,661	48,670	1,909	3,017	610	455	44,052	38,697	1,653	2,751	749	202

Continued

Appendix table 4-29

Total number and percent of full-time instructional faculty, by field and race or ethnic origin: Fall 1987 and Fall 1992, continued

Field	1987 Total	1987 White	1987 Asian	1987 Black	1987 Hispanic	1987 Native American	1992 Total	1992 White	1992 Asian	1992 Black	1992 Hispanic	1992 Native American
	Percent											
Total	100.0	88.8	5.2	3.2	2.1	0.7	100.0	87.4	5.5	4.7	2.1	0.4
Science and engineering, total	100.0	89.0	6.2	2.2	2.2	0.4	100.0	85.6	8.2	3.9	2.0	0.3
Natural sciences	100.0	89.9	6.4	1.2	2.1	0.5	100.0	86.2	8.3	3.3	1.8	0.3
Social and behavioral sciences	100.0	89.7	2.6	4.8	2.4	0.5	100.0	88.8	3.3	5.3	2.2	0.4
Engineering	100.0	83.8	13.6	0.5	2.1	0.0	100.0	75.8	18.8	2.8	2.4	0.3
Non-science and -engineering, total	100.0	88.7	4.7	3.6	2.1	0.9	100.0	88.5	3.8	5.2	2.1	0.4
Business	100.0	86.0	8.8	2.8	0.7	1.7	100.0	89.5	5.8	3.4	0.8	0.6
Education	100.0	88.5	1.4	6.3	2.8	1.0	100.0	88.2	1.3	7.9	2.2	0.6
Fine arts	100.0	90.8	1.7	3.1	3.9	0.6	100.0	88.2	2.7	6.0	2.6	0.5
Health sciences	100.0	87.5	7.8	2.7	1.1	0.8	100.0	88.5	5.3	4.8	1.2	0.3
Humanities	100.0	90.5	2.0	2.4	4.4	0.7	100.0	88.8	3.3	3.9	3.7	0.3
Other programs	100.0	89.0	3.5	5.5	1.1	0.8	100.0	87.8	3.8	6.3	1.7	0.5

NOTES: Numbers may not equal totals as a result of rounding. Asian includes Pacific Islanders. Persons of Hispanic origin may be of any race.
SOURCE: National Center for Education Statistics. (1994). [Special tabulations from the 1993 national study of postsecondary faculty]. Unpublished data.

Indicators of Science and Mathematics Education 1995

Appendix table 4-30

Number and percent of full-time instructional faculty, by field and sex: Fall 1987 and Fall 1992

	1987				1992			
Field	Total	Male	Female	Percent female	Total	Male	Female	Percent female
Total	399,853	300,121	99,732	24.9	365,348	259,670	105,678	28.9
Science and engineering, total	133,069	111,025	22,045	16.6	142,685	118,360	24,325	17.0
Natural sciences	72,043	60,028	12,015	16.7	78,016	66,023	11,993	15.4
Social and behavioral sciences	41,974	32,415	9,559	22.8	45,082	33,900	11,182	24.8
Engineering	19,053	18,582	471	2.5	19,587	18,437	1,150	5.9
Non-science and -engineering, total	266,783	189,096	77,687	29.1	222,663	141,310	81,353	36.5
Business	25,023	19,835	5,188	20.7	28,162	21,777	6,384	22.7
Education	25,673	15,610	10,063	39.2	28,099	15,212	12,887	45.9
Fine arts	26,072	19,745	6,327	24.3	25,637	17,641	7,996	31.2
Health sciences	85,762	59,724	26,038	30.4	44,883	24,098	20,784	46.3
Humanities	49,594	34,717	14,877	30.0	51,831	32,479	19,352	37.3
Other programs	54,660	39,465	15,195	27.8	44,052	30,102	13,949	31.7

NOTE: Numbers may not equal totals as a result of rounding.
SOURCE: National Center for Education Statistics. (1994). [Special tabulations from the 1993 national study of postsecondary faculty]. Unpublished data.

