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ABSTRACT

Efforts to reform and restructure science and mathematics education should be based on a sound assessment of current conditions, the rate of improvement, and problems in the system. This report focuses on indicators of the condition of science and mathematics education at state and national levels. The 1999 report presents new state indicators from the 1997-98 school year and examines trends, by state, from 1990 to 1998 on indicators of student achievement, content and instruction, and context and conditions for teaching. Among the student achievement indicators, the study found that proficiency on the National Assessment of Educational Progress (NAEP) in mathematics had a significant improvement: the percentage of grade 8 students scoring at or above the proficient level was 23% at the national level, and 27% of students were at or above the proficient level in science at grade 8. Among the findings in the area of content and instruction, the study found that seven states had over three-fourths of high school students take three years of high school mathematics in 1998. The number of mathematics and science teachers rose in the 1990s in the area of teacher preparation and supply. In the area of conditions and context for teaching, it was found that in 35% of grade 4 classrooms, one computer is available for mathematics instruction, 29% have two or more computers available, and only 6% have no computers available. Appendices provide more detailed data and information by state. (Contains 72 references.) (ASK)

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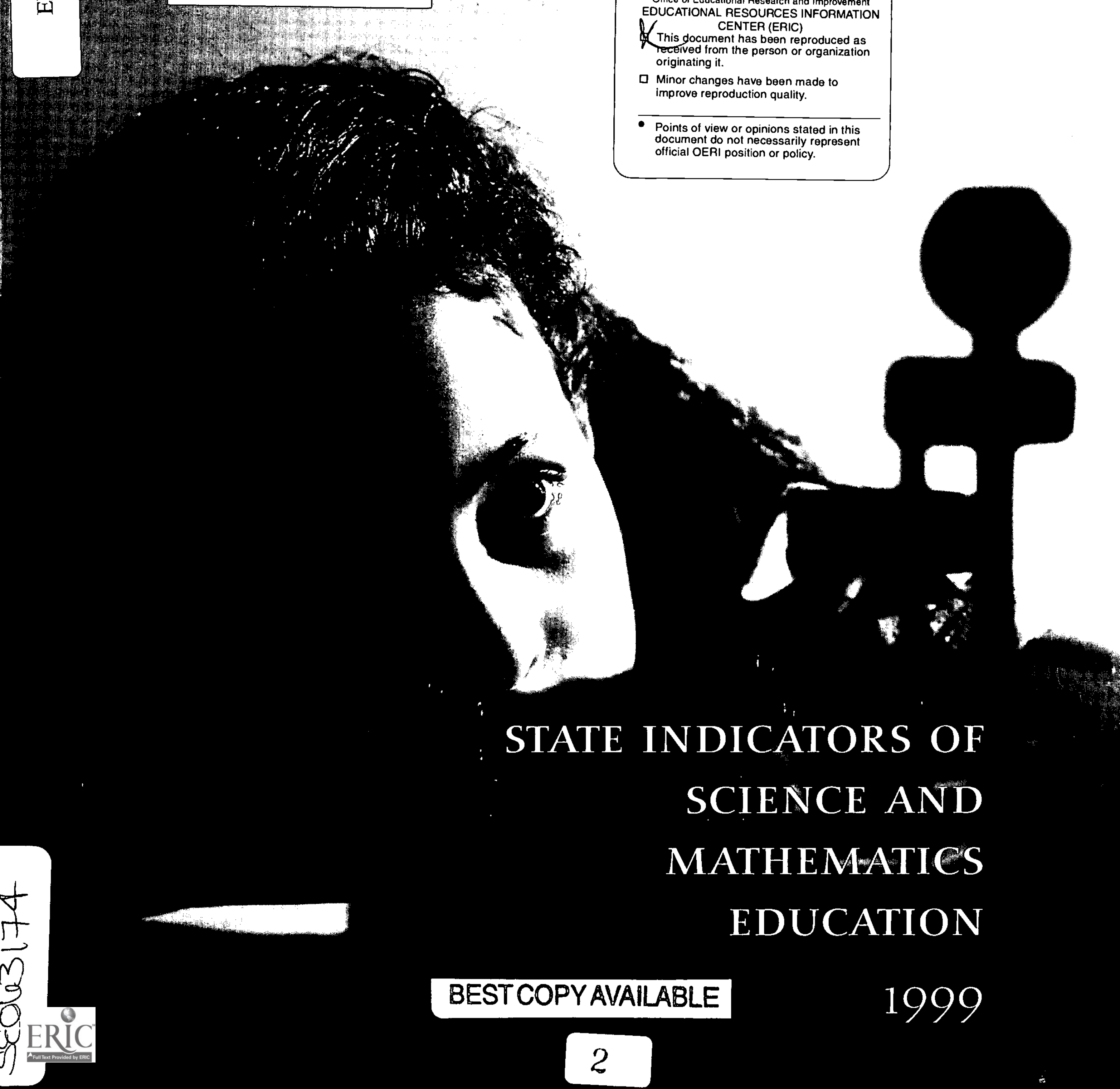

STATE INDICATORS OF SCIENCE AND MATHEMATICS EDUCATION

1999

COUNCIL OF CHIEF STATE SCHOOL OFFICERS

STATE INDICATORS OF SCIENCE AND MATHEMATICS EDUCATION

1999

State-by-State Trends and New Indicators from the 1997–98 School Year

Rolf K. Blank
Doreen Langesen

The development of this report was supported by a grant from the National Science Foundation (REC 98-03080). Data for the report were obtained through the cooperation of the state departments of education and the Naitonal Center for Education Statistics at the U.S. Department of Education.

The Council of Chief State School Officers (CCSSO) is a nationwide, nonprofit organization of the public officials who head departments of elementary and secondary education in the states, the District of Columbia, the Department of Defense Education Activity, and five extra-state jurisdictions. CCSSO seeks its members' consensus on major education issues and expresses their view to civic and professional organizations, to federal agencies, to Congress, and to the public. Through its structure of standing and special committees, the Council responds to a broad range of concerns about education and provides leadership on major education issues.

The State Education Assessment Center was established by chief state school officers to improve the information base on education in the United States, especially from a state perspective. The Center works to improve the breadth, quality, and comparablity of data on education, including state-by-state achievement data, instructional data, indicators of education quality, and performance assessment of teachers and students.

The State Science and Mathematics Indicators were developed through collaboration of the Council's Assessment Center with all of the state departments of education, the National Science Foundation, and the U.S. Department of Education. The Indicators were selected and designed to provide valid, comparable state-by-state and national data on the condition of science and mathematics education in elementary and secondary schools. Data are reported every two years using a consistent set of indicators.

The Science and Mathematics Indicators project is supported by a grant from the National Science Foundation, Division of Research, Evaluation, and Communication of the Education and Human Resources Directorate.

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Acknowledgments

This report is the result of successful cooperation of the Council of Chief State School Officers with the state departments of education, the National Science Foundation (NSF), and the U. S. Department of Education. The State Science and Mathematics Indicators were initiated in 1986 as a result of the commitment of the National Science Foundation to improving the quality of information on science and mathematics education in the nation's schools. The Council's work in developing a system of state-level indicators of science and mathematics education is made possible by the collective decision of the state superintendents and commissioners to have valid, comparable state-by-state data to assess educational progress.

The Science and Mathematics Indicators receive strong support from each of the state superintendents and commissioners. State data managers, science and mathematics specialists, and assessment directors have willingly given their time, expertise, and assistance to the project. State education staff have played active roles in the selection of indicators and design of a data reporting system, and some indicators are based on data from state education information systems.

The Council very much appreciates the strong support by the National Science Foundation for development and continuation of the State Science and Mathematics Indicators. We particularly acknowledge Bernice Anderson, NSF program officer, and Larry Suter, deputy director of the Division of Research, Evaluation, and Communication at NSF, who have provided important guidance and suggestions throughout development of the state indicators. The National Center for Education Statistics of the U.S. Department of Education provided state-by-state data analyses from the Schools and Staffing Survey for this report. Results from the NAEP Trial State Assessment in mathematics and science are also reported as state indicators. We very much appreciate the support and assistance of NCES.

The Council staff and the states have benefited greatly from the insightful recommendations and suggestions of expert advisors since the beginning of our work. State leaders, science and mathematics educators, researchers, and federal agency staff who advise us have ensured that the indicators are soundly based on research and that they provide important information for policy and program decisions.

Summary of State Science and Mathematics Indicators: 1999

The Council of Chief State School Officers' goal in producing this report on science and mathematics indicators is to assist state, national, and local policymakers and educators in making informed decisions. Efforts to reform and restructure science and mathematics education need to be based on a sound assessment of current conditions, the rate of improvement, and problems in the system. This report focuses on science and mathematics indicators at state and national levels.

Improving student learning in mathematics and science is a priority for our elementary and secondary schools. The National Education Goals of the President and governors, set in 1989, state that science and mathematics achievement of American high school graduates will be first in the world by the year 2000. Educators at local, state, and national levels are working to implement national professional standards for mathematics education. The new national standards for science education will further advance science education reform.

