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.

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

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.

Indicators of Science and Mathematics Education 1995

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.

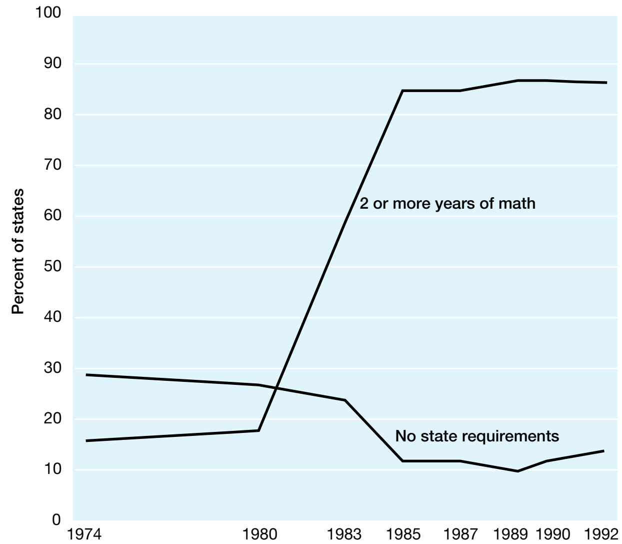
Standards continued on page 37.

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.)

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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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,

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. ■

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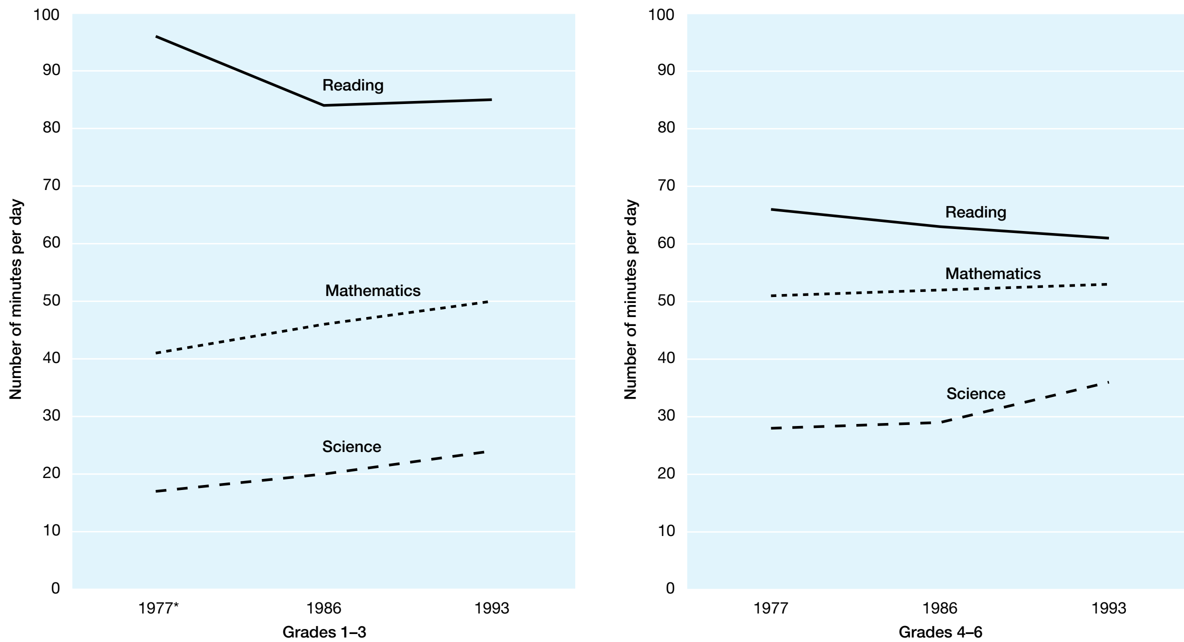
FIGURE 3–2

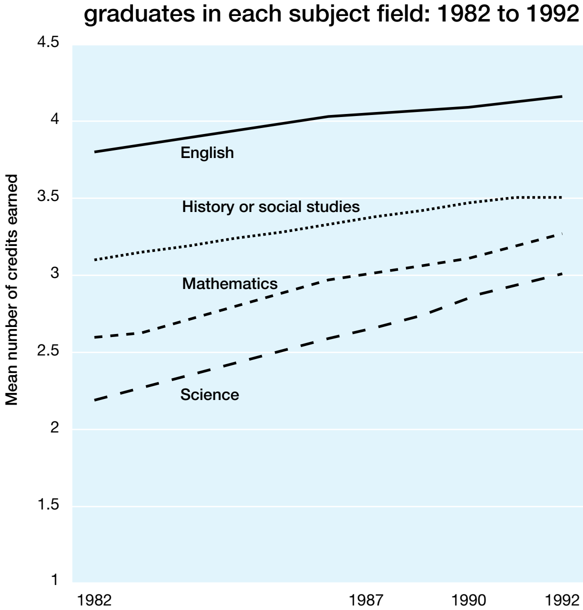
Average number of minutes per day spent teaching each subject to self-contained classes, by grade range: 1977 to 1993



* 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

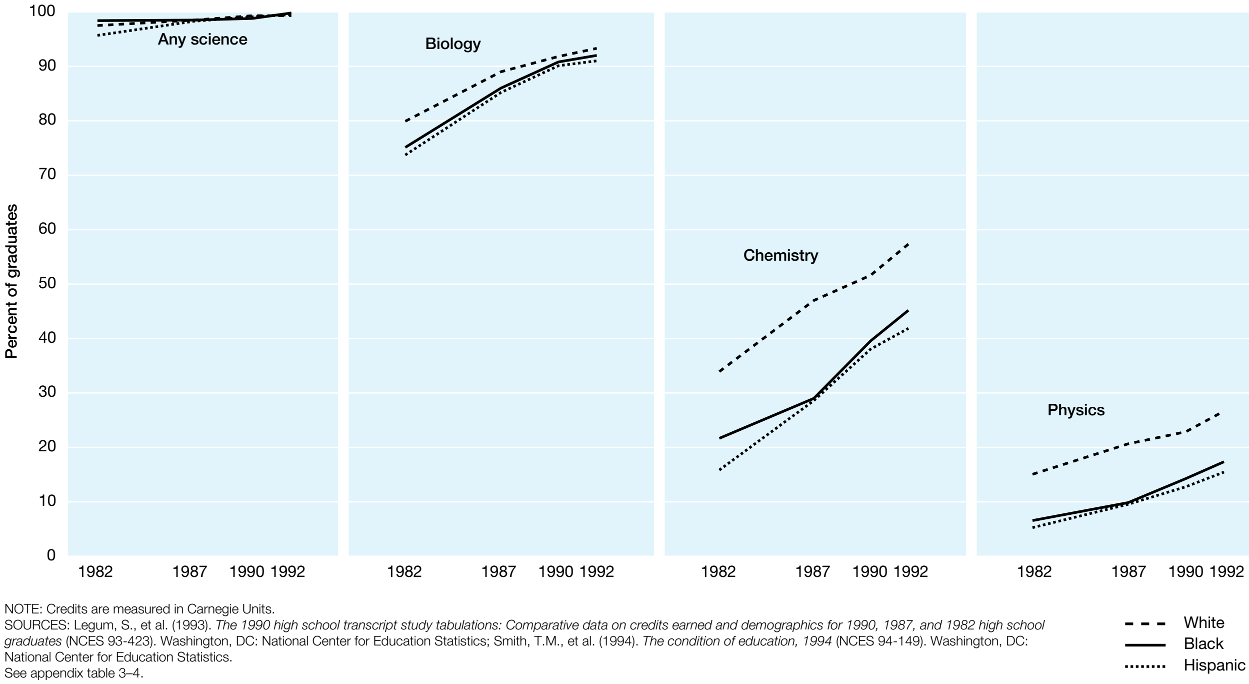
FIGURE 3–4

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

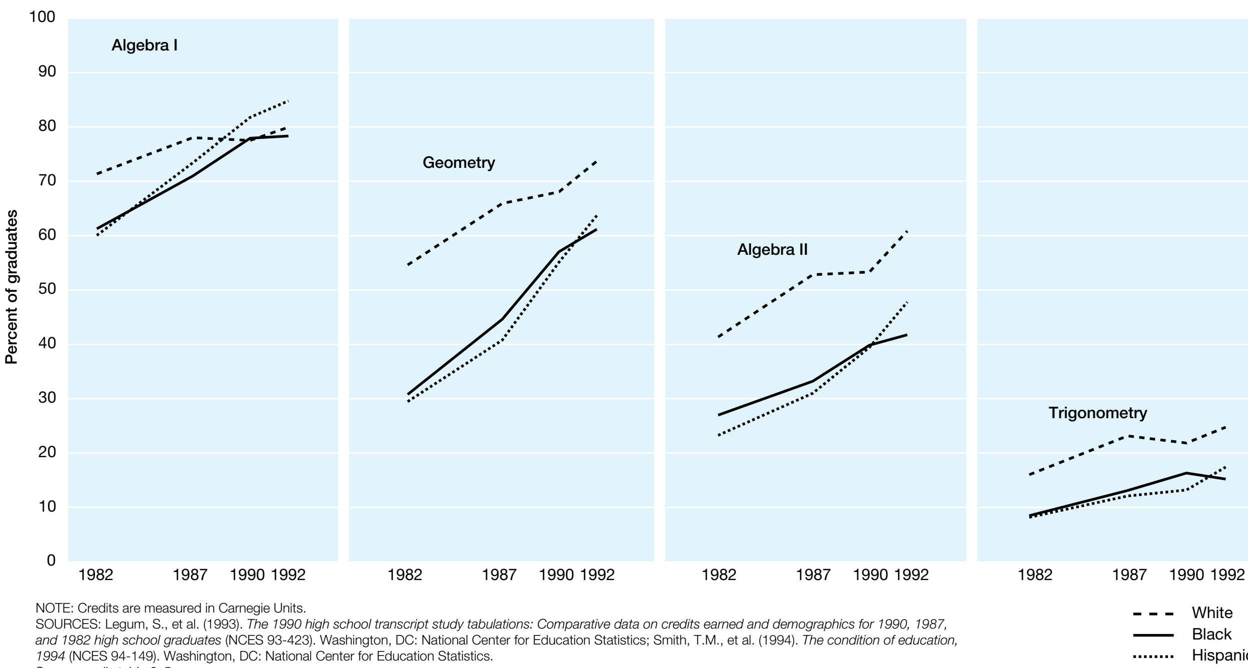
Percent of high school graduates earning credits in science courses, by race or ethnic origin: 1982 to 1992