Appendix table 4-31

Principal activity of full-time higher education faculty and instructional staff, by field: Fall 1992

Field	Number of faculty	Percent Total	Teaching	Research	Other
Total	595,340	100.0	66.8	11.5	21.7
Engineering	26,588	100.0	68.9	16.5	14.6
Natural sciences, total	121,989	100.0	63.3	23.6	13.1
Life science	50,652	100.0	45.2	38.8	16.0
Physical science	29,884	100.0	68.6	19.0	12.4
Computer science	14,439	100.0	77.4	10.5	12.0
Mathematical science	27,014	100.0	83.7	7.3	9.0
Social and behavioral sciences	62,422	100.0	73.3	9.6	17.1
Non-science and -engineering, total	384,341	100.0	66.7	7.6	25.7
Health sciences	91,280	100.0	48.2	13.0	38.8
Education	41,304	100.0	71.1	3.1	25.8
Business	41,552	100.0	80.1	6.7	13.3
Humanities	79,875	100.0	82.1	2.9	15.0
Fine arts	33,328	100.0	85.2	1.1	13.7
Other	97,002	100.0	57.5	10.8	31.7

NOTES: Other activity includes clinical service, administration, community or public service, technical activities, on sabbatical from institution, or other unclassified activities. Totals may not equal 100 percent as a result of rounding.
SOURCE: National Center for Education Statistics. (1994). [Special tabulations from the 1993 national study of postsecondary faculty]. Unpublished data.

Appendix table 4-32

Mean number of classes taught by full-time faculty, by field, institutional type, and sex: Fall 1992

Field	Total	Type of institution											
		Doctoral			Master			Bachelor			2-year college		
		All	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female
Agriculture	2.3	1.8	1.8	1.3	2.9	3.0	2.7	5.0	5.0	--	3.8	3.8	3.7
Bioscience	2.2	1.7	1.6	1.8	2.6	2.7	2.5	2.6	2.5	2.6	3.4	3.4	3.2
Physical science	2.3	1.7	1.7	1.8	2.7	2.7	2.5	2.9	3.1	2.3	3.1	3.0	3.1
Mathematics	3.2	2.0	2.0	2.2	3.3	3.3	3.1	3.2	3.3	3.2	4.0	4.1	3.9
Computer science	3.4	2.1	2.1	1.9	2.9	2.8	3.2	3.8	3.6	4.2	4.4	4.3	4.6
Social science	2.9	2.1	2.1	2.2	3.2	3.2	3.2	3.0	3.0	2.8	4.0	4.0	3.9
Engineering	2.4	1.8	1.8	1.4	2.8	2.8	3.0	2.5	2.6	1.0	3.5	3.6	3.1
Business	3.3	2.3	2.3	2.4	3.0	3.0	3.1	4.0	3.9	4.1	4.5	4.6	4.4
Education	3.1	2.5	2.7	2.4	3.3	3.4	3.2	3.2	3.0	3.4	3.8	3.9	3.7
Fine arts	3.4	2.8	2.7	2.8	3.4	3.4	3.5	3.4	3.5	3.1	4.3	4.4	4.0
Health science	2.4	2.1	2.1	2.1	2.7	2.6	2.7	2.5	3.7	2.4	2.7	3.2	2.6
Humanities	3.2	2.4	2.4	2.4	3.2	3.2	3.1	3.1	3.1	3.1	4.1	4.2	4.0
Other	3.1	2.2	2.3	2.2	3.2	3.3	3.0	3.2	3.2	3.1	3.7	3.7	3.6

-- Too few sample cases for a reliable estimate.
SOURCE: National Center for Education Statistics. (1992). [Special tabulations from the 1993 national study of postsecondary faculty]. Unpublished data.

Appendix table 4-33

Number and percent of academic departments of engineering that require or offer communications courses to faculty and graduate students, by size of department: 1992

	Total	Smaller departments (20 or fewer faculty)	Larger departments (more than 20 faculty)
Number of departments	744	523	221
	Percent of academic departments		
Course offered to			
Faculty	39	32	53
Graduate students	40	31	60
Course required of			
Faculty	7	9	6
Graduate students	33	24	39
Areas covered by course			
Teaching techniques	83	82	85
Academic or career advising	66	60	70
English language skills	29	34	21
American customs and behavior	30	24	35

NOTE: Includes only electrical, mechanical, and civil engineering.
SOURCE: Burton, L., & Celebuski, C. A. (1994). *Higher education surveys: Undergraduate education in electrical, mechanical and civil engineering* (HES Survey No. 16). Washington, DC: National Science Foundation.