The Council has led development of a system of state-by-state indicators of the condition of science and mathematics education. The indicators are intended for use by policymakers and educators to assess progress in improving mathematics and science education in our schools. This report is the fifth in a series of biennial Council reports on *State Indicators of Science and Mathematics Education*. The 1999 report presents new state indicators from the 1997-98 school year and examines trends, by state, from 1990 to 1998 on indicators of: (a) student achievement; (b) content and instruction; (c) teacher preparation and supply; and (d) context and conditions for teaching. The indicators were selected through consultation with state education leaders, science and mathematics educators, representatives of national professional organizations, and education researchers. The Council's work in development of science and mathematics education indicators is supported by the National Science Foundation.

An electronic, Internet version of this report is available on the CCSSO website: (www.ccsso.org/publications).

Summary of Indicators for 1999

Chapter One: Indicators of Student Achievement in Mathematics and Science

POLICY ISSUES

Is student achievement in mathematics and science improving, and how does achievement compare state to state?

Are students learning challenging content?

Are schools improving the performance of all students?

- **Improvement in Student Proficiency on NAEP Mathematics, Grade 8.**
  From 1990 to 1996, 27 states made significant improvement in the percentage of grade 8 students reaching the "Proficient" level on the National Assessment of Educational Progress (NAEP) in Mathematics. Eight states had over 30% of students score at/above Proficient level in 1996. Nationally, 23% of students scored at/above the Proficient level in 1996. (Figure 1, Table 1)

- **NAEP Mathematics, Grade 4.**
  From 1992 to 1996, seven states made significant improvement in the percentage of grade 4 students reaching the Proficient level on the NAEP Mathematics Assessment. Six states had at least 25% of students score at/above the Proficient level in 1996. Nationally, 20% of grade 4 students scored at/above the Proficient level. (Figure 2, Table 2)

- **Student Proficiency on NAEP Science, Grade 8.**
  The first state-level NAEP in Science was given to grade 8 students in 1996. Nationally, 27% of students were at or above the Proficient level in science at grade 8. Ten states had more than 35% of students at/above Proficient, and state scores varied from 12 to 41% of students at/above Proficient. (Table 3)

- **Race/Ethnicity and NAEP Proficiency.**
  Only nine states reduced the disparity in the NAEP Mathematics performance of minority and white students from 1992 to 1996. For the nation, the white-black difference in percent of grade 8 students at/above the Basic level declined by two percentage points over four years—in 1996, 73% of white students scored at/above Basic as compared to 26% of Blacks. (Figure 3, Table 4)

- **Advanced Placement Exams in Mathematics and Science.**
  Nationally, 5% of grade 12 students took AP mathematics examinations in 1998, and 6% took science examinations. Eight states increased participation in AP Math exams by three percentage points or more from 1992 to 1998. In science, eight states increased the percent of students taking AP Science (Biology, Chemistry or Physics) exams by three or more percentage points from 1992 to '98. (Tables 5, 6).

Chapter Two: Indicators of Mathematics and Science Content and Instruction

POLICY ISSUES

What proportion of students take challenging higher-level mathematics and science courses in high school?

What courses do middle grade students take?

Are minority students increasing their participation in higher level courses?

Is there a continuing gender gap in math and science?

- **Higher-Level Mathematics Courses.**
  Seven states had over three-fourths of high school students take three years of high school mathematics (indicated by enrollment in algebra 2 or integrated math 3) in 1998: Nebraska, Massachusetts, Kentucky, North Dakota, Missouri, Mississippi, and Maine. Nationally, 63% of students took three years of high school mathematics in 1998, as compared to 49% in 1990, an increase of 14 percentage points in eight years. Since 1990, the proportion of high school graduates taking four years of high school mathematics increased from 28% to 39% of graduates. (Figure 4, Table 7)

- **Course Enrollments by Grade.**
  In a majority of states, 10 to 20% of grade 10 students take algebra 2 or integrated math 3, and 30 to 40% of grade 11 students take this level math course. (Table 9)

- **Higher-Level Science Courses.**
  Ten states had over 60% of students that took three years of high school science (indicated by chemistry enrollments) in 1998. Nationally, 54% of students took three years of high school science as of 1998, as compared to 45% in 1990, an increase of nine percentage points in eight years. In nine states, more than 30% of students took four years of science, as indicated by physics enrollments, and the national average for physics was 24%. (Figure 5, Table 10)

- **State Graduation Requirements and Course Enrollments.**
  A majority of states increased their requirements since the mid-1980s and enrollments have increased significantly in most states. During the 1997–98 school year, almost half (45%) of public high school students were taking a higher level math course, an increase of 11 percentage points since 1990. Just over one-fourth of high school students (26%) were taking a higher level science course during 1997–98, which represents an increase of five percentage points since 1990. (Tables 13, 14)

- **Grade 8 Mathematics Enrollments.**
  Nationally, 18% of students in grade 8 took a first-year algebra course in 1997–98, and 21% took pre-algebra. The algebra enrollment in grade 8 went up by seven percentage points since 1990. (Table 15)

- **Science in Grades 7–8.**
  In 1997–98, general science was the science course taken by 31% of grades 7 and 8 students, 15% took life science, and 12% took earth science. Integrated science had the highest middle grades enrollments in nine states. (Table 16)

- **Race/Ethnicity and Higher Level Math and Science.**
  Thirteen states reported math and science enrollments by student race/ethnic group. Black and Hispanic enrollments in higher level math and science courses lagged enrollments for whites and Asians in all 13 states. From 1990 to '98, four of eight states with trend data raised the rate of enrollments of Black and Hispanic students in higher level math and science courses. (Table 17)

- **Mathematics and Science Teaching Practices.**

  Use of Calculators, Grade 4 and Grade 8
  From 1992 to '96, use of calculators in math class in grade 4 increased from 18 to 34% using them once per week or more, according to teacher reports. Eight states had over 40% of grade 4 students using calculators weekly or more, according to their teachers. By comparison, in 1996, 49% of grade 8 students reported they used calculators in math class almost every day, and 76% used them at least once per week in class. (Tables 20, 21)

  Discuss Solutions to Math Problems with Other Students
  At grade 8, 36% of students report they discuss math problems almost every day, and 65% discuss math problems in class at least once per week. This instructional practice is very prevalent across the nation. (Table 21)

  Write About Solving Math Problems, Grade 8
  One-third of students in grade 8, nationally, write about how to solve math problems once per week or more. Many state standards recommend that instruction develop students' abilities to communicate mathematically, such as by writing about how to solve a math problem. Three states have over 50% of grade 8 students writing about math problems weekly.

  Hands-On Science Activities/Investigations
  Surveys of teachers indicate that hands-on activities or investigations are used at least once a week in over three-fourths of 8th grade science classes (83% nationally). The state percentages of classes with weekly hands-on activities or investigations vary widely, from under 50% of classes in a few states to almost 90% of classes in other states.

Chapter Three: Indicators of Teacher Preparation and Supply

POLICY ISSUES

What are current trends and projections by state for well-prepared, qualified mathematics and science teachers?

What proportion of current teachers of mathematics and science have knowledge and skills in their field at the level outlined by professional standards?

- **Numbers of Math and Science Teachers Rise in 1990's.**
  From 1990 to 1998, the number of teachers of high school mathematics increased by 29,000 (or 25%), to a total of over 140,000 math teachers. The number of teachers in biology increased by 13,000 and chemistry by 6,000 (or 25%), and earth science by 5,000 (40%). In middle grades teaching, the number of math teachers increased since 1990 by 18,000 to 99,000, and the number of science teachers increased by 9,000 to 74,000. (Tables 23, 24)

- **Certified Teachers in High School Fields.**
  As of 1998, half the states had over 95% of high school math teachers certified in mathematics. Ten states had less than 90% certified. The national average was 88%, which was a decline of two percentage points since 1990. In high school chemistry, half the states had over 95% certified teachers, and ten states had less than 80% certified chemistry teachers. From 1990 to '98, the national rate of certified chemistry teachers declined by three percentage points. (Table 25)

- **Certified Middle Grades Teachers.**
  Nationally, 72% of grade 7-8 mathematics teachers are certified in math, which is an increase of seven points from 1996. Five percent of math teachers are certified in elementary teaching, and 22% are not certified. In science, 73% of grade 7-8 teachers are certified in science, 5% were certified in elementary teaching, and 22% are not certified. (Table 26)

- **Professional Development in Mathematics and Science.**
  In 12 states, over 55% of grade 8 students were taught by mathematics teachers that received more than 16 hours professional development in teaching mathematics in 1995-96. The national average was 48% receiving over 16 hours of development in math. In science, 57% of students were taught by grade 8 teachers that received 16 or more hours professional development in science or science education. In four states over 40% of teachers received more than 35 hours professional development in science. (Table 28)

- **Minority Teachers.**
  Southeastern states, California, and Hawaii have the highest proportion of science and math teachers that are from minority populations. In a majority of states, the minority teachers are one-third or less the number of minority students. The numbers of minority teachers in mathematics and science have increased slightly from 1990 to 1998, although the percent of all teachers that are minority has declined in a number of states.(Table 29)

- **Female Teachers.**
  The proportion of high school mathematics and science that are women has significantly increased since 1990. For example, 56% of mathematics teachers in grades 9-12 are now women, as compared to 45% in 1990. In chemistry, 44% of teachers are women as compared to 34% in 1990. (Figures 8, 9)

Chapter Four: Indicators of Context and Conditions for Teaching

- **Students Per Teacher.**
  In high school mathematics, six states have student/teacher ratios of over 125 to 1, while 11 states have ratios of less than 100 to 1. In high school chemistry, five states have student/teacher ratios of over 125 to 1, and 15 states have ratios of less than 100 to 1. (Table 33)

- **Class Size.**
  In high school mathematics, the average number of students per class varies across the states from 18 students per class to 28 students per class. Science classes in high schools vary by state from 18 students per class to 29 students per class.