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)

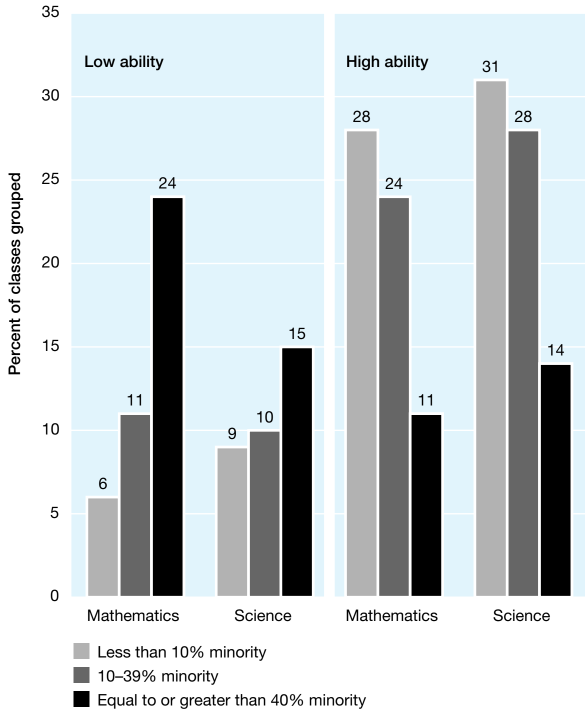
NOTES: Courses completed in grades 7 and 8 were not counted as part of a sequence. Standard errors appear in parentheses.
SOURCE: Legum, S., et al. (1993). *The 1990 high school transcript study tabulations: Comparative data on credits earned and demographics for 1990, 1987, and 1982 high school graduates* (NCES 93-423). Washington, DC: National Center for Education Statistics.

Indicators of Science and Mathematics Education 1995

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

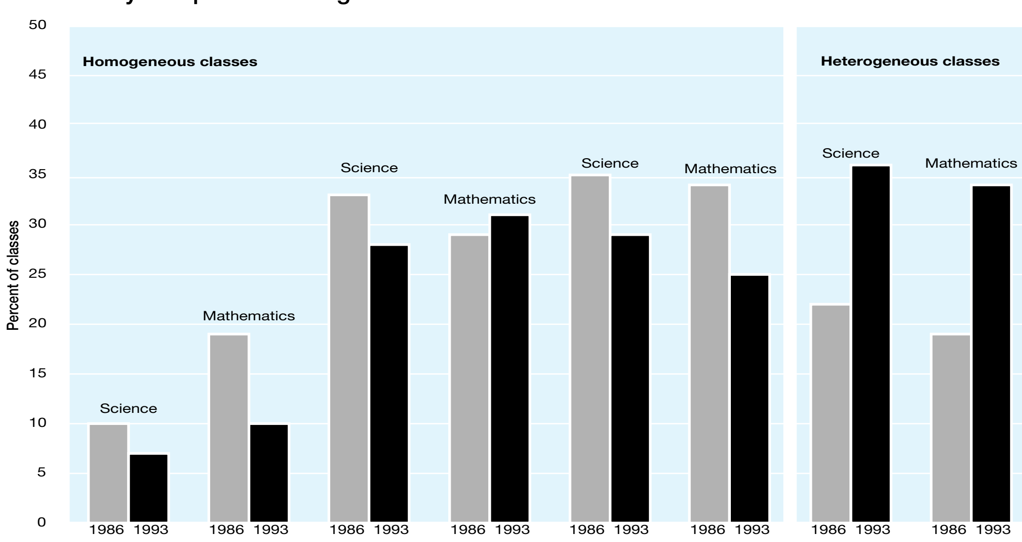
A well-prepared teaching force is critical to effective science and mathematics education. This section paints a picture of the teaching population and addresses teacher characteristics, teacher preparation, and professional development.

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

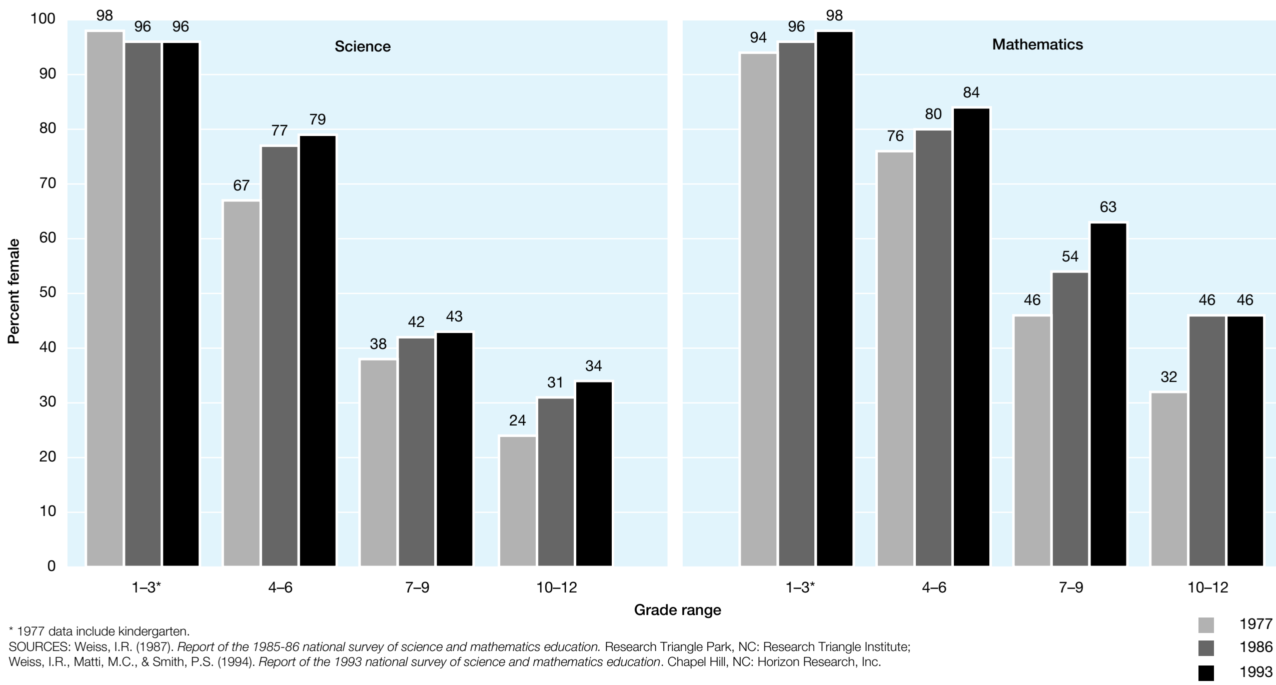
Ability composition of high school science and mathematics classes: 1986 and 1993



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

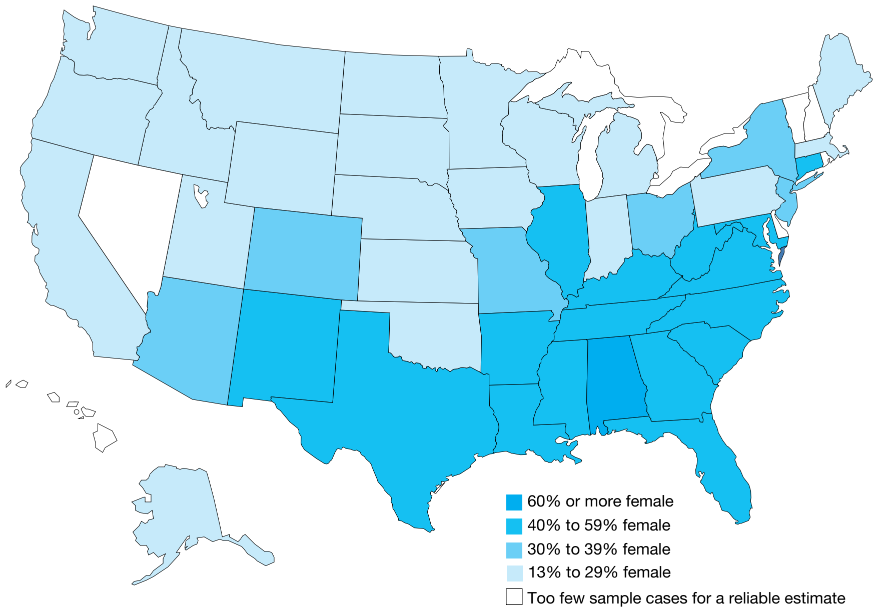
Blacks, Hispanics, and other minority groups continue to be underrepresented in the science and mathematics teaching force; in 1993, when minorities constituted roughly 30 percent of student enrollment, only 6 to 10 percent of science and mathematics teachers, depending on grade range, were members of 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

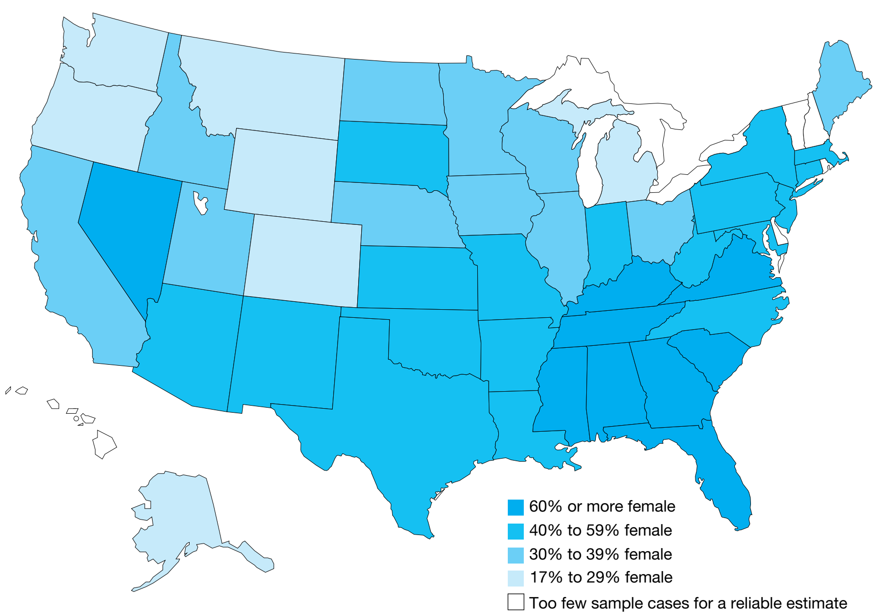
Percent of public high school science teachers who are female, by state: 1991