Appendix table 4-34

Percent of courses taught by full-time instructional faculty using different formats, by type of institution and instructor's field: Fall 1992

Type of institution and field	Total	Lecture	Seminar	Discussion group	Laboratory or problem session	Other
Doctorate-granting institutions, total	100.0	61.1	13.2	10.6	8.7	6.4
Natural sciences	100.0	75.2	7.7	5.9	9.4	1.9
Engineering	100.0	84.7	4.2	1.1	7.8	2.3
Social and behavioral sciences	100.0	67.8	20.2	7.8	1.9	2.3
Non-science and -engineering	100.0	52.9	14.6	13.6	9.9	9.0
Master's-granting institutions, total	100.0	62.8	7.9	11.5	8.8	9.0
Natural sciences	100.0	79.2	2.9	3.9	11.0	2.9
Engineering	100.0	75.2	3.5	3.3	15.3	2.7
Social and behavioral sciences	100.0	77.4	10.1	5.5	2.9	4.1
Non-science and -engineering	100.0	54.9	9.0	15.2	9.0	11.9
Bachelor's-granting institutions, total	100.0	52.0	11.3	17.6	8.9	10.3
Natural sciences	100.0	71.4	5.4	6.2	13.9	3.1
Engineering	100.0	68.5	3.3	0.0	28.2	0.0
Social and behavioral sciences	100.0	67.3	15.8	12.0	2.2	2.7
Non-science and -engineering	100.0	42.6	12.0	22.3	8.8	14.2
Two-year institutions, total	100.0	66.2	2.3	10.1	14.4	7.0
Natural sciences	100.0	84.6	0.7	2.1	10.5	2.1
Engineering	100.0	78.5	0.9	3.1	15.9	1.6
Social and behavioral sciences	100.0	86.1	3.8	5.0	3.0	2.2
Non-science and -engineering	100.0	57.1	2.7	13.6	16.9	9.6

NOTE: Other includes role playing or simulation, television or radio, group projects, and cooperative learning groups.
SOURCE: National Center for Education Statistics. (1994). [Special tabulations from the 1993 national study of postsecondary faculty]. Unpublished data.

Appendix table 4-35

Percent of mathematics departments offering selected academic activities to undergraduate mathematics majors, by activity and type of institution: 1990

Activities	Institution type		
	Doctorate-granting	Master's-granting	Bachelor's-granting
Regular problem-solving opportunities	69	63	25
Research projects	59	47	37
Senior project or thesis	23	36	28
Regular social activities with faculty	21	45	53

SOURCE: Albers, D.J., Loftsgaarden, D.O., Rung, D.C., & Watkins, A.E. (1992). *Statistical abstract of undergraduate programs in the mathematical sciences and computer science in the United States: 1990-91 CBMS survey* (MAA Notes No. 23). Washington, DC: Mathematical Association of America.

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Appendix table 4-36

Number of calculus sections requiring selected course activities, by type of institution: 1990

Course	Institution type		
	Doctorate-granting	Master's-granting	Bachelor's-granting
	Number of sections		
Total	3,690	1,813	3,580
Writing activities	75	32	762
Group projects	52	34	163
Computer assignments	167	139	466
	Percent		
Total	100.0	100.0	100.0
Writing activities	2.0	1.8	21.3
Group projects	1.4	1.9	4.6
Computer assignments	4.5	7.6	13.0

SOURCE: Albers, D.J., Loftsgaarden, D.O., Rung, D.C., & Watkins, A.E. (1992). *Statistical abstract of undergraduate programs in the mathematical sciences and computer science in the United States: 1990-91 CBMS survey* (MAA Notes No. 23). Washington, DC: Mathematical Association of America.

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Appendix table 4-37

Percent of college and university equipment and instrumentation at doctorate-granting institutions used for instruction and research: 1990

Usage	Percent
Research only	63
Predominantly research	29
Predominantly instruction	5
Instruction only	3

NOTE: Includes only movable instrumentation and equipment originally costing $10,000 to $999,999 owned by research-performing colleges and universities for use in the natural sciences and engineering, from 1988 to 1989.

SOURCE: National Science Foundation. (1991). *Characteristics of science/engineering equipment in academic settings: 1989-90* (NSF 91-315). Washington, DC: NSF.

Postscript

This chapter reflects on the process of developing statistical indicators of science and mathematics education. These indicators, which are statistics that shed light on important policy issues, inform policy makers about the state of current science and mathematics education and recommend areas for future investigation. The chapter reviews the frameworks for choosing the statistical indicators in this report. It also reflects on the status of data sources for the chosen indicators and suggests areas that require greater attention in future volumes as well as additional research.