- **Use of Computers in Math and Science.**
  In 35% of grade 4 classrooms one computer is available for mathematics instruction, 29% have two or more computers available, and only six percent have no computers available. The most common use is mathematical games. In grade 8 classrooms, 26% have no access to computers in school, and the most common use is for drill and practice. In grade 8 science, computers are used by 54% of students and about one-fourth use them for simulations and modeling. Only 38% of students have access to a computer in their classroom. (Tables 34, 35, 36).

Introduction

Development of State Education Indicators for Policymakers

In cooperation with the state departments of education, federal agencies, and professional organizations, the Council of Chief State School Officers (CCSSO) has developed a system of state indicators of the quality of science and mathematics education in public schools. The present report is the fifth in a series of biennial reports on state indicators. The reports are primarily intended for use by policymakers and educators.

The design, management, and reporting of indicators has been supported by the National Science Foundation (NSF) since the project was initiated in 1986. The state departments of education make major contributions to the system through advice on selection of indicators, collecting and reporting data from schools, and disseminating the indicators within states. In selecting and reporting state indicators, we also consult with science and mathematics educators, education researchers, and statistical experts. The Council places high priority on advocating for improving the quality and comparability of assessments and data that can produce reliable indicators of the health of our elementary and secondary schools.

Why State Science and Mathematics Education Indicators?

The science and mathematics indicators developed by CCSSO and the states meet at least three kinds of interests expressed to us by policymakers and educators:

- Reliable, comparable indicators, by state, to assess progress toward the National Education Goals and state goals
- A range of indicators and data to analyze the effects of state education policies and reform initiatives
- Measures of the quality of science and mathematics education that are useful to educators and policymakers to plan programs, identify problems, and recommend new initiatives.

Efforts to develop a system of national and state indicators of the quality of science and mathematics education began in the mid-1980s. Widely read reports on the condition of elementary and secondary education, including *A Nation at Risk* (National Commission on Excellence in Education, 1983) and *Educating Americans for the 21st Century* (National Science Board, 1983) helped spur national and state reform initiatives; these reports also increased attention on improving the quality and availability of information to monitor progress and report on current conditions.

A central reason for national and state cooperation toward a system of comparable state-level education indicators is that states establish much of the legal and policy structure for education. State leaders recognized that making major decisions about funding, programs, and standards requires high-quality information that is regularly and readily available.

"Reaching a new standard of excellence requires clear educational objectives, strong leadership and firm commitment at all levels. Goals must be set and press toward those goals assessed... The Federal government should finance and maintain a national mechanism for measuring student achievement and participation [in mathematics, science and technology education] in a manner that allows national, state and local evaluation and comparison of educational progress."

Educating Americans for the 21st Century
National Science Board, 1983

In the 1980s, states initiated a broad set of education policy reforms, including increased course credit requirements for graduation (particularly in mathematics and science), higher standards for teacher preparation, teacher tests for certification, higher levels for teacher pay, state curriculum guidelines and frameworks, and new statewide student assessments [Blank & Dalkilic, 1992; Blank & Espenshade, 1988; National Governors' Association (NGA), 1986]. An initial motivation for the Council's system of science and mathematics indicators was to track these policy changes over time and report statistical indicators to assist states in analyzing the relationship of policies and reforms to improvements in education quality. The National Education Goals, established in 1989, provided another incentive for state education indicators. CCSSO has worked with the National Education Goals Panel (NEGP) to share state data and develop indicators that will be broadly useful to national and state policymakers and educators.

Now, many states have placed a high priority on developing new state curriculum frameworks and standards for academic subjects that are the basis for state education improvements. In mathematics, the National Council of Teachers of Mathematics (NCTM) *Curriculum and Evaluation Standards* and *Teaching Standards* (1989, 1991) are reflected in new state curriculum frameworks and in state efforts toward implementing mathematics education reforms (Blank, et al, 1997; Blank & Pechman, 1995). In science, many states are developing new frameworks and standards using guidance from the American Association for Advancement of Science (AAAS) *Benchmarks for Science Literacy* (1993) and the NRC *National Science Education Standards* (National Research Council, 1995). State education representatives advised CCSSO that they are very interested in having indicators for science and mathematics education that will help them assess the progress of schools toward national and state standards.

The state indicators are also aimed at assisting state leaders and others in identifying state and national trends, planning and evaluating programs, and working on new initiatives. For example, the CCSSO indicators provide comparable state-level data to describe baseline conditions across 25 states involved with the NSF's Statewide Systemic Initiatives (SSI), and the science-math state indicators can help to track overall progress at the state level and provide comparisons among SSI states and other states. All state education agencies administer the federally-funded Eisenhower Science and Mathematics Program for teacher professional development, and these science-math state indicators meet the needs for assisting in planning and evaluating the Eisenhower program by provide state statistics on the demographic characteristics of the teaching force, rate of new teachers entering science and mathematics, the current preparation of teachers in their assigned fields, and trends in professional development of science and mathematics teachers.

The science and mathematics indicators have other practical applications. State administrators have used course enrollment data to analyze differences in the level of course taking in their states, as compared to states in their region and states with similar demographic characteristics. Policymakers have been able to compare the proportion of science and mathematics teachers with a degree in their teaching field with recommended and proposed standards for teacher preparation. Teacher educators have identified teacher shortages by science specialization and by gender and race to target teacher recruitment and professional development programs.

How Are State Indicators Selected? Are They Comparable and Reliable?

The CCSSO system of state education indicators is based on three premises:

- Indicators should reflect the needs of users of education data, particularly policymakers and educators. Each chapter is prefaced by key policy issues addressed by the indicators.
- Indicators should be selected with consideration and input from the providers of data, such as state data managers, districts, and schools. We continually evaluate the quality and reliability of data provided, and seek technical advice on analyzing and reporting indicators.
- Indicators should be informed by a research-based model of the education system, including state context, school processes and resources, and student outcomes; and selected indicators should be measured with valid, reliable data.

Initially, we designed a conceptual framework for the state science and mathematics indicators through meetings with an expert panel and state education representatives and by review of the research literature on indicators and science and mathematics education (Murnane & Raizen, 1988; National Science Board, 1983, 1993; National Study Panel on Education Indicators, 1991; NGA, 1986; Oakes, 1986, 1989; Porter, 1991; Shavelson, McDonnell, & Oakes, 1987). Using this framework, we developed a list of desired, or ideal, science and mathematics indicators, organized in six categories: student outcomes, instructional time/participation, curriculum content, teacher quality, school conditions, and equity. A survey of states and analysis of existing national surveys provided the basis for determining data availability on desired indicators and the potential for new data collection for the indicators (CCSSO, 1988).

A key step was convening a task force of state science and mathematics specialists (data users) and data managers (providers), education researchers, and federal education staff to weigh the desired indicators against both the quality of available data and the feasibility of collecting and reporting data by state. After discussion and analysis, the group reached a consensus on a priority list of indicators that led to the first CCSSO report (Blank and Dalkilic, 1991). Subsequently, we have convened advisory panels representing educators, researchers, and state education leaders to review the state science and mathematics indicators and to recommend improvements in methods of reporting.

In the present report, we have continued to maintain two initial decisions about the method of analyzing and reporting state indicators. First, the CCSSO report does not add up or otherwise combine individual indicators, such as state rate of enrollment in advanced courses and average student achievement, to produce a composite score for a state. Reporting which states are "ahead" or "behind" other states is not a main purpose of the indicators (CCSSO, 1985). We encourage the use and interpretation of multiple indicators, which may be measuring different aspects of science and mathematics education. Second, this report provides no analysis of cause-and-effect relationships between indicators. The emphasis is on reporting variation and trends by state for individual indicators. Some sections refer to analyses that have been done, and we encourage further analysis of the data presented here. The indicators were selected by using a model of the educational system that helps educators identify factors that explain improvement in educational outcomes. See Blank (1993) for further information and elaboration on the process of selecting and developing state education indicators.