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)

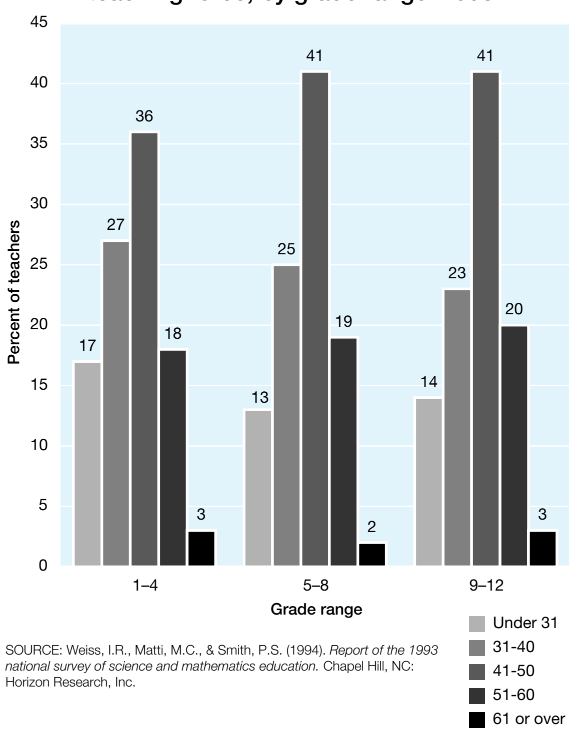
NOTE: Standard errors appear in parentheses.
SOURCES: Weiss, I.R. (1987). *Report of the 1985-86 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute; Weiss, I.R., Matti, M.C., & Smith, P.S. (1994). *Report of the 1993 national survey of science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

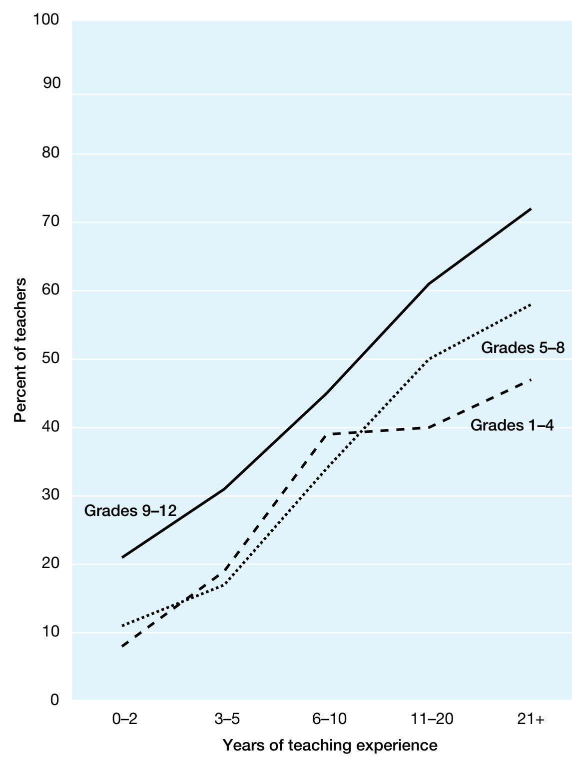
Autonomy

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

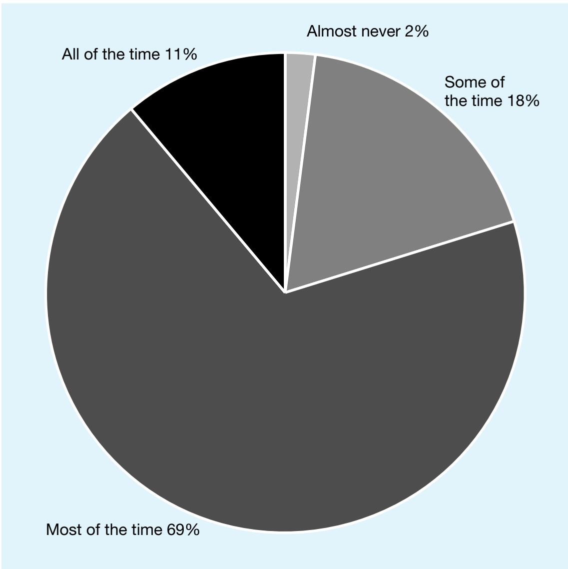
	Often		Sometimes		Never	
Year	Percent of students	Average NAEP mathematics proficiency	Percent of students	Average NAEP mathematics proficiency	Percent of students	Average NAEP mathematics proficiency
1978	59 (2.0)	309 (1.6)	35 (1.9)	291 (2.1)	6 (0.7)	284 (3.5)
1982	65 (1.7)	307 (1.5)	29 (1.6)	291 (2.1)	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.

Indicators of Science and Mathematics Education 1995

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.

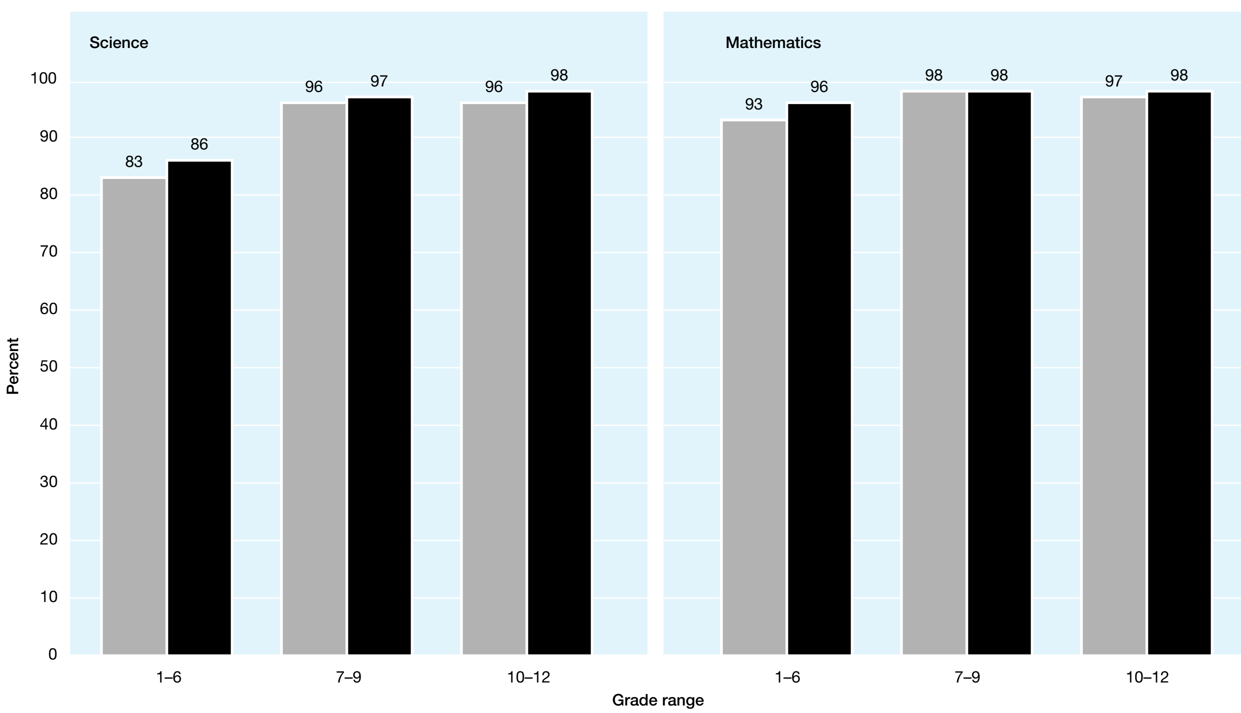
In 1986, about 92 percent of science teachers and 96 percent of mathematics teachers said they enjoyed teaching, compared with 1993, when 94 percent of science teachers and 97 percent of mathematics teachers said the same. Elementary science teachers were the group least likely to enjoy teaching in both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

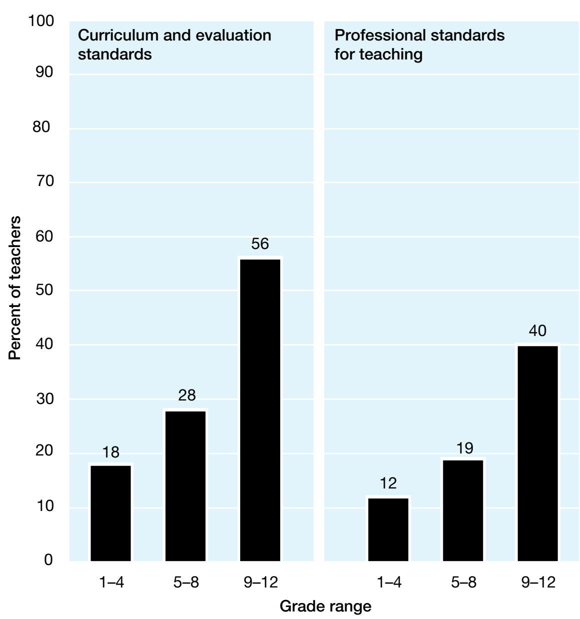
Roughly three out of four science teachers in all grades indicated that hands-on activities should definitely be a part of science instruction, and nearly that many considered teaching of applications of science in daily life to be essential.

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.)

FIGURE 3–16

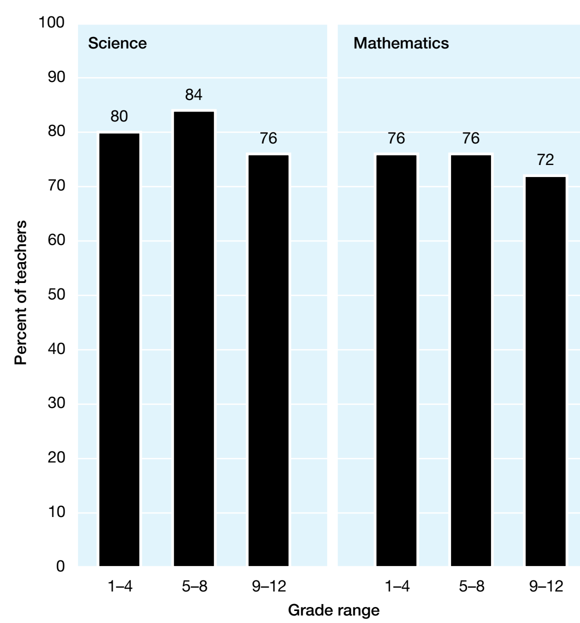
Percent of mathematics teachers who are "well aware" of the NCTM standards documents, by grade range: 1993



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.