The selection of topics for this report reflects the major issues that are important to the Directorate for Education and Human Resources (EHR) of the National Science Foundation (NSF). EHR is actively involved with conducting research and supporting projects that lead to improvements in student achievement in science and mathematics for all students in the United States. Thus, the indicators in this volume reflect the concerns about how the current efforts to establish standards for science and mathematics education are understood and implemented. They also reflect the changes that are occurring to establish greater equity among male and female students and students of all races and ethnic groups.

Indicators in the Current Volume

The indicators presented in this volume are a synthesis of available statistics about science and mathematics education. Authors selected them from existing national surveys. The authors of this report attempted to select indicators of evidence of change in the Nation's mathematics and science education system. They examined sources of data on trends in student achievement, teacher knowledge and practices, content of curriculum, high school coursetaking, and changes in characteristics of postsecondary students, graduates, and faculty.

The authors of this volume selected indicators of shifts toward the standards of excellence and equity of the education system during the past 2 decades. Moreover, they selected indicators to monitor U.S. efforts to reform the entire education system by setting high expectations for all students' performance and obtaining a greater alignment among components of the education system. For elementary and secondary education, the selection of indicators monitors curriculum coverage, teacher practices, and student achievement. This selection was influenced by national standards, which were developed by professional education associations. For postsecondary education, the selection of indicators monitors the extent of access to science and engineering postsecondary education by underrepresented minorities and females.

Many of these indicators were informed by three commissioned reports about science and mathematics education. These reports followed the Commission on Excellence report of 1983 that brought renewed national attention to the need to reform the elementary and secondary school system. The following section reviews the recommendations of three of those reports in light of the topics addressed by this volume.

Indicators for Elementary and Secondary Education

Three major reports were prepared during the 1980s to define issues of concern to NSF—

- *Educating Americans for the 21st Century: A Plan of Action for Improving Mathematics, Science and Technology Education for All American Elementary and Secondary Students so that Their Achievement Is the Best in the World by 1995*,
- *Indicator Systems for Monitoring Mathematics and Science Education*, and
- *Improving Indicators of the Quality of Science and Mathematics Education in Grades K–12*.

These reports suggested means for developing indicators of science and mathematics education.

Educating Americans for the 21st Century

The Commission on Precollege Education in Mathematics, Science and Technology prepared a plan to improve science, mathematics, and technology education and presented it to the National Science Board in September 1984. This report said that objective measurement of achievement and participation in mathematics and science was necessary and should be performed. It recommended that the National Assessment of Educational Progress (NAEP), which began in 1968, be modified to include assessment of states and the Nation in order to monitor progress using the most up-to-date testing techniques. The report writers' assumption was that the Nation's best students ranked equally with those of any other nation, but that the average American student's achievement was low compared with other advanced countries of the world. Thus, the report encouraged efforts to measure the progress of all students. It recommended that certain skills be monitored, including the ability to write for a purpose and apply high-level problem-solving skills to analyze and draw conclusions.

Many of the policies that were implemented after the report was released were consistent with these recommendations. For example, in 1990, the NAEP began to include state-by-state comparisons on a trial basis. These comparisons became a regular part of the survey in 1992. In addition, new forms of national testing were developed to measure high-order thinking skills. Indicators' development also extended into monitoring the changes in student achievement levels for students at high and low levels of achievement.

No specific indicators have been developed for this volume to measure writing skills or the ability to analyze information. Current performance assessment scoring methods recognize these goals, but in practice, national data collection strategies were still under development at the time of writing the current report. Future reports should be able to include reliable indicators of trends in student performance of thinking and writing skills consistent with the recommendations by the 1984 NSF Commission from new survey information that is currently being collected by the NAEP. The future analyses should maintain a focus on how such new indicators would measure progress toward good practices, such as toward adopting the standards of mathematics and science and achieving greater equity of performance among students.