What Are the Sources of Data?

We used four primary sources of data to report the 1999 state science and mathematics indicators:

1. The National Assessment of Educational Progress (NAEP) assessments in mathematics and science, administered by the NCES, are used to report indicators of student achievement by state, and teachers questionnaires were used for data on teaching practices in mathematics and professional development of teachers.

2. Results from the Advanced Placement examinations, administered by The College Board, also provide indicators of student achievement.

3. The Schools and Staffing Survey is a source for state-representative data on teacher preparation and school conditions for science and mathematics. The Survey is conducted by NCES.

4. The Council collected aggregated data from state departments of education on indicators of course enrollment, teacher assignments and characteristics, teacher certification, and new teachers in math and science. The data were collected through state information systems, and reported to CCSSO using standard data categories.

Organization of the Report

The state indicators are outlined in the next four chapters of the report. Chapter 1 describes indicators of student achievement in mathematics and science, with an emphasis on achievement by student race/ethnicity and gender. Chapter 2 includes indicators of curriculum, instructional practices, and class time, with a focus on their relation to state policies and professional standards. Chapter 3 provides state indicators of the quality of preparation of teachers and trends in the supply of teachers. Chapter 4 has several indicators of conditions in schools for science and mathematics teaching. The Conclusions chapter provides an overview of the use of the state indicators to analyze education policies.

The Appendices provide detailed data and information by state. Appendix A has state policy information and student background data by state; Appendix B provides examples of NAEP mathematics and science assessment exercises; Appendix C gives details on data sources and computations; and Appendix D provides a directory of course definitions and titles.

Chapter One

Indicators of Student Achievement in Mathematics and Science

Student Proficiency on NAEP

Mathematics and Science Proficiency by Student Race/Ethnicity and Gender

Students Taking Advanced Placement Examinations

Student Proficiency on NAEP

CCSSO strongly supports the development and use of state-level student assessments from NAEP as an indicator of student learning in mathematics and science. The Council led the consensus planning process that produced the Assessment Framework for the 1990 NAEP mathematics assessment, the first NAEP to report state-by-state scores, and the Framework for the 1996 NAEP Science Assessment, the first with state level science results. In the view of the Council, the NAEP assessment is the best source for student achievement indicators that are comparable state-to-state and adequately assess the range and depth of knowledge and student skills recommended by states and school districts.

POLICY ISSUES

Is student achievement in mathematics and science improving, and how does achievement compare state to state?

Are students learning challenging content?

Are schools improving the performance of all students?

The NAEP assessment results and supporting questionnaires from students and teachers are based on a sample of 2,000 students per state at each assessed grade. The data do not provide a way for states to analyze student achievement for each school and district. The results, however, are still extremely valuable as indicators. NAEP results provide a way to monitor state progress in student achievement; to assess education received by specific groups of students; and, very important, to determine the relationship of student achievement to characteristics of schools, classroom practices, and teachers, by state. The state-level NAEP results reported here are primarily drawn from reports of the National Center for Education Statistics after the 1996 NAEP assessments in mathematics and science: Mathematics (Reese, et al, 1997; Shaughnessy, et al., 1998); Science (Bourque, et al, 1997; Keiser, et al, 1998).

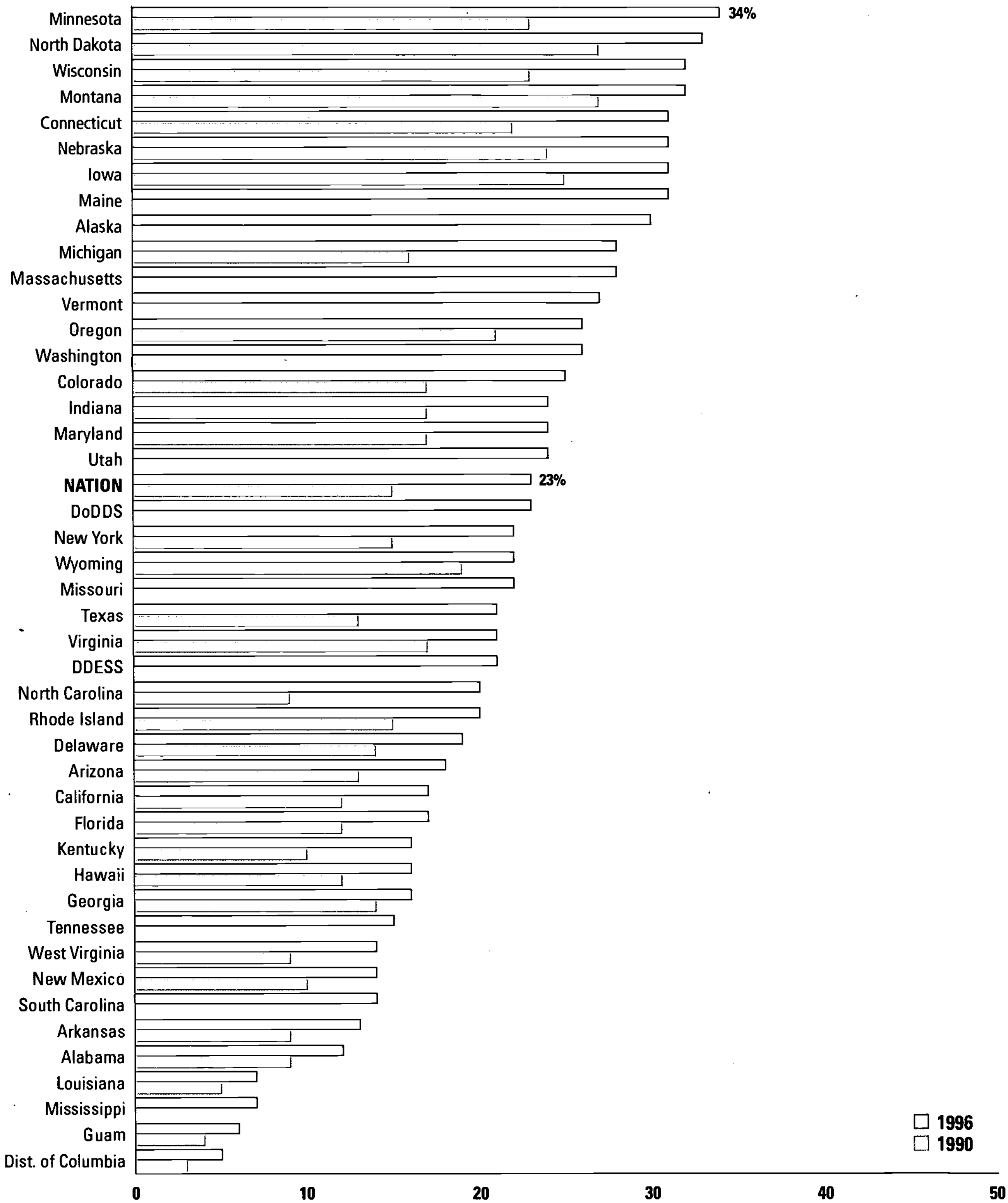
Mathematics Proficiency of Grade 8 Students

- **Improvement in Student Proficiency on NAEP Mathematics, Grade 8.**

From 1990 to 1996, 27 states made significant improvement in the percent of grade 8 students reaching the "Proficient" level on the National Assessment of Educational Progress (NAEP) in Mathematics. Eight states had over 30 percent of students score at/above Proficient level in 1996. Nationally, 23 percent of students scored at/above the Proficient level in 1996.

The improvement in NAEP scores for grade 8 mathematics by state are displayed in Figure 1, showing the percent of students at/above Proficient for 1990 and 1996. Table 1 gives the scores by state alphabetically, including the percent at/above the Proficient level and the Advanced level and the average proficiency on the NAEP scale (0 to 500 scale for Assessments in grades 4, 8, and 12).

FIGURE 1 **Percent of Grade 8 Students At or Above Proficient Mathematics Level, 1990 to 1996 NAEP**



EXAMPLE: The percent of grade 8 public school students in Minnesota at or above the Proficient level increased 11 percentage points from 1990 to 1996.