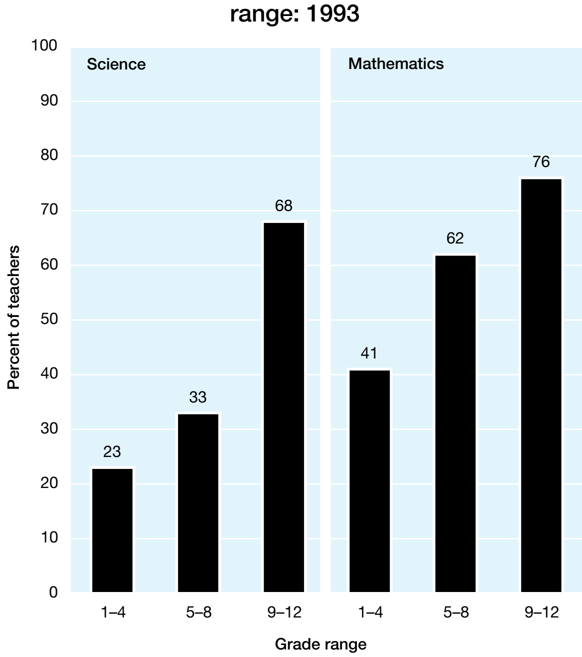
- High school mathematics teachers supported the frequent use of calculators—73 percent indicated that "students should be able to use calculators most of the time." Elementary mathematics teachers were less likely to support extensive use of calculators. (See figure 3-19 and appendix table 3-17.)
- 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

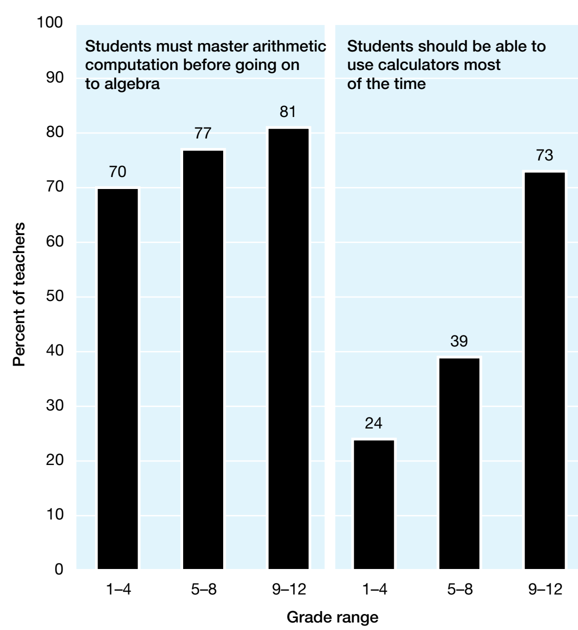
Percent of science and mathematics teachers agreeing that students learn science or mathematics best in classes with students of similar abilities, by subject and grade range: 1993



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

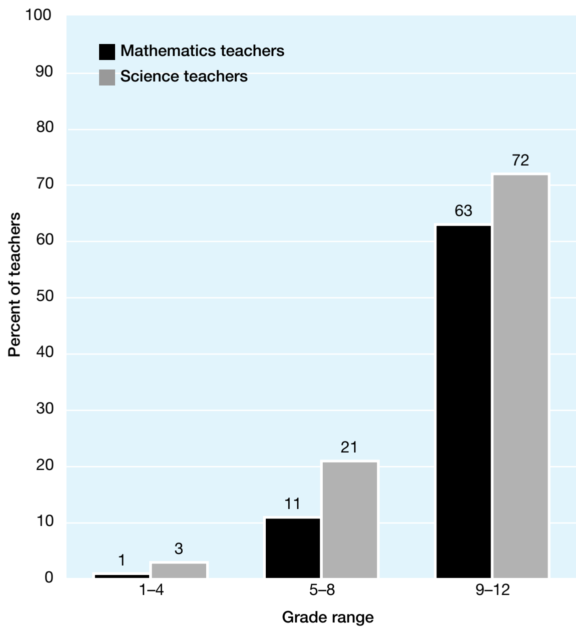
* 1977 data include kindergarten.
SOURCES: Weiss, I.R. (1987). *Report of the 1985–86 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute; Weiss, I.R. (1994). *1993 National survey of science and mathematics education.* Unpublished tabulations.
See appendix table 3-19.

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

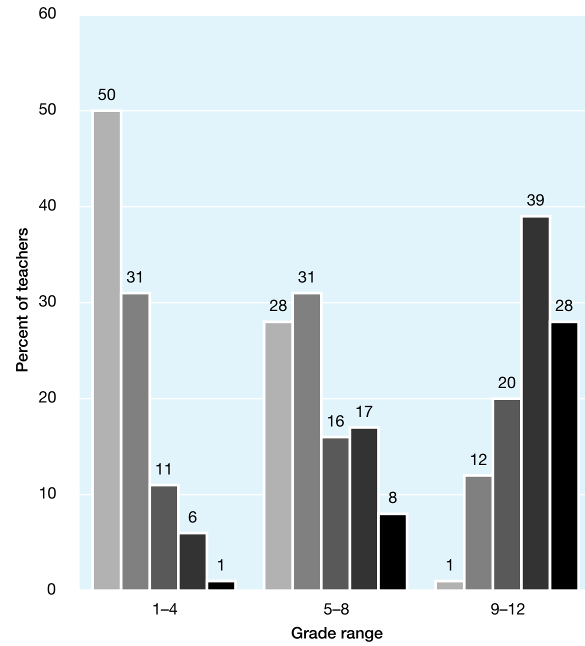
Percent of science and mathematics teachers with undergraduate or graduate majors in science or mathematics fields, by grade range: 1993



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

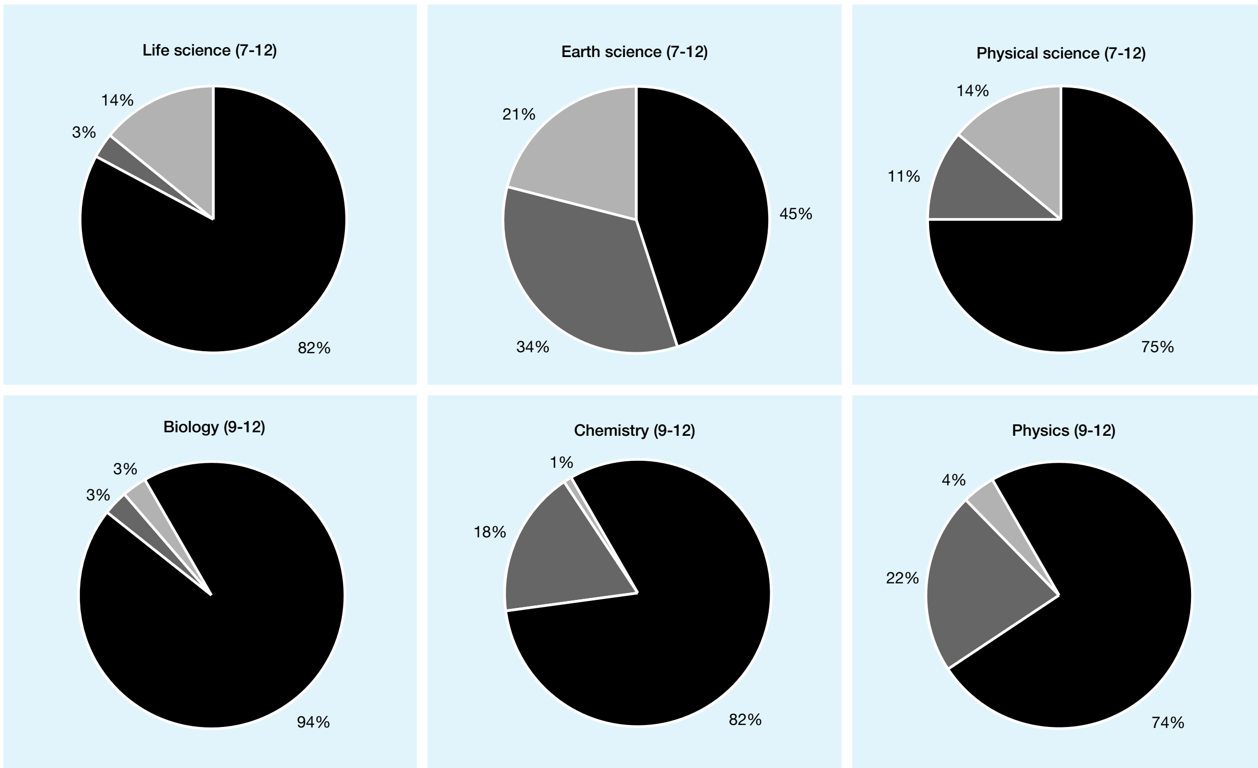
Percent of teachers with majors and minors in science or mathematics and science or mathematics education, by grade range: 1993

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

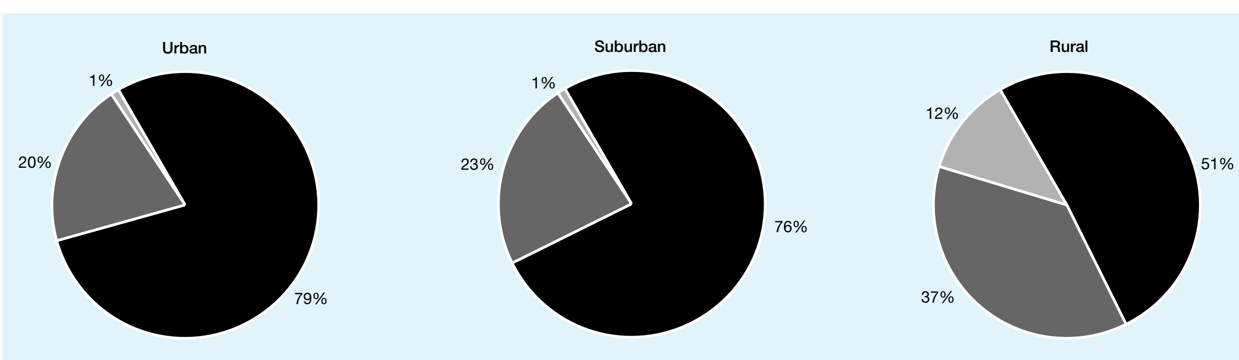


NOTE: Totals may not add to 100 percent as a result of rounding.
SOURCE: Weiss, I.R., Matti, M.C., & Smith, P.S. (1994). *Report of the 1993 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research, Inc.
See appendix table 3–22.