Indicator Systems

In 1987, the RAND Corporation released *Indicator Systems for Monitoring Mathematics and Science Education*. This report sought to identify for NSF a set of indicator systems that would allow monitoring of precollege science and mathematics education. The report focused on science and mathematics indicators since other agencies, such as the National Center for Education Statistics, have major responsibility for collecting information on all aspects of education. RAND's report suggested that a "patchwork" of existing indicators be constructed from existing data sources (such as NAEP) and that developmental research be undertaken to create better indicators that could be used constructively by policy makers and educators. Specific recommendations were that

- an indicator system be developed both to describe and to relate essential elements of the mathematics and science education system;
- key indicators be developed for both the national and state levels;
- critical gaps in existing indicators and analytical methods be identified;
- the amount and quality of data available on mathematics and science education be expanded;
- studies be conducted to analyze the causes of observed changes and suggest alternative policy implications;
- new measures on student achievement be developed to measure knowledge such as the ability to think critically and apply knowledge in solving problems;
- new measures be developed on teacher quality, depth of coverage, and scientific accuracy of the curriculum; and
- procedures be developed to analyze and report indicators that ensure that results are well reviewed and disseminated appropriately.

The report suggested a general model for the specific elements of an indicator system. This model was organized around inputs, processes, and outputs of school systems. The system identified student achievement, attitudes, and aspirations as the main outcomes of schooling. Process indicators were divided into curriculum, instruction, teaching, and school quality. Inputs included fiscal resources, student background, and teacher quality. For each of these areas, the report recommended 99 specific indicators that should be monitored, and it linked them to existing data sources. Additionally, RAND recommended that NSF develop state-level information and create comparisons of different natures (across time, with normative standards, with other countries, and with different populations). The report recommended that NSF not develop its own expensive surveys, but that it develop new measures for existing data collection efforts and develop new measures from them.

Since the report's publication, many of the recommendations have been implemented. For instance, NSF adopted this biennial indicators report with a defined review process. Also, cooperation between the Department of Education and NSF has continued. This has increased the amount of information available about science and mathematics. In addition, the number of state-level indicators has increased. However, these indicators are not yet as well developed as the national indicators because the sample sizes are too small to permit comparison of change over time for each state. Therefore, they cannot be reported regularly as evidence for change within particular states. Finally, as the RAND report recommended, researchers have performed some studies that explore the causes of student achievement (DeAngelis & Talbert, 1995, April; Miller, 1992, April; Schiller, 1995, May 30; Schneider, Plank, & Wang, 1994, August; Sui-Chu & Willms, 1995, April). These studies provide alternative strategies for education policies. They are written for the purpose of describing correlations between schooling experiences and student achievement.

Since 1987, the amount of survey data for elementary curriculum, instructional techniques, and assessments increased substantially. Iris Weiss' (1987) surveys of teachers have increased the amount of information available on what teachers know and how they present materials in class. (See also Weiss, Matti, & Smith, 1994.) Additionally, surveys of students and teachers in several longitudinal studies have increased the information available about the science and mathematics topics that students are exposed to in school. The general model suggested in RAND's report encouraged investigative models of the effects of changes in curriculum and teacher experience to student performance.

Improving Indicators

Recommendations in *Improving Indicators of the Quality of Science and Mathematics Education in Grades K–12* were based on the premises that

- all students need to leave school with adequate knowledge and reasoning skills to be able to renew their knowledge of science and mathematics throughout their lives; and
- student learning is determined by what teachers and students do in schools.

The report, written by the Committee on Indicators of Precollege Mathematics and Science for the National Academy of Sciences, reviewed the needs of the education system and recommended a series of topics that required further development and monitoring. It recommended seven key indicators and a set of supplementary indicators to expand the issues.

The key indicators involved

- learning among students,
- literacy among adults,
- enrollment in science and mathematics courses,
- nature of classroom instruction,
- teachers' knowledge,
- salaries of college graduates, and
- quality of curriculum content in state guidelines and materials.

The supplementary indicators involved

- amount of time spent on science and mathematics homework,
- college courses completed by teachers,
- teachers' use of time outside the classroom for activities related to teaching,
- materials used for instruction,
- Federal financial support, and
- resources committed by scientific bodies for school improvement.

The report recommended that these 13 indicators cover five areas: student learning, student behavior, teaching quality, curriculum quality, and financial support. It recommended that

- an accelerated program of research and development be carried out to construct free-response materials and techniques that measure skills not measured with multiple-choice tests—these materials would help in the development of indicators of learning in science and mathematics;
- information be gathered on the number of minutes per week that elementary students devote to science and mathematics, as well as the number of semesters of science and mathematics that secondary students take, to develop indicators of student behavior;
- teachers be tested on the same content and skills that their students are expected to master and that information be gathered on teacher preparation, such as undergraduate and graduate college coursework, in order to develop indicators of teaching quality;
- exemplary frameworks of science and mathematics content coverage be constructed for elementary and secondary grades, with the highest priority given to early elementary and middle schools, in order to develop indicators of curriculum quality—the frameworks would be used to match textbooks, state guidelines, and materials, such as tests and exercises, to analyze the content of the implemented curriculum for indicators of content coverage; and
- a set of accounts be developed on the expenditures of science and mathematics education from departments and agencies of the Federal Government for indicators of financial and leadership support.