SOURCE: *NAEP 1996 Mathematics Report Card for the Nation and the States*, U.S. Department of Education.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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TABLE 1 **Mathematics Proficiency of Grade 8 Students, 1996 NAEP; Improvement 1990 to 1996**

STATE	PROFICIENT %, 1996	PROFICIENT Change 1990 to '96	% at Advanced Level, 1996	Average Proficiency, NAEP Scale 1996
Minnesota	34	+11 ◇	6 ◇	284
North Dakota	33	+6 ◇	4	284
Montana *	32	+5 ◇	5 ◇	283
Wisconsin *	32	+9 ◇	5 ◇	283
Connecticut	31	+9 ◇ □	5	280
Iowa *	31	+6 ◇	4	284
Maine	31	+6 □ ('92)	6 □	284
Nebraska	31	+7 ◇	5 ◇ □	283
Alaska *	30	–	7	278
Massachusetts	28	+5 ('92)	5	278
Michigan *	28	+12 ◇ □	4 ◇	277
Vermont *	27	–	4	279
Oregon	26	+5 ◇	4	276
Washington	26	–	4	276
Colorado	25	+8 ◇	3	276
Indiana	24	+7 ◇	3	276
Maryland *	24	+7 ◇	5 ◇	270
Utah	24	+2 ('92)	3	277
DoDDS	23	–	3	275
NATION	**23**	**+8** ◇	**4**	**271**
Missouri	22	+2 ('92)	2	273
New York *	22	+7 ◇	3	270
Wyoming	22	+3 ◇	2	275
DDESS	21	–	5	269
Texas	21	+8 ◇	3	270
Virginia	21	+4	3	270
North Carolina	20	+11 ◇ □	3 ◇ □	268
Rhode Island	20	+5 ◇ □	3	269
Delaware	19	+5 ◇ □	3	267
Arizona	18	+5 ◇	2	268
California	17	+5 ◇	3	263
Florida	17	+5 ◇	2	264
Georgia	16	+2	2	262
Hawaii	16	+4 ◇	2	262
Kentucky	16	+6 ◇	1	267
Tennessee	15	+3 ('92)	2	263
New Mexico	14	+4 ◇	2	262
South Carolina *	14	-1 ('92)	2	261
West Virginia	14	+5 ◇ □	1	265
Arkansas *	13	+4 ◇	2	262
Alabama	12	+3	1	257
Louisiana	7	+2	0	252
Mississippi	7	+1 ('92)	0	250
Guam	6	+2	0	239
Dist. of Columbia	5	+2	1	233

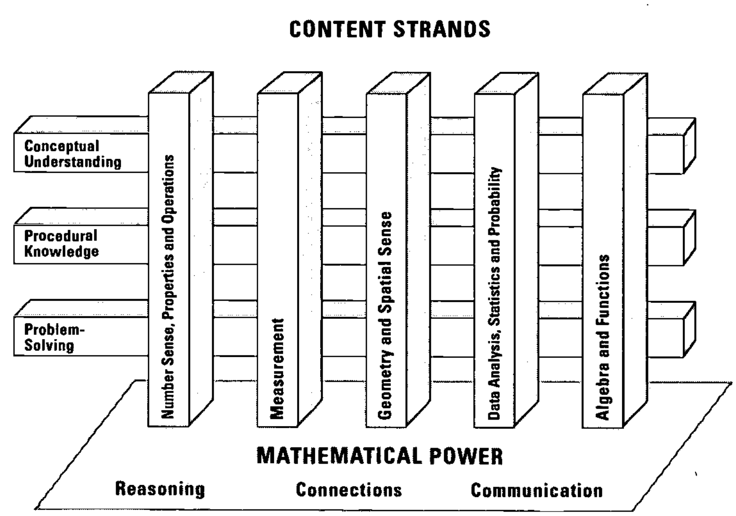
NOTES: * Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.
◇ Significantly higher than **1990** NAEP mathematics proficiency at about the 95% confidence level.
□ Significantly higher than **1992** NAEP mathematics proficiency at about the 95% confidence level.
('92) = higher than 1992 NAEP, no data for 1990. – Indicates jurisdiction did not participate in 1990 or 1992.
States not participating in 1996 NAEP mathematics: Idaho, Illinois, Kansas, Nevada, New Hampshire, New Jersey, Ohio, Oklahoma, Pennsylvania, South Dakota.

SOURCE: *NAEP 1996 Mathematics Report Card for the Nation and the States* (see for standard errors of estimates).
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

- ▷ Almost all of the 40 states participating in 1996 NAEP showed improvement in grade 8 scores since 1990, with more than half showing a statistically significant improvement of +4 percentage points or more. Michigan, Minnesota, and North Carolina improved their percent of students at/above Proficient by 11 points in six years.
- ▷ In 1996, eight states had 30 percent or more students at or above the Proficient level (Connecticut, Iowa, Maine, Minnesota, Montana, Nebraska, North Dakota, and Wisconsin) while seven states and three extra-state jurisdictions were below 15 percent (Mississippi, South Carolina, Louisiana, Alabama, Arkansas, West Virginia, New Mexico, District of Columbia, Guam, and Virgin Islands.)
- ▷ Nationally, 23 percent of grade 8 students scored at or above the Proficient level in 1996, an improvement of eight points from 1990. The results also show that four percent were at or above the Advanced level, while 61 percent of grade 8 students scored at or above the Basic level, and, 39 percent of students scored below the Basic level.

Our reporting on NAEP mathematics assessment results for 1996 and trends by state since 1990 focus on the percent of public school students that score at or above the Proficient level. The NAEP definition for the "Proficient" level is based on the Mathematical Framework for the 1996 Assessment, which is graphically presented below.

Mathematics Framework for the 1996 Assessment



Source: NAEP 1996 Mathematics Report Card for the Nation and the States, U.S. Department of Education.

The definition of "Proficient" according to the National Assessment Governing Board is:

> Eighth grade students performing at the Proficient level should apply mathematical concepts and procedures consistently to complex problems in the five NAEP content strands—Number Sense, Properties, and Operations; Measurement; Geometry and Spatial Sense; Data Analysis, Statistics and Probability; and Algebra and Functions . (Reese, Miller, Mazzeo, & Dossey, 1997).

The NAEP mathematics assessment framework was strongly influenced by the mathematics standards developed by the National Council of Teachers of Mathematics in 1989. The NAEP Mathematics Assessment draws questions from the five framework mathematics strands shown in the framework. The assessment questions are categorized according to the domains of "mathematical abilities" and "mathematical power." Mathematical abilities "describes the nature of the knowledge or processes involved in successfully handling the task presented by the question— involving conceptual understanding, procedural knowledge or a combination of both in problem solving." Mathematical power refers to the students' ability "to reason, to communicate and to make connections of concepts and skills across mathematical strands, or from mathematics to other curricular areas" (Reese, et al, 1997, p. 2).

NAEP Assessments and Levels

NAEP results began to be reported using three achievement levels — Basic, Proficient, Advanced — in 1993 (Mullis, et al, 1993). CCSSO also began reporting using the NAEP levels in reporting state mathematics and science indicators (Blank and Gruebel, 1993). The percentage of students at or above the Proficient level is defined as a key indicator by the National Education Goals Panel in its annual reporting on Goal 3 (NEGP, annual report). There are several reasons for our decision to use the NAEP levels. NAEP scores are more understandable and interpretable by the public and by educators when reported against standards for students expected knowledge and performance in a subject, e.g., mathematics, rather than being reported as a number on a scale, as in a norm-reference test, where the student score is only compared to the relative performance of other students, or students in other districts or states. States have moved toward use of achievement or performance levels for state assessment programs (Blank, et al, 1998).

The NAEP assessments in mathematics and science are based on rigorous, challenging academic standards. They include different types of questions, including multiple choice items, short open-ended questions, and extended or "constructed response" questions in mathematics and "hands-on," laboratory tasks in science. The NAEP assessments are more demanding than the typical state test assessment, as shown by the percent of students at Proficient level on NAEP mathematics in comparison to percent of students meeting a "proficient" or "mastery" level on most state assessments (Blank , et al, 1998).

