

Chapter 1

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Introduction

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

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

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

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

THE CONTEXT FOR THIS REPORT

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

they selected indicators for this volume. These events all affect interpretation of the selected indicators.

POLICY

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

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

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

SYSTEMIC REFORM

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

- ◆ high standards for learning expected from all students;
- ◆ alignment among the parts of the educational system; and
- ◆ a change in the governance of education, which includes greater school site flexibility and control over resources and strategies of curriculum implementation. Systemic reform efforts include more, however, than just a vision of change in classroom instruction. They
 - ◆ involve the community and the public in promoting change by encouraging partnerships among the sectors of education institutions and among parents, businesses, and the community to develop goals for students;

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

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

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

STANDARDS

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

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

These standards are not merely a restatement of the status quo. They stress high levels of science and mathematics competency. They call for a different kind of instruction, emphasizing depth of understanding over breadth of coverage and instruction to promote problem solving. In addition, the role of the teacher becomes one of coach or model—with students expected to engage in

hands-on, inquiry-based learning—rather than purveyor of knowledge. The principles within the standards are widely accepted by leaders of the education associations to provide a path to excellence.

ASSESSMENT

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

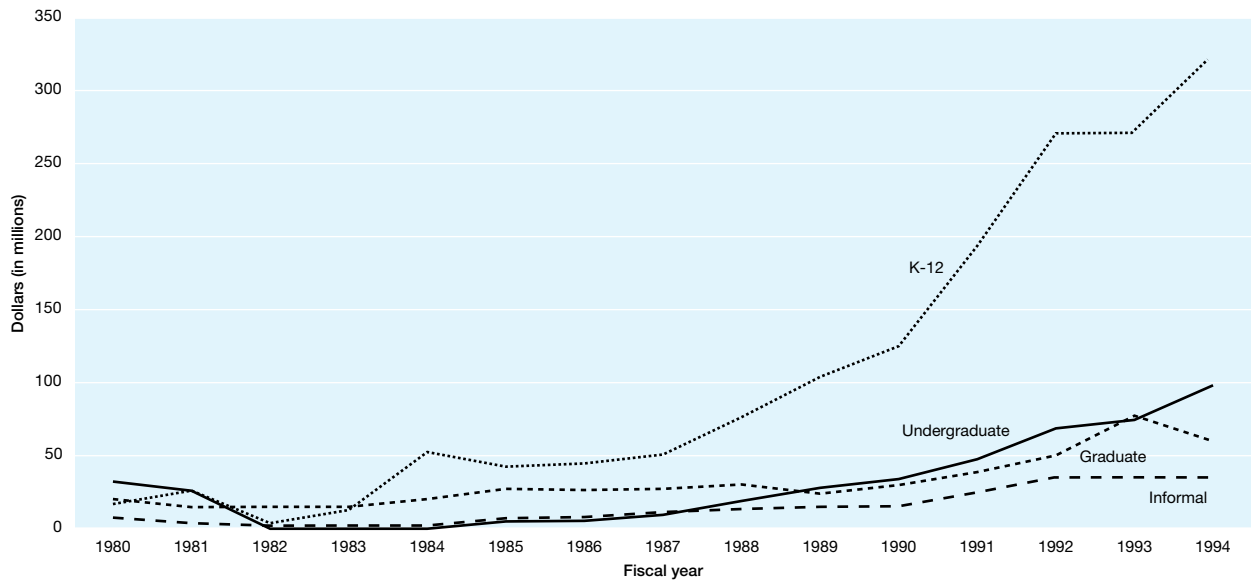
FEDERAL FUNDING

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

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FIGURE 1-1

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



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

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

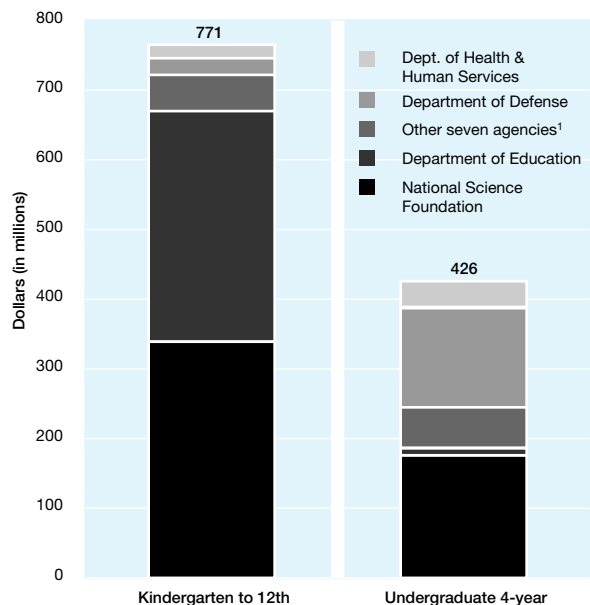
Although Federal funding is a small portion of the state and local government expenditures for science and mathematics education, changes in Federal funding may provide useful indicators of changes in national priorities. NSF's financial contribution to education represents about one-fourth of the total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