This volume incorporated many of the recommendations in *Improving Indicators of the Quality of Science and Mathematics Education in Grades K–12,* including using indicators on learning among students, coursetaking, nature of instruction, amount of time spent on science and mathematics, courses completed by teachers, teachers' use of time outside the classroom, materials used for instruction, and Federal financial support. However, some recommendations have not yet been developed into indicators. The areas involve adult literacy, teachers' knowledge, and the number of resources committed by scientific bodies.

Some work is being done to remedy this situation. For instance, measures of adult literacy currently are being developed by NSF. However, attempts to develop measures of teachers' knowledge have been difficult because of objections by the teaching community that teacher assessment should not be a concern of policy makers. Studies of resources committed to science and mathematics education by government and nongovernment sources have not yet been conducted. This is an important area for future study. Other areas for future study are discussed below.

Future Directions

The publication of indicators of science and mathematics education require reliable sources of data from elementary, secondary, and postsecondary institutions. Typically, special data collection efforts are required for specific subject areas of science and mathematics because these subjects represent small components of a large education system. The reports discussed in this postscript have suggested mechanisms for integrating the existing surveys of students and teachers into a systematic collection of data. Such efforts could enhance the amount of information available for science and mathematics education.

This indicators report has shown the value of integrating subject area topics into existing surveys, such as the assessment of student learning, the measure of teacher practices in the classroom, and the relationships between secondary school coursetaking with field choice in higher education. However, the development of indicators that measure the issues raised by reform efforts will require new efforts with new types of survey techniques. For instance, monitoring of systemic reform efforts will require indicators on

- alignment among parts of the education system;
- changes in governance;
- number of community, business, and school partnerships; and
- integration of elementary and secondary school systems with postsecondary education.

In addition, new indicators will be required to

- measure changes in student achievement, coursetaking, and teaching practices for states;
- show the relationship between planned and implemented changes to elementary and secondary science and mathematics curriculum, including adoption of technology, as reform efforts continue;
- measure coursetaking and course content within postsecondary institutions;
- monitor the science and mathematics literacy of college graduates; and
- monitor the transition of graduates into the workforce.

Indicators will need to be developed specifically for postsecondary education, because the sources of data concerning students and faculty in undergraduate institutions are limited. The issues of the quality of teaching and learning in colleges and universities have been infrequently addressed in national reports that review the condition of science and mathematics education. Few data sources inquire about teaching practices or the content covered by students. Also, the quality of teaching is infrequently covered in national surveys of higher education or faculty.

NSF has asked the Grants Board of the American Educational Research Association (AERA) to map out a strategy for developing indicators of undergraduate mathematics education. The project is developing a conceptual framework for indicators that will be useful in monitoring the status of undergraduate mathematics education, especially with respect to assessing effects of the various reform initiatives of NSF. The project targets lower division programs for the entire population of students, not just those majoring in mathematics. Concern is for the broad spectrum of public and private institutions including community colleges, liberal arts colleges, comprehensive universities, and research universities. A national panel of experts in undergraduate mathematics education and assessment is expected to release a report in early 1996.

Undergraduate indicators are proposed for

- curriculum and instruction—the content and pedagogy of educational programs;
- student outcomes and assessment—what students know about mathematics and how that knowledge is assessed;
- student participation—the characteristics of students served by mathematics programs; and
- educational institutions and systems—the context within which the teaching and learning of mathematics takes place.

The recommendations of the AERA committee will form a useful basis for restructuring the current data collection efforts for postsecondary education. New surveys and strategies for expanding existing surveys may be needed to provide a strong basis for continued monitoring of undergraduate education.

Concluding Remarks

This biennial assessment of trends in science and mathematics education has found that significant progress has been made in the scope and analysis of national surveys to monitor significant changes in the educational systems of the United States. Yet, as efforts to reform the elementary and secondary system expand, new indicators of governance, partnerships, and alignment among various parts need to be developed, and research on the measurement of learning of science and mathematics must be extended into undergraduate education. Future reports of trends in science and mathematics education shall address the areas outlined in this postscript. ■

Chapter 5 References

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