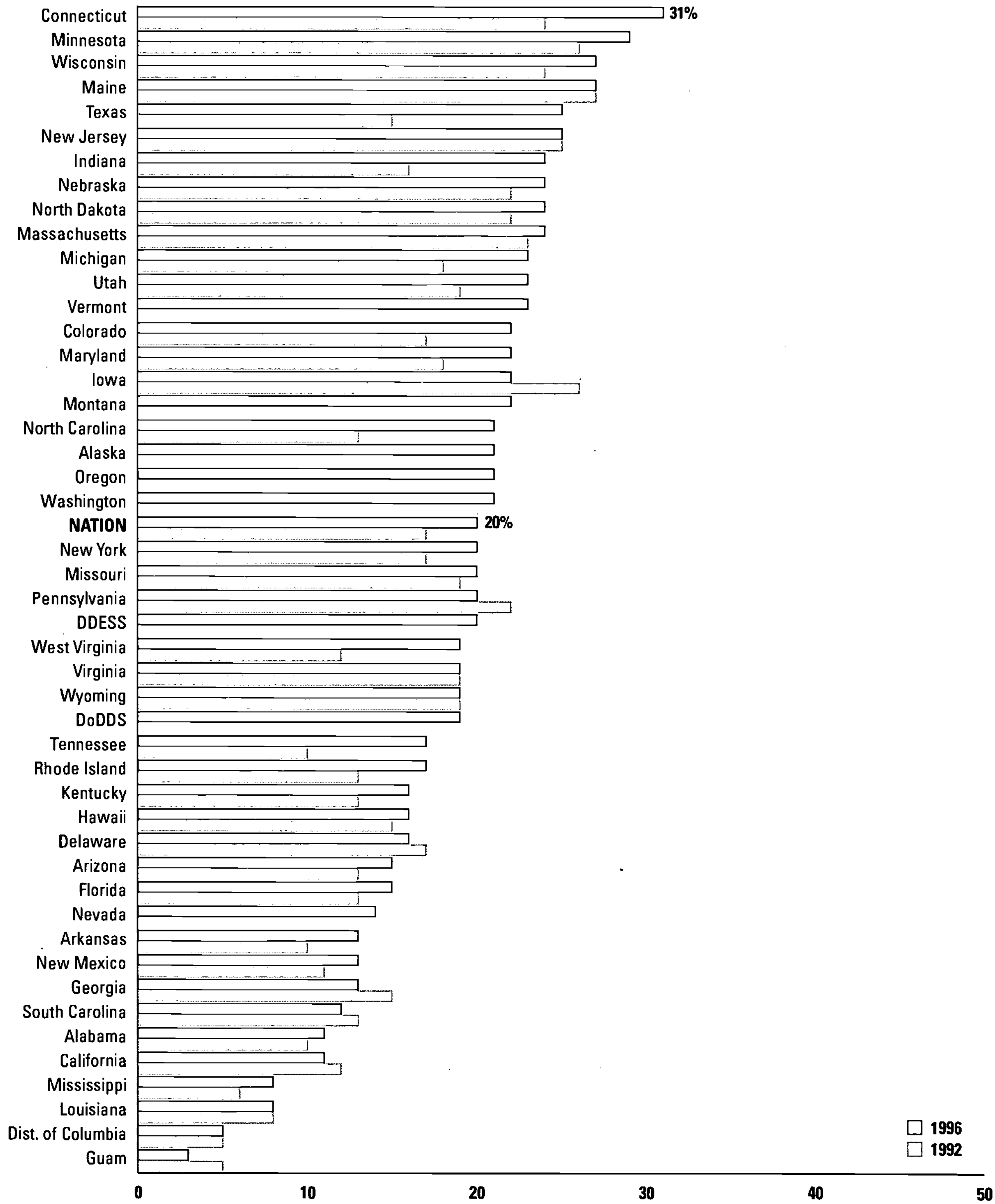
Mathematics Proficiency of Grade 4 Students

- **NAEP Mathematics, Grade 4.**

  From 1992 to 1996, seven states made significant improvement in the percent of grade 4 students reaching the Proficient level on the NAEP Mathematics Assessment. Six states had at least 25 percent of students score at/above the Proficient level in 1996. Nationally, 20 percent of grade 4 students scored at/above the Proficient level.

  The improvement in NAEP scores for grade 4 students in mathematics by state are displayed in Figure 2, showing the percent of students at/above Proficient for 1992 and 1996. Table 2 gives the scores by state alphabetically, including the percent at/above Proficient, the change over 4 years, the percent at/above Basic and Advanced levels, and the average proficiency on the NAEP scale (0 to 500 scale for assessments across grades 4, 8, and 12).

FIGURE 2 **Percent of Students in Grade 4 At or Above Proficient Mathematics Level, 1992 to 1996 NAEP**



EXAMPLE: The percent of grade 4 public school students in Texas at or above the Proficient level increased 10 percentage points from 1992 to 1996.

SOURCE: NAEP 1996 Mathematics Report Card for the Nation and the States, U.S. Department of Education.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE 2 *Mathematics Proficiency of Grade 4 Students, 1996 NAEP; Improvement 1992 to 1996*

STATE	PROFICIENT %, 1996	PROFICIENT Change 1992 to '96	% at or Above Basic Level, 1996	% at Advanced Level, 1996	Average Proficiency, 1996
Connecticut	31	+7 □	75 □	3	232
Minnesota	29	+3	76	3	232
Maine	27	0	75	3	232
Wisconsin	27	+3	74	3	231
New Jersey •	25	0	68	3	227
Texas	25	+10 □	69 □	3 □	229
Indiana	24	+8 □	72 □	2	229
Massachusetts	24	+1	71	2	229
Nebraska	24	+2	70	2	228
North Dakota	24	+2	75	2	231
Michigan •	23	+5	68 □	2	226
Utah	23	+4	69	2	227
Vermont •	23	—	67	3	225
Colorado	22	+5 □	67 □	2	226
Iowa •	22	-4	74	1	229
Maryland	22	+4	59	3	221
Montana •	22	—	71	1	228
Alaska •	21	—	65	2	224
North Carolina	21	+8 □	64 □	2	224
Oregon	21	—	65	2	223
Washington	21	—	67	1	225
DDESS	20	—	64	2	224
Missouri	20	+1	66	1	225
NATION	**20**	**+3**	**62**	**2**	**222**
New York •	20	+3	64 □	2	223
Pennsylvania •	20	-2	68	1	226
DoDDS	19	—	64	1	223
Virginia	19	0	62	2	223
West Virginia	19	+7 □	63 □	2	223
Wyoming	19	0	64	1	223
Rhode Island	17	+4	61	1	220
Tennessee	17	+7 □	58 □	1	219
Delaware	16	-1	54	1	215
Hawaii	16	+1	53	2	215
Kentucky	16	+3	60 □	1	220
Arizona	15	+2	57	1	218
Florida	15	+2	55	1	216
Nevada •	14	–	57	1	218
Arkansas •	13	+3	54	1	216
Georgia	13	-2	53	1	215
New Mexico	13	+2	51	1	214
South Carolina •	12	-1	48	1	213
Alabama	11	+1	48	1	212
California	11	-1	46	1	209
Louisiana	8	0	44	0	209
Mississippi	8	+2	42 □	0	208
Dist. of Columbia	5	0	20 □	1	187
Guam	3	-2	23	0	188

NOTES: • Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.
□ Significantly higher than 1992 NAEP mathematics proficiency at about the 95% confidence level.
— Indicates jurisdiction did not participate in 1992.
States not participating in 1996 NAEP mathematics: Idaho, Illinois, Kansas, New Hampshire, Ohio, Oklahoma, South Dakota.

SOURCE: NAEP 1996 Mathematics Report Card for the Nation and the States (see for standard errors of estimates).
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

- Twenty-three (of 43) states had a higher percent of grade 4 students at/above Proficient level on 1996 NAEP mathematics assessment than in 1992. Seven states showed improvement that was statistically significant (over four percentage points)—Colorado, Connecticut, Indiana, North Carolina, Tennessee, Texas, and West Virginia.
- Nationally, 20 percent of grade 4 students were at or above the Proficient level, which represents improvement of three percentage points from 1992. Six states had 25 percent or more of their grade 4 students at or above the Proficient level— Connecticut, Maine, Minnesota, New Jersey, Texas, and Wisconsin.
- Basic Level — Ten states had 70 percent or more of their grade 4 students at or above the Basic level on NAEP 1996 Mathematics. Nationally, 62 percent of grade 4 grade students were at/above Basic level, and 38 percent of students were below Basic.

The NAEP scores for Mathematics can be disaggregated by content strands in the mathematics assessment framework. The averages by content areas are available from the National Center for Education Statistics in the national NAEP report card (Reese, et al, 1997), individual state NAEP reports (a report on each participating state), and the cross-state NAEP report (Shaugnessy, et al. 1998). The scores are disaggregated for grades 4 and 8 mathematics according to: Numbers/Operations, Measurement, Statistics/Probability, Algebra/Functions, and Geometry.

The NAEP results in these tables and graphs show a statistical distribution of where states are in relation to other states and the nation, but it is difficult to get an idea of what mathematics students at a given level can actually do. To provide a glimpse of the mathematics content and skills of students represented by the NAEP scores and levels, we provide sample exercises (or problems) in Appendix B. The 1996 sample exercises indicate the overall percentage of students scoring well on the problem and the percentage for students at or above the Proficient level.

Science Proficiency of Grade 8 Students

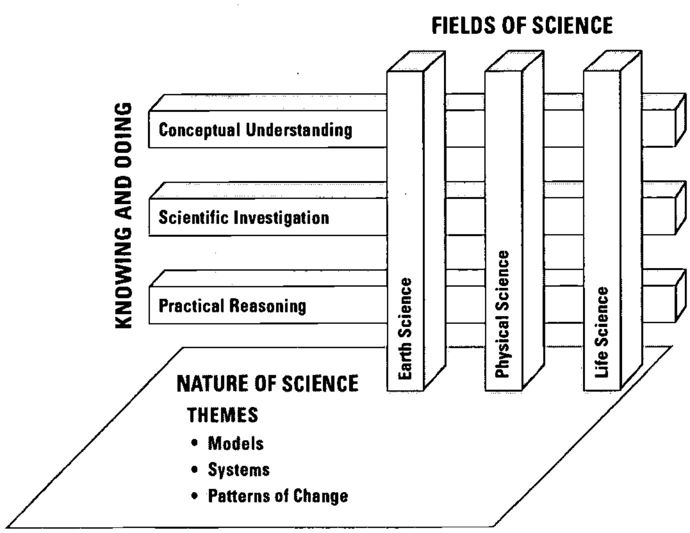
- **Student Proficiency on NAEP Science, Grade 8.**

The first state-level NAEP in Science was given to grade 8 students in 1996. Nationally, 27 percent of students were at or above the Proficient level in science at grade 8. Ten states had more than 35 percent of students at/above Proficient, and state scores varied from 12 to 41 percent of students at/above Proficient.