- Six or more courses in that science
- Six or more courses in other science discipline
- Fewer than six courses in any science discipline

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.

- Teach one science course
- Teach two science courses
- Teach three or more science courses

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

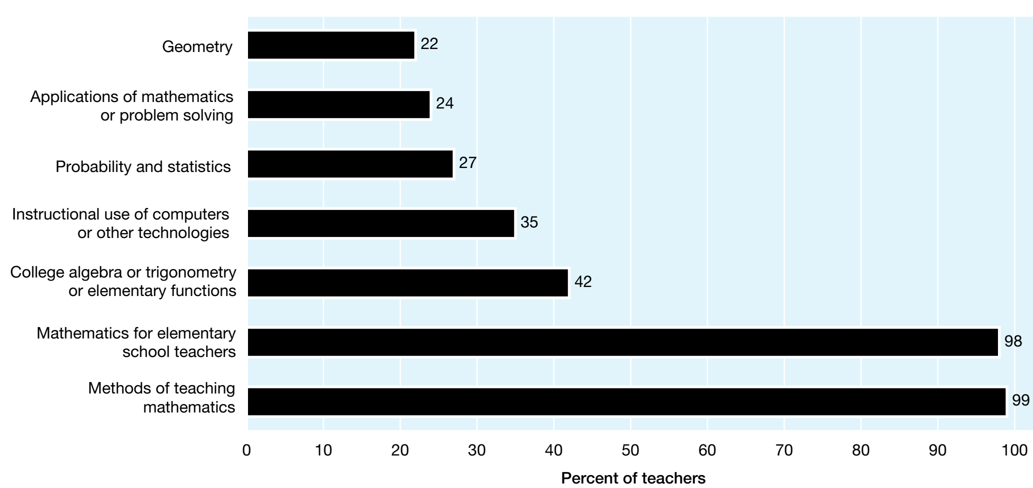
Almost all elementary school mathematics teachers have taken college courses in mathematics for elementary school teachers and in methods of teaching mathematics. However, far fewer have had college coursework in geometry or probability and statistics—areas that the *NCTM Curriculum and Evaluation Standards* 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

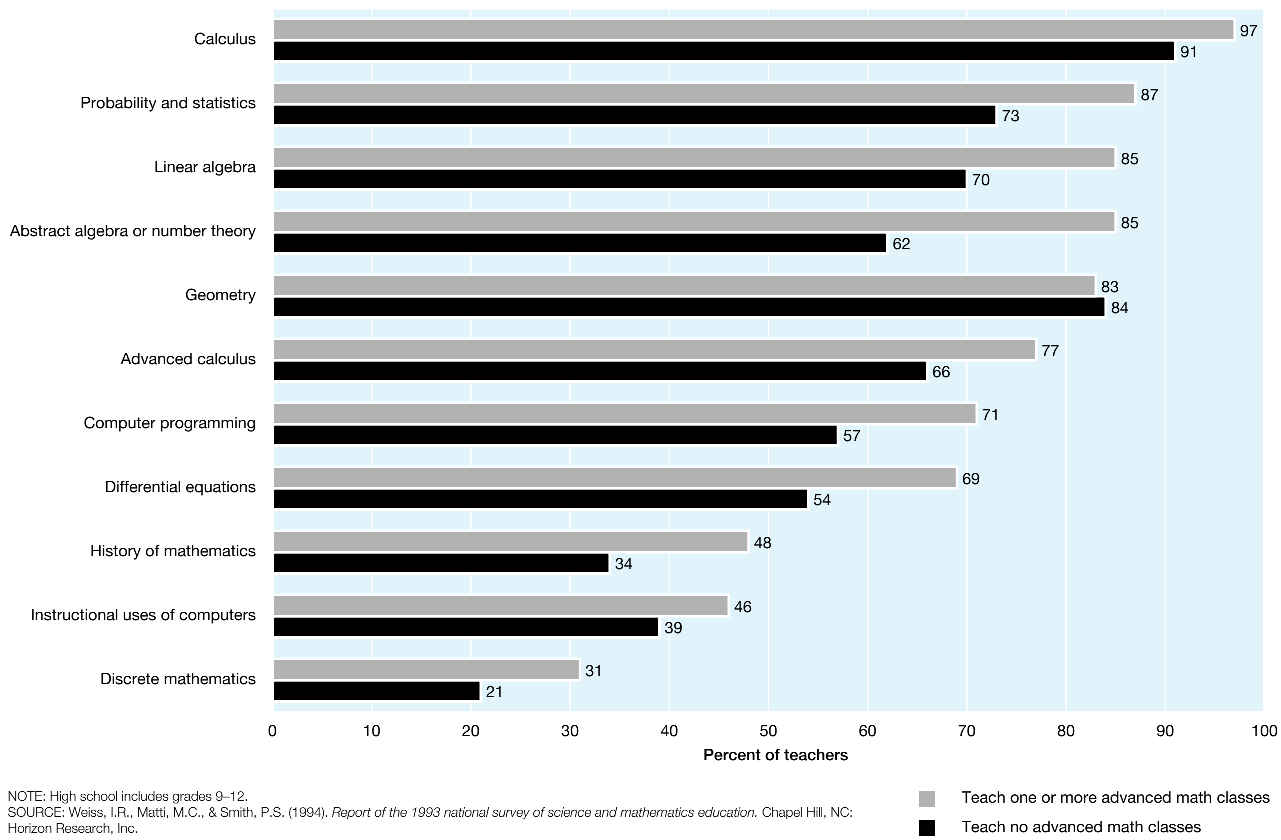
An evaluation of teachers' undergraduate or graduate majors and the number of courses they complete in their field of assignment are two ways to gauge how well teachers understand science and mathematics. Another way is to evaluate teachers' perceptions of their own preparation—how well prepared they 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.

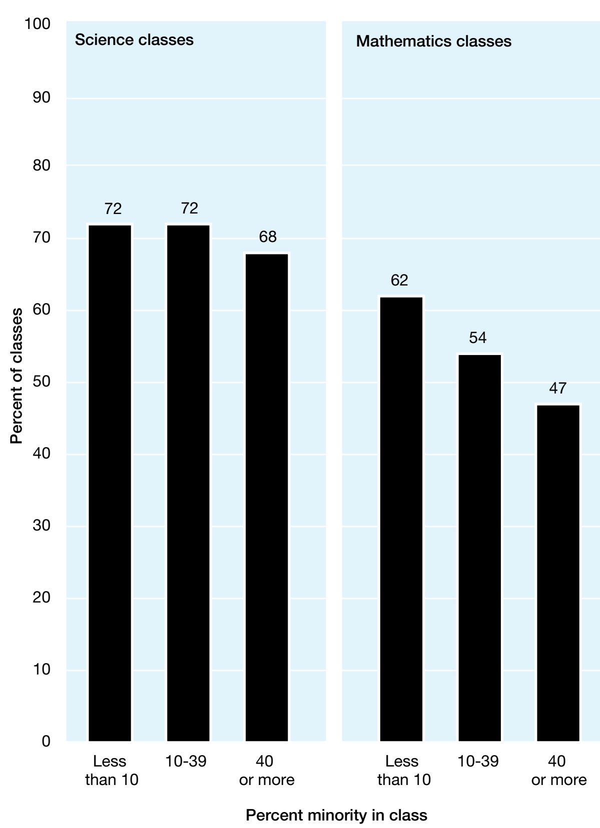
Most high school mathematics teachers felt well qualified to teach most of the recommended topics; however, only about 30 percent of these teachers felt well qualified to teach probability and statistics, mathematical structure, and the conceptual underpinnings of calculus. (See appendix table 3-27.)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

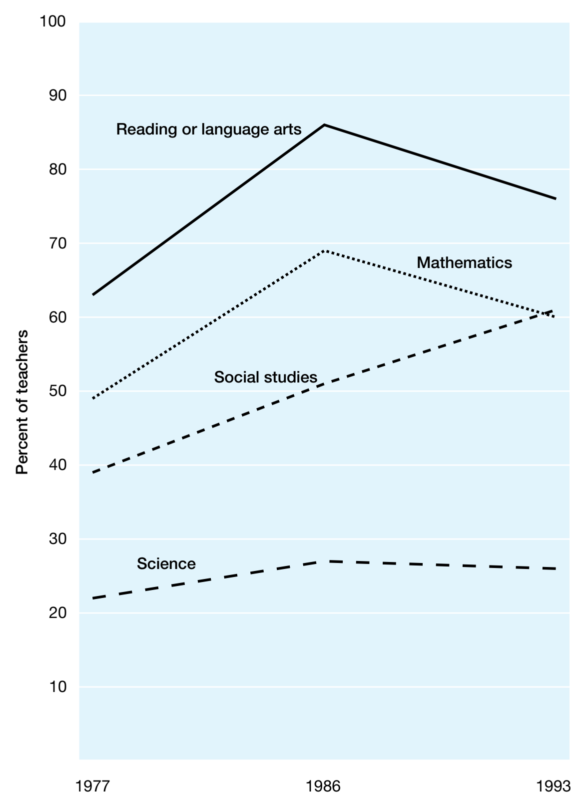
Percent of grades 7–12 science and mathematics classes taught by teachers with undergraduate or graduate major in the field, by percent of minority students in class: 1993