DEMOGRAPHICS

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

FIGURE 1-2

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



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

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

ELEMENTARY AND SECONDARY

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

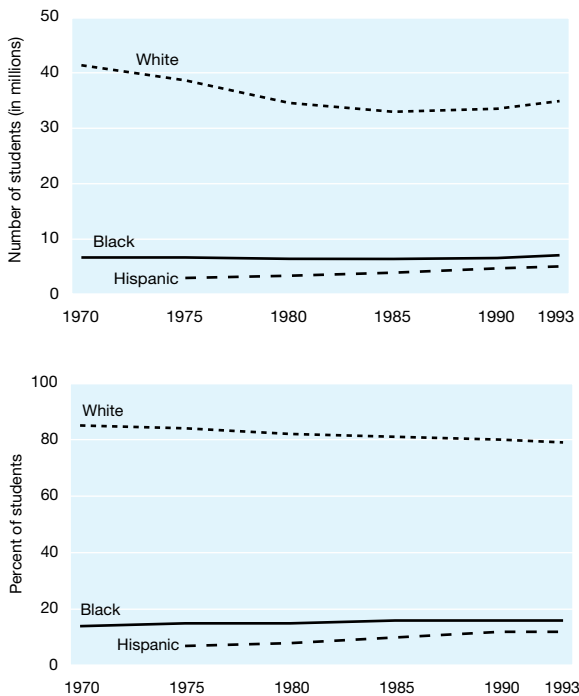
Corresponding to the increase in the Hispanic population was an increase in the number of children who did not speak English in the home. (See figure 1-4 and

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

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

FIGURE 1-3

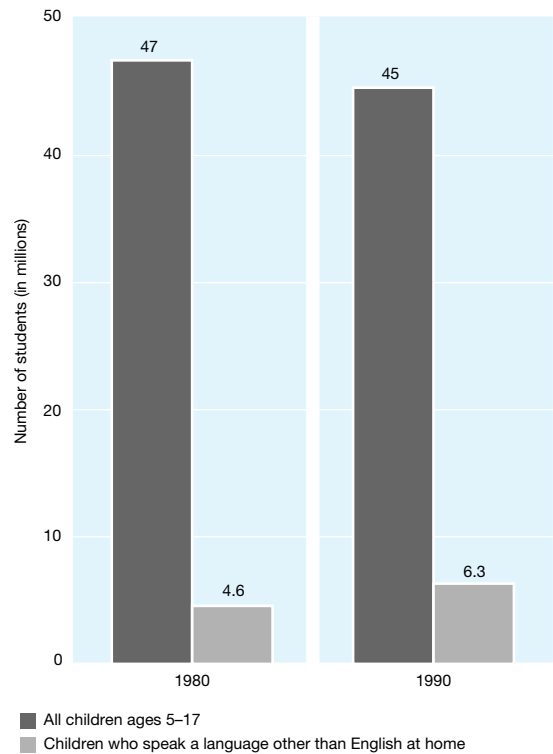
Number and percent of students enrolled in grades 1–12, by race or ethnic origin: 1970 to 1993



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

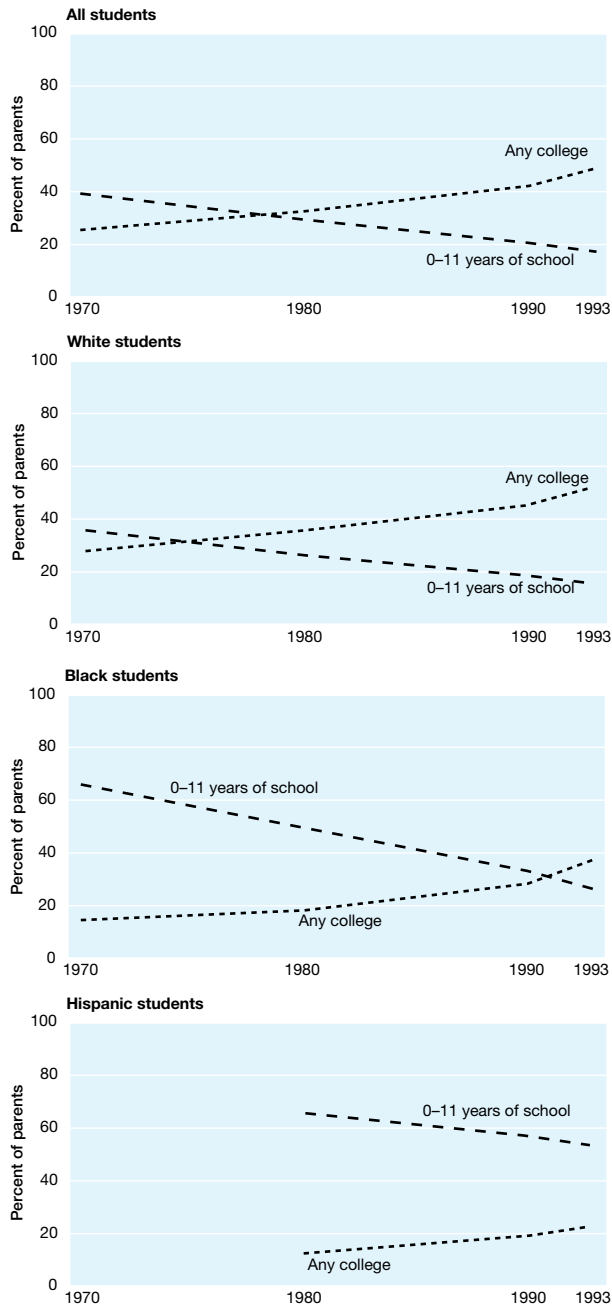
FIGURE 1-4

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



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

FIGURE 1-5
Education level of parents of elementary or secondary school students, by student race or ethnic origin: 1970 to 1993