In 1996, the first state-level NAEP science assessment was conducted for grade 8 students, and the first NAEP Report Card with state data was released by NCES the following May (O'Sullivan, Reese, Mazzeo, 1997). Later in 1997, results were released with the NAEP Science Performance Standards (Bourque, et al, 1997). The NAEP science assessment was based on a new assessment framework. Half of the assessment time for the 1996 grade 8 science NAEP involved hands-on or constructed response exercises. The assessment changed significantly from earlier NAEP science exams, although national trends on NAEP are being maintained.

The science assessment framework, shown graphically below, included five content strands.

Science Framework for the 1996 Assessment



Source: Adapted from the National Assessment Governing Board's Science Framework for the 1996 National Assessment of Educational Progress.

The 1996 science NAEP results are reported by state for grade 8 in Table 3 using the performance standards approved by the National Assessment Governing Board. The definition of Proficient defined by the Boards follows:

> Students performing at the Proficient level demonstrate much of the knowledge and many of the reasoning abilities essential for understanding of the earth, physical, and life sciences at a level appropriate to Grade 8. For example, students can interpret graphic information, design simple investigations, and explain such scientific concepts as energy transfer. Students at this level also show an awareness of environmental issues, especially those addressing energy and pollution.

TABLE 3 Science Proficiency of Grade 8 Students, 1996 NAEP

STATE	PROFICIENT % at or Above Proficient Level, 1996	% at or Above Basic Level, 1996	% at Advanced Level, 1996	Average Proficiency, 1996
Maine	41	78	4	163
North Dakota	41	78	3	162
Montana*	41	77	3	162
Wisconsin*	39	73	4	160
Minnesota	37	72	3	159
Massachusetts	37	69	4	157
Iowa*	36	71	3	158
Connecticut	36	68	3	155
Nebraska	35	71	3	157
Wyoming	34	71	2	158
Vermont*	34	70	3	157
Utah	32	70	2	156
Colorado	32	68	2	155
Oregon	32	68	3	155
Michigan*	32	65	3	153
DoDDS	31	68	2	155
Alaska*	31	65	3	153
Indiana	30	65	2	153
Missouri	28	64	2	151
DDESS	27	65	2	153
Washington	27	61	2	150
NATION	**27**	**60**	**3**	**148**
Virginia	27	59	2	149
New York*	27	57	2	146
Rhode Island	26	59	2	149
Maryland*	25	55	2	145
North Carolina	24	56	2	147
Kentucky	23	58	2	147
Arizona	23	55	2	145
Texas	23	55	1	145
Arkansas*	22	55	1	144
Tennessee	22	53	2	143
West Virginia	21	56	1	147
Delaware	21	51	1	142
Florida	21	51	1	142
Georgia	21	49	1	142
California	20	47	1	138
New Mexico	19	49	1	141
Alabama	18	47	1	139
South Carolina*	17	45	1	139
Hawaii	15	42	1	135
Louisiana	13	40	1	132
Mississippi	12	39	1	133
Guam	7	28	0	120
Dist. of Columbia	5	19	0	113

EXAMPLE: The percentage of grade 8 public school students in Montana at or above the Proficient level was 41 percent in 1996.

NOTES: * Indicates that the state did not satisfy one or more of the guidelines for school participation rates.
States not participating in 1996 NAEP science: Idaho, Illinois, Kansas, Nevada, New Hampshire, New Jersey, Ohio, Oklahoma, Pennsylvania, South Dakota.

SOURCE: NCES, NAEP 1996 Science Assessment.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

- Fifteen states plus the Defense Dependents Schools (overseas) scored significantly (4% or more) above the national average of 27 percent of students at/above Proficient. Scores varied from Maine at 41 percent to Alaska at 31 percent at/above Proficient. Eleven states scored near the national average of 27 percent at/above Proficient.
- Nationally, 60 percent of students in grade 8 scored at/above the Basic level, with states ranging from 78 percent to 39 percent meeting Basic level of performance in science.

To give readers a better picture of what grade 8 students who score well on NAEP know and can do in science, we have included several release exercises from the 1996 assessment in Appendix B. Also in the Appendix is a graphic listing types of items students got correct at different points on the NAEP scale. The example exercises are accompanied by the scores for students on the exercise. Readers can also get an idea of the types of problems that students work with on the NAEP science exam.

Mathematics and Science Proficiency by Student Race/Ethnicity and Gender

- **Race/Ethnicity and NAEP Proficiency.**

Only nine states reduced the disparity in the NAEP Mathematics performance of minority and white students from 1992 to 1996. For the nation, the white-black difference in percent of grade 8 students at/above the Basic level declined by two percentage points over four years—in 1996, 73 percent of white students scored at/above Basic as compared to 26 percent of Blacks.

A high priority for the Council's science and mathematics indicators is reporting on trends in equity in educational opportunity, conditions, and outcomes. One approach to indicators of equity in math and science education is disaggregating state averages according to differences in students' race/ethnicity and gender.

Minority-White Disparity by State

- Nine states reduced the disparity in Mathematics performance of grade 8 students in their largest minority group as compared to white students, from 1992 to 1996. For the nation, the white-black difference in percent of grade 8 students at/above Basic declined by two percentage points for the nation over four years.

The minority-white disparity measure for analyzing race/ethnic differences in student achievement is based on the percent of students at or above the Basic level on NAEP because the state percentages for each race/ethnic group are often too small for useful comparisons. Student performance at "Basic level" does *not* mean students are meeting a minimum level of expectations for the subject (as in the "minimum competency" tests used by states in the 1970's). The definition of "Basic" set by the Governing Board is: Eighth-grade students performing at the Basic level should exhibit evidence of conceptual and procedural understanding in the five NAEP content strands. This level of performance signifies an understanding of arithmetic operations—including estimation—on whole numbers, decimals, fractions, and percents.

Figure 3 graphically shows the disparity between the percent of white students at/above the Basic level on NAEP mathematics at grade 8 and the percent for the largest minority group in each state. For example, the disparity in 1996 for Oregon is 24 percentage points—the difference between 70 percent of white Oregon students at or above the Basic level and 46 percent for Hispanic Oregon students. The disparity between white and black students in New York is 45 percentage points, a decline in the difference from 53 percentage points in 1992. Each state's disparity can be compared with the disparity for the nation of 46 points between whites (73 percent) at or above Basic and the percentage for black students (27 percent).

Table 4 provides state-by-state percentages of students scoring at/above the Basic level on grade 8 NAEP mathematics for five race/ethnic groups. The Table also shows the 1996 disparity between white students and the largest minority group in percent at/above Basic level, and the change in the minority-white disparity (in percentage points) from 1992 to 1996 (negative number indicates a decline in disparity).