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

FIGURE 3–28

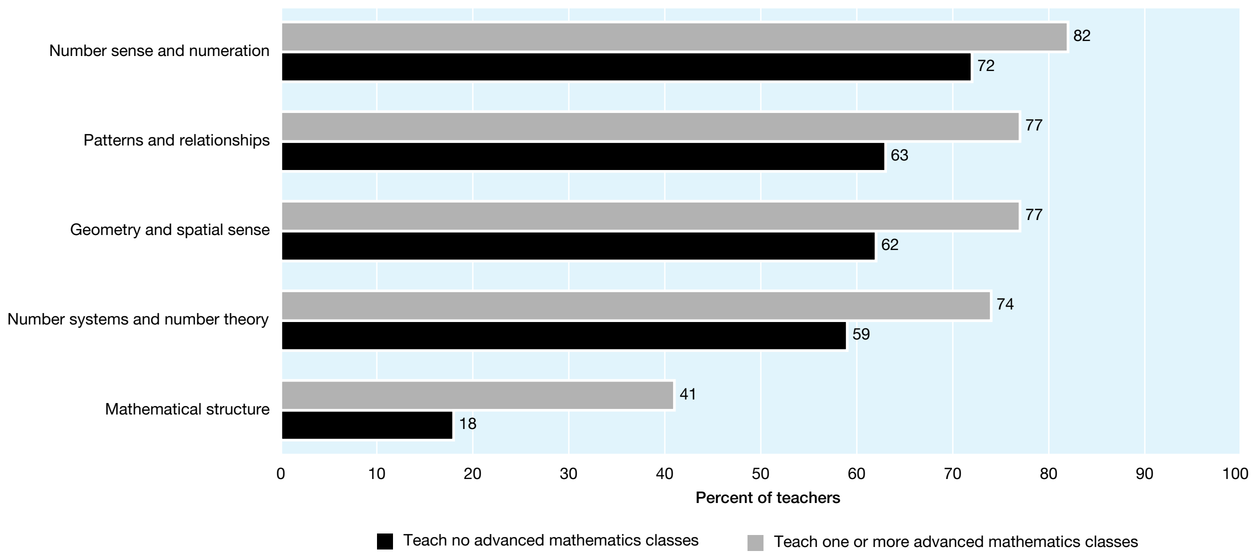
Percent of self-contained elementary teachers feeling very well qualified to teach each subject: 1977 to 1993



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

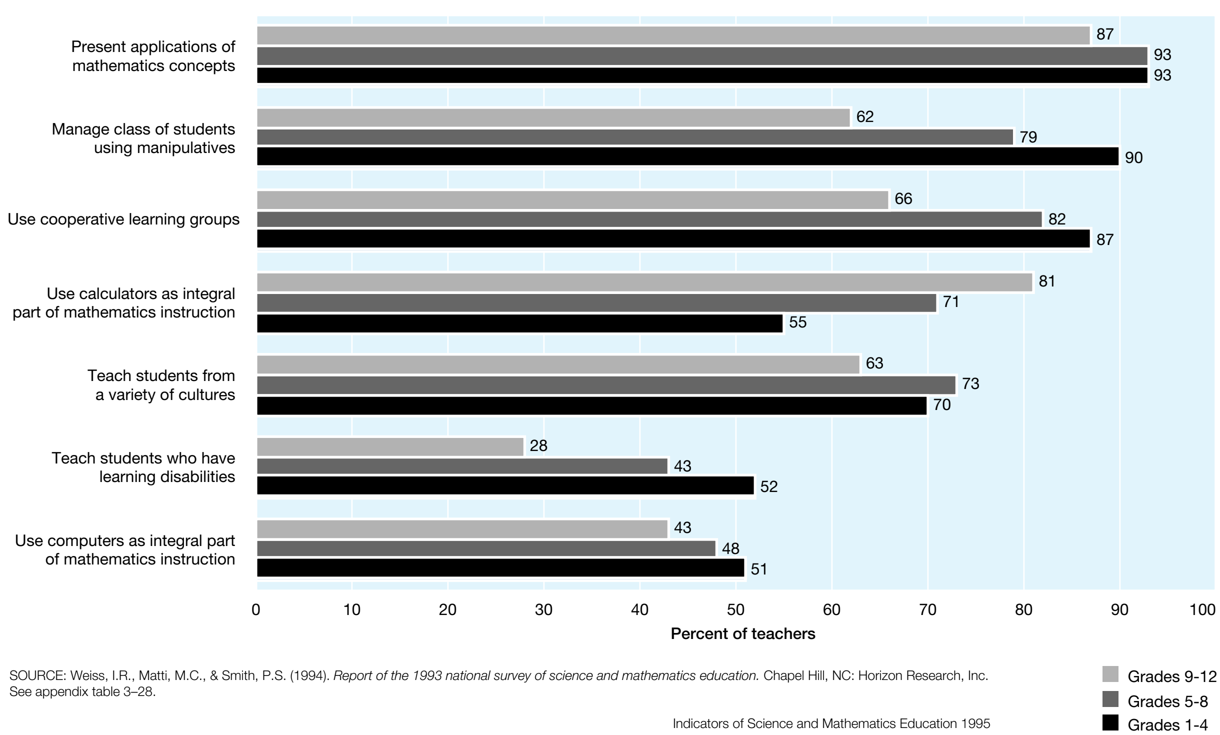
Percent of high school mathematics teachers considering themselves well qualified to teach each mathematics topic, by teaching assignment: 1993



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

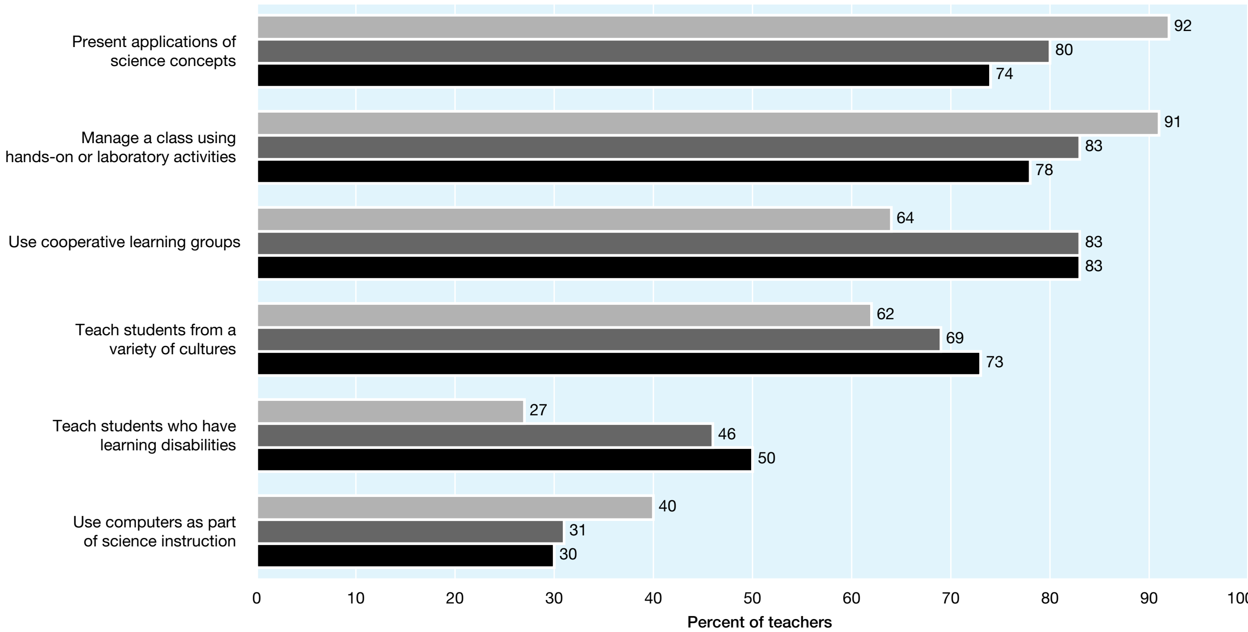
Percent of mathematics teachers considering themselves well prepared for mathematics teaching tasks, by grade range: 1993



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

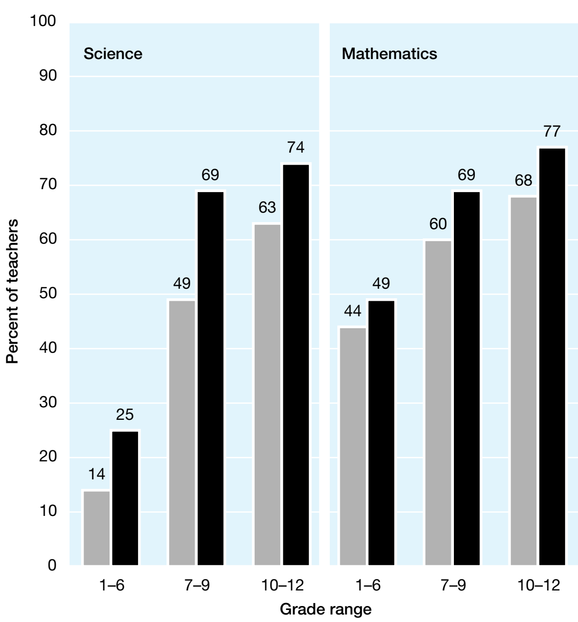
Percent of science teachers considering themselves well prepared for science teaching tasks, by grade range: 1993



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.

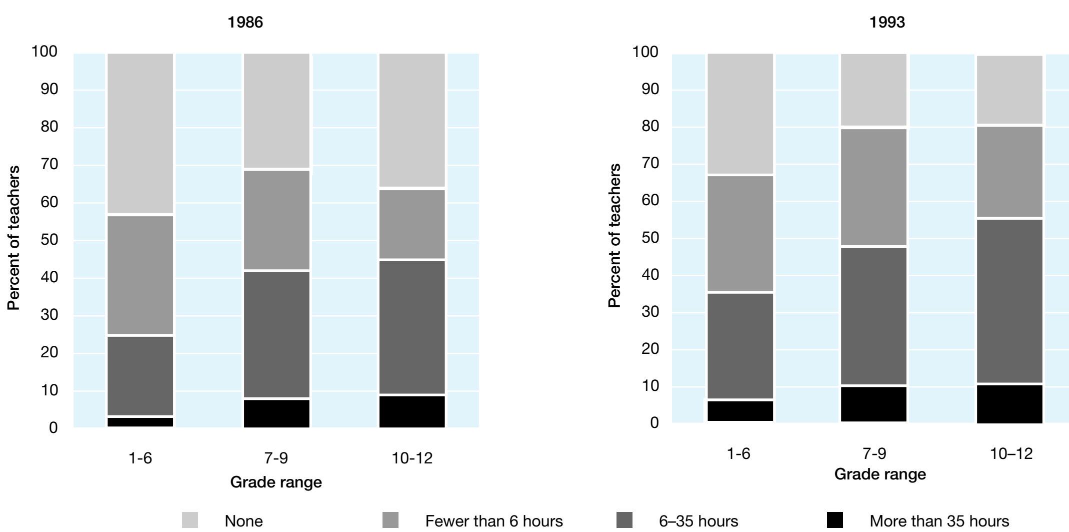
However, between 1986 and 1993, the number of teachers participating in professional development education increased. (See figure 3-33.) For example, in 1993, 81 percent of grades 10–12 mathematics teachers indicated they had participated in at least some professional development activities in mathematics 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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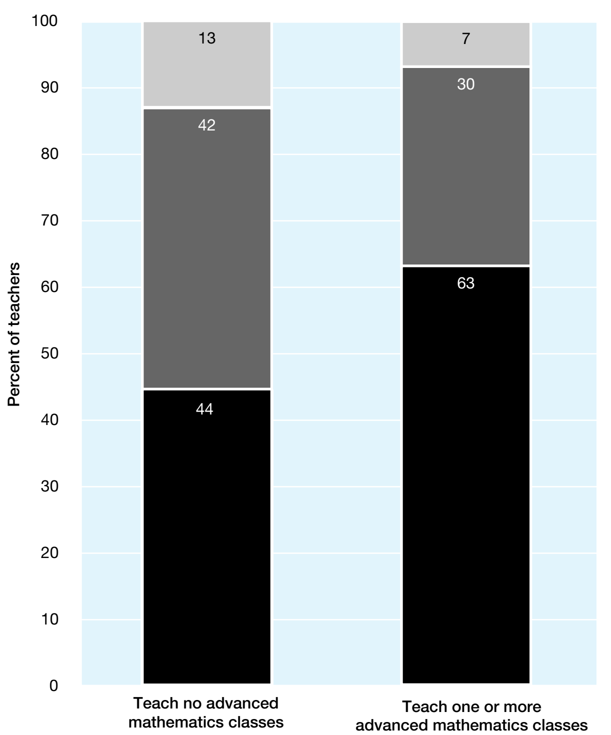
to receive it. In 1993, only 44 percent of the high school mathematics teachers who taught lower level classes had 16 or more hours of in-service education in the past 3 years, compared with 63 percent of those who taught at least one advanced mathematics class. (See figure 3-34.)