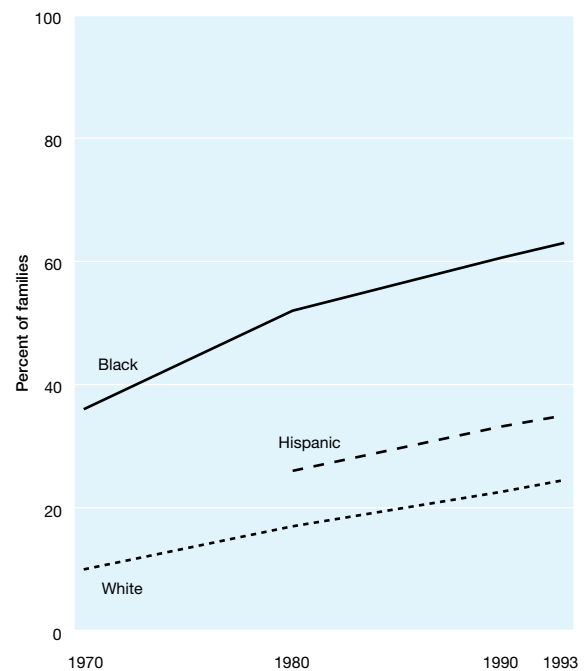
NOTES: Data not available for Hispanics before 1980. Persons of Hispanic origin may be of any race. SOURCES: U.S. Bureau of the Census. (1990). *School enrollment—social and economic characteristics of students: U.S. Bureau of the Census. (1971). School enrollment: October 1970 (Current Population Reports,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

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

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

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

FIGURE 1-6
Percent of white, black, and Hispanic families with only one parent present, by race or ethnic origin: 1970 to 1993



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

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

POSTSECONDARY

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

THE ORGANIZATION OF THE REPORT

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

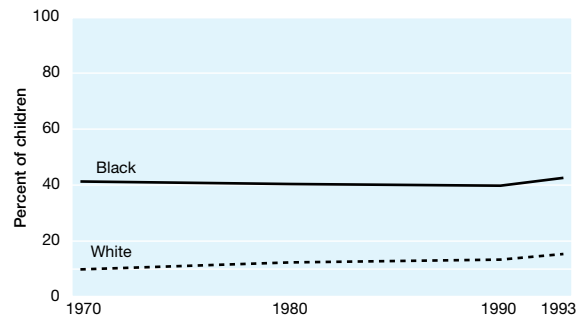
Chapter 2 provides an update on the achievement of students, looking at overall changes in achievement and differences by sex, race and ethnic origin, and region. The chapter reports some “good news,” in terms of excellence and equity; however, many questions remain.

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

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

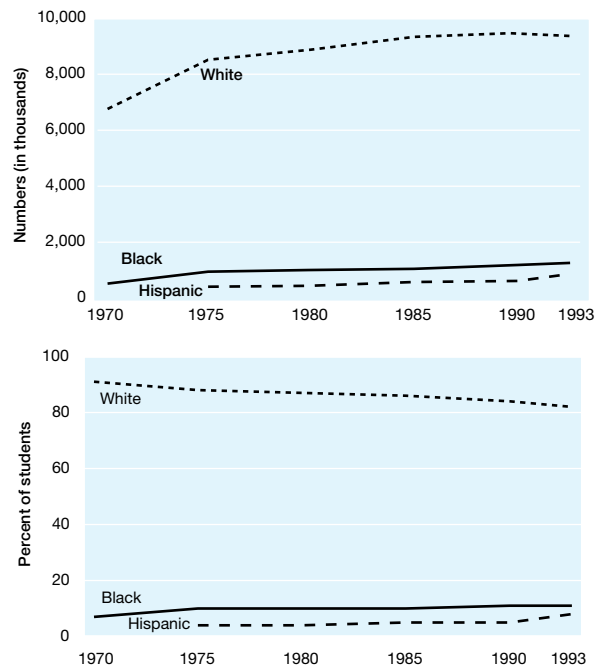
Chapter 5, the concluding chapter, contains additional reflections, not as much on what the indicators say, but on what the present system of indicators does not say. The chapter returns to policy issues and suggests critical themes that researchers should pursue in the future. ■

FIGURE 1-7
Percent of white and black children ages 6–17 below the poverty level: 1970 to 1993



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

FIGURE 1-8
Race or ethnic origin of students enrolled in college: 1970 to 1993



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

ENDNOTES

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

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

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

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