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.

- None
- Fewer than 16 hours
- 16 hours or more

Instructional Practices

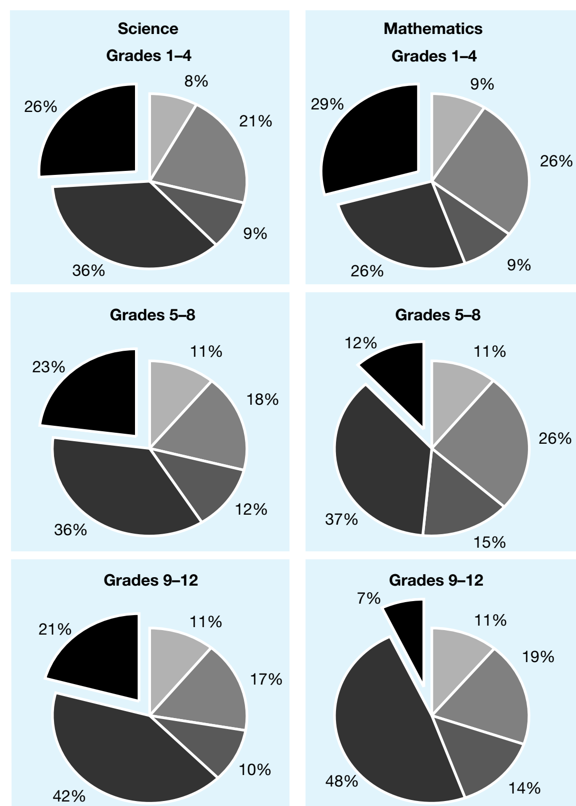
Much of current educational reform calls for changes in the way instruction is delivered within a classroom. The indicators in this section provide a picture—necessarily limited by the available data—of what goes on inside the science and mathematics classrooms. The indicators address use of in-class 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

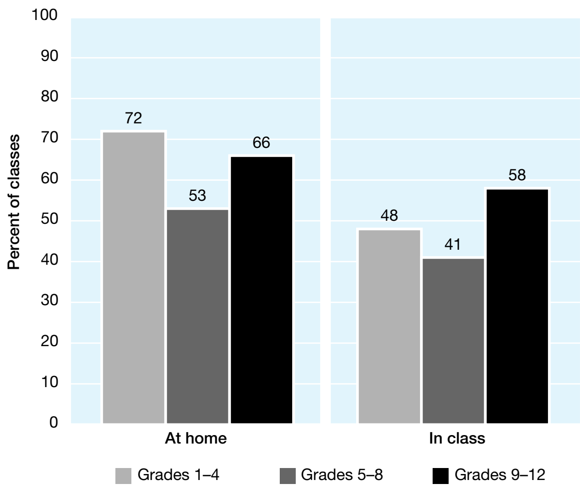


- Daily routines, interruptions, and other noninstructional activities
- Individual students reading textbooks, and other noninstructional activities
- Nonlaboratory small-group work
- Whole-class lecture or discussion
- Working with hands-on, manipulative, or laboratory materials

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

		Students answering "yes"		Students answering "no"	
Classroom science activity	Year	Percent of students	Average NAEP science proficiency	Percent of students	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.)

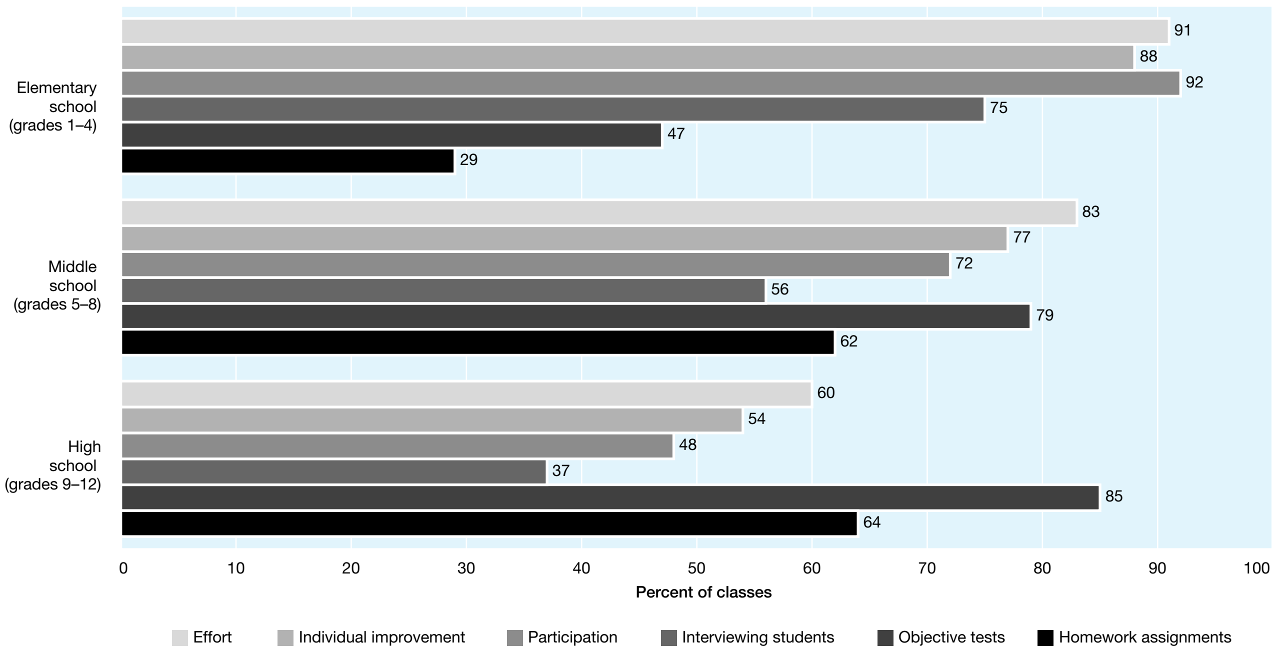
Trends from 1977 to 1992 (Mullis et al., 1994) indicate that students are using more sophisticated and technology-based materials in the classroom. For example, over that period, 9-year-old science students were increasingly likely to use thermometers, microscopes, and calculators, although they experimented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

	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	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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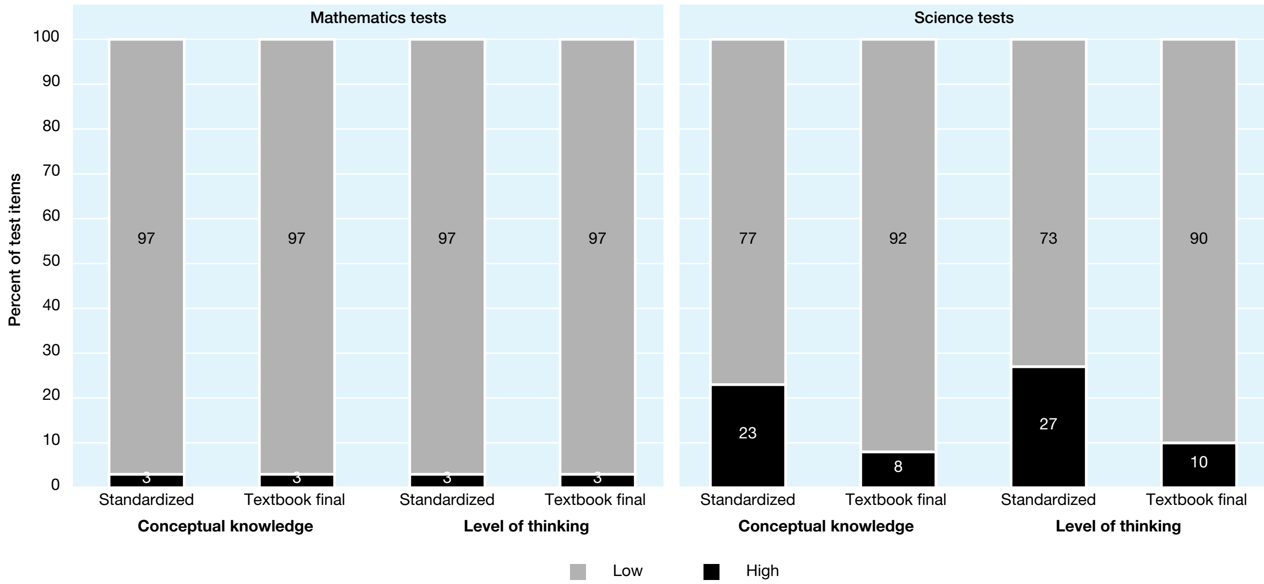
FIGURE 3-38

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

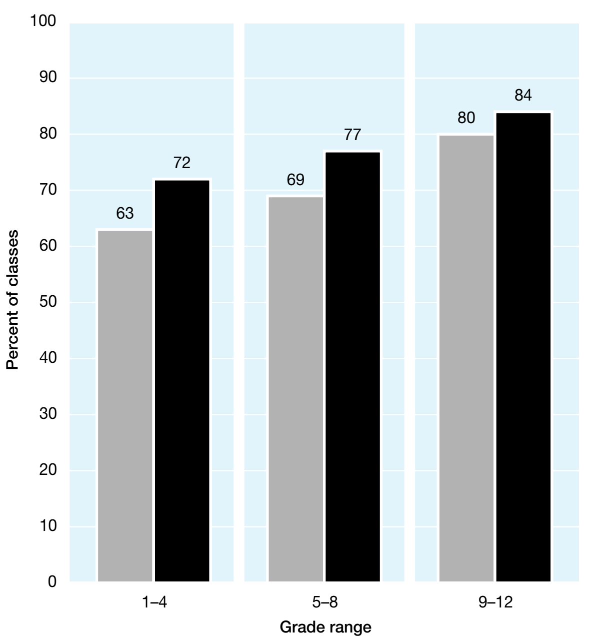
Percent of science and mathematics teachers reporting classroom preparation for mandated standardized tests, by minority presence: 1992

	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

	Grades 1-6			Grades 7-9			Grades 10-12		
Factor	**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)

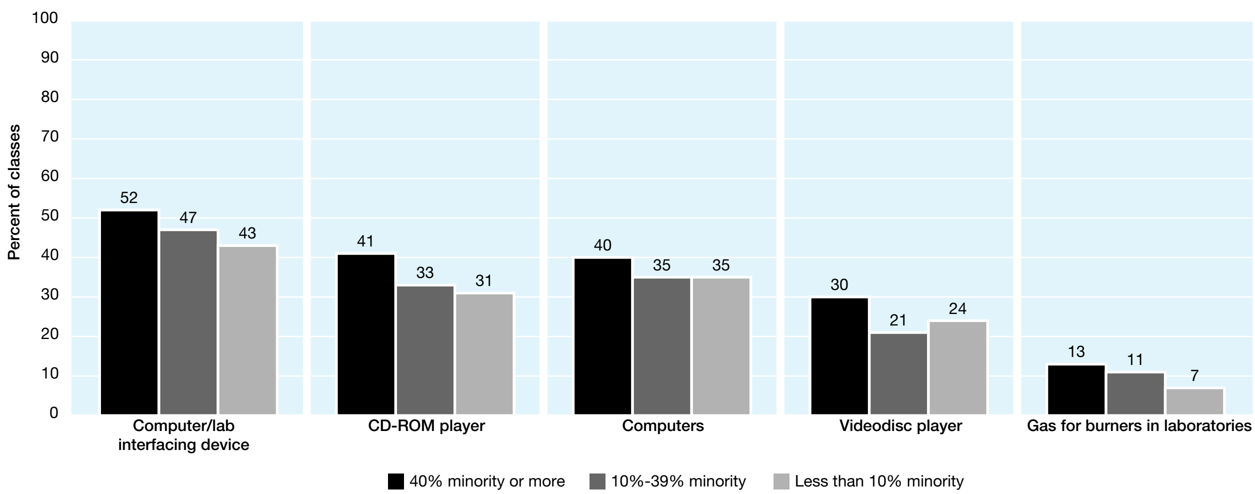
-- Not applicable.
* The 1977 survey used estimates for teachers of grades K-6.
NOTE: Standard errors appear in parentheses.
SOURCES: Weiss, I.R. (1987). *Report of the 1985-86 national survey of science and mathematics education.* Research Triangle Park, NC: Research Triangle Institute; Weiss, I.R., 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

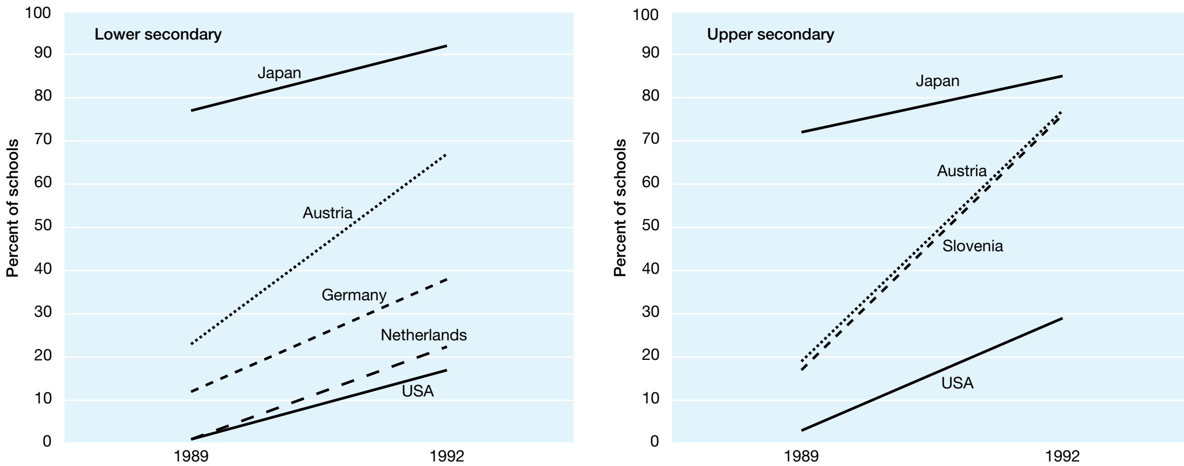
Percent of high school science classes for which teachers report various types of equipment are needed but not available, by percent minority in class: 1993



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

	Grade range		
Type of computer use	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)

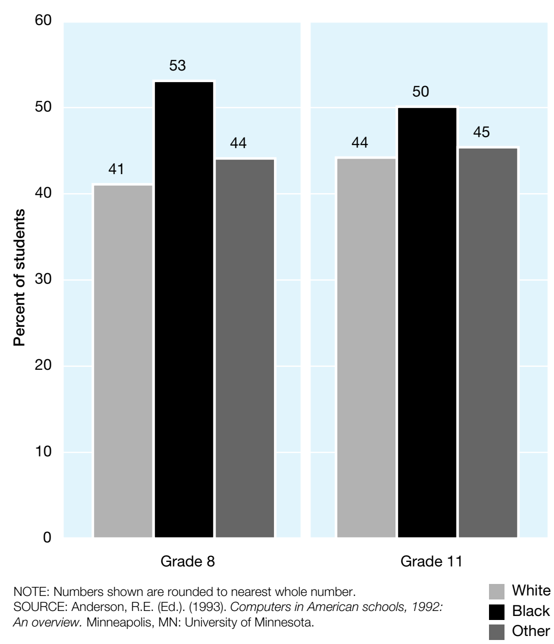
NOTE: Standard errors appear in parentheses.
SOURCE: Weiss, I.R., Matti, M.C., & Smith, P.S. (1994). *Report of the 1993 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research, Inc.

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.

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-

TEXT TABLE 3-12

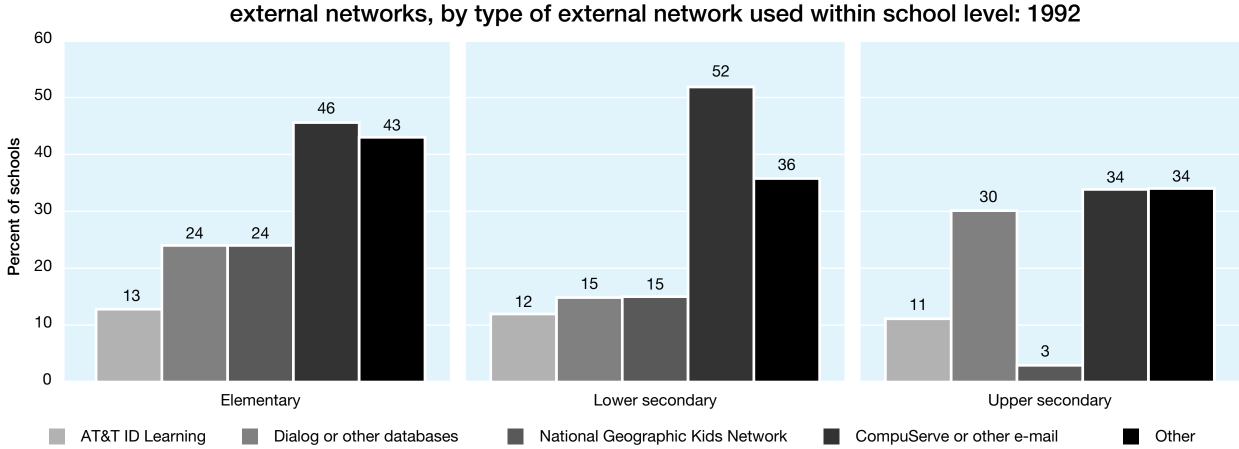
Percent of U.S. students ever taught a computer skill or programming course, by race within grade level: 1992

Skill or course	Race	Grade 5	Grade 8	Grade 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.

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

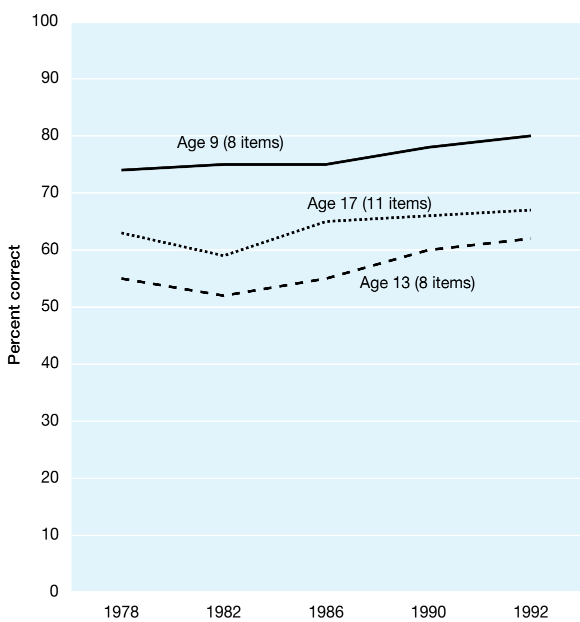
Many different types of calculator are used in mathematics classrooms. In 1993, four-function calculators were popular across all grade levels; whereas, at the high school level, scientific and graphing calculators were becoming more evident. (See text table 3-13.) The large percent of high school mathematics 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.

Indicators of Science and Mathematics Education 1995

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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