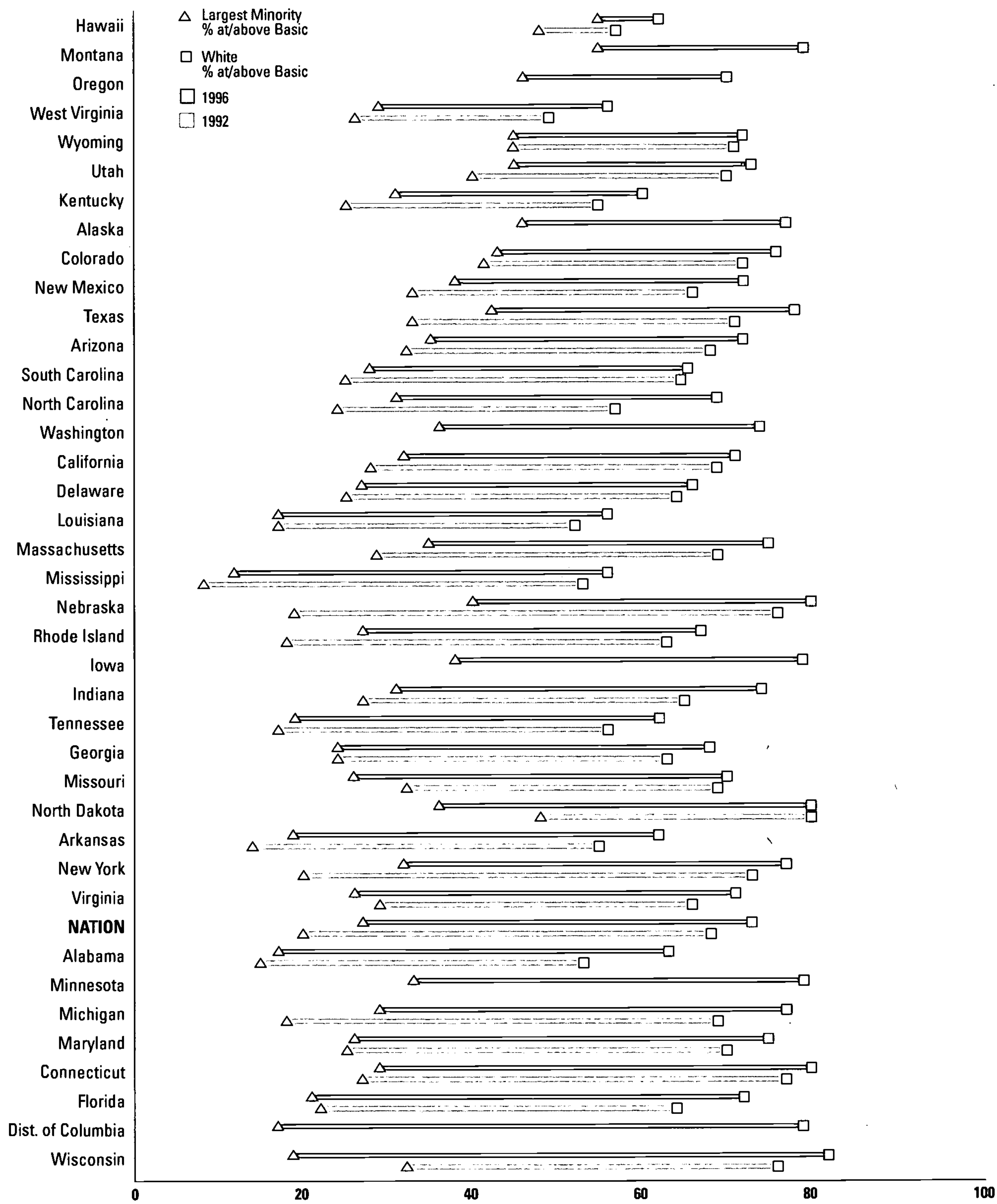
Summary on Race/Ethnic Disparity:

- All states have a significant disparity between the percent of white students at or above the Basic level and the percentage for the largest minority group (1996: low in Hawaii at 7 points, high in Wisconsin at 63 points).
- Mathematics disparity: The national difference between white and black students in percent at/above Mathematics Basic level is 46 percentage points (73% versus 27%). The disparity for white and Hispanic students is 36 points, and for white vs. American Indian students the disparity is 23 points.
- Science disparity: The difference in scores at the Basic level between white and Black students is 49 percentage points (73% white students, 23% Black students). The disparity between white students and other groups are as follows: between Hispanic and white students 37 percentage points, Asian/Pacific Island compared to white is disparity of 13 points, and the difference is also 13 points for American Indian compared to white students.
- Scores for the largest minority population in each state scoring increased in 24 states between 1992 and 1996. In most of these states the scores for white students increased at about the same rate, thus the overall disparity for the nation declined only 2 percentage points.
- The only states to close the disparity gap more than two percentage points over four years were Michigan (decreased 3%), Nebraska (decreased 17%), New York (decreased 8 %), Rhode Island (decreased 5%).

Within State vs. Between State Variation in NAEP Scores

The differences in mathematics proficiency by race/ethnicity point out an important fact about the variation in NAEP proficiency scores. Differences in student math proficiency are much greater within each state than are the differences between the states. For example, if we consider the distribution of student scores in Iowa, the difference between students at the 10th percentile versus students at the 90th percentile is 77 points on the 0 to 500 NAEP scale (244 vs. 321), whereas the difference between the average proficiency of Minnesota students and the average

FIGURE 3 **Disparity in Basic Mathematics Level Between Largest Minority Group and White Students, Grade 8, 1992 to 1996 NAEP**



EXAMPLE: In Maryland, 26% of largest minority group (black) at/above Basic level in '96 and 25% in '92; 75% of whites at/above Basic in '96 and 70% in '92.

SOURCE: NAEP 1996 Mathematics Report Card for the Nation and the States (see for standard errors of estimates).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE 4 *Race/Ethnic Differences in Basic Mathematics Level for Grade 8 Students, 1996 NAEP*

	PERCENT AT OR ABOVE BASIC LEVEL, 1996						
	White	Black	Hispanic	Asian/ Pacific Islander	American Indian	Disparity White-Minority 1996	Change in Disparity 1992 to '96
NATION	**73%**	**27% □**	**37%**	**58%**	**50%**	**46**	**-2**
STATE							
Alabama	63	17 □	23	*	*	46	+8
Alaska •	77	*	44	65	46 □	31	–
Arizona	72	34	35 □	*	40	37	+1
Arkansas •	62	17 □	*	*	*	45	+4
California	71	25	32 □	67	*	39	-2
Colorado	76	40	43 □	76	*	33	+2
Connecticut	80	29 □	37	70	*	51	+1
Delaware	66	27 □	36	*	*	39	0
Dist. of Columbia	79	17 □	16	*	*	62	–
DDESS	74	39	52	*	*	–	–
DoDDS	77	39	59	72	*	–	–
Florida	72	21 □	39	*	*	51	+9
Georgia	68	24 □	36	*	*	44	+5
Guam	*	*	16	31 □	*	*	–
Hawaii	62	*	33	55 □	*	7	-2
Indiana	74	31 □	44	*	*	43	+5
Iowa •	79	38 □	57	*	*	41	–
Kentucky	60	31 □	*	*	*	29	-1
Louisiana	56	17 □	24	*	*	39	+4
Maine	78	*	*	*	* □	*	–
Maryland •	75	26 □	36	86	*	49	+4
Massachusetts	75	35 □	26	67	*	40	0
Michigan •	77	29 □	37	*	*	48	-3
Minnesota	79	33 □	49	60	*	46	–
Mississippi	56	16 □	11	*	*	40	+1
Missouri	70	26 □	48	*	*	44	0
Montana •	79	*	52	*	55 □	24	–
Neb;raska	80	40 □	44	*	*	40	-17
New Mexico	72	*	38 □	*	37	34	+1
New York •	77	32 □	30	75	*	45	-8
North Carolina	69	31 □	41	*	*	38	+5
North Dakota	80	*	55	*	36 □	44	+12
Oregon	70	*	46 □	78	46	24	–
Rhode Island	67	31	27 □	56	*	40	-5
South Carolina •	65	28 □	26	*	*	37	-2
Tennessee	62	19 □	32	*	*	43	+4
Texas	78	31	42 □	86	*	36	2
Utah	73	*	45 □	62	*	28	2
Vermont •	74	*	*	*	*	*	–
Virginia	71	26 □	44	74	*	45	+8
Washington	74	27	36 □	66	45	38	–
West Virginia	56	29 □	30	*	*	27	+4
Wisconsin •	82	19 □	45	*	*	63	+19
Wyoming	72	*	45 □	*	35	27	+1

NOTES: • Indicates that the jurisdiction did not satisfy one or more of the guidelines for school participation rates (1996).
□ Race/ethnic minority group with largest enrollment.
* Sample size insufficient to permit reliable estimates.
For change in disparity: "-" means *decline* in disparity; "+" means *increase* in disparity.
– Data not available.

SOURCE: NAEP 1996 Mathematics Report Card for the Nation and the States (see for standard errors of estimates).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

proficiency of Mississippi students is 34 points (284 average score Minnesota, 250 average score in Mississippi). This difference in state averages does indicate that students in the highest scoring state are performing in mathematics at about 3 grades higher than lowest state (grade 8 average = 272 scale points, grade 4 average = 224, or a difference of about 12 scale points per grade).

National Trends on NAEP by Race/Ethnicity and Gender

NCES reports and analyzes two national trends for NAEP mathematics and science scores due to the change in the NAEP Assessment Frameworks and change in the methods of assessment starting in 1990.

(A) *Long-Term NAEP Trends on Mathematics and Science.* The original NAEP trend analysis, going back to its inception in 1969, is based on a core set of multiple-choice test items and the initial assessment framework that tracks the degree of change in students mathematics and science knowledge over almost 30 years. CCSSO has chosen to analyze NAEP trends from 1982 to present to track change in student performance following the education reforms and policy initiatives developed at state and national levels in response to *A Nation At Risk* the highly influential report of the National Commission on Excellence in Education (1983).

(B) *New Main NAEP Assessment in Mathematics.* In 1990, a new NAEP mathematics framework was applied in developing the assessment and open-ended questions were introduced to the assessment. In 1992, extended constructed response questions were added to the math assessment. NCES and NAGB established a new trend line in 1990 for mathematics. In the 1996 NAEP Report Card for Mathematics trends are analyzed for the new main NAEP over the six-year period.

CCSSO has decided to use both the "long-term" and "main" NAEP trend analyses, and to report the trends by student race/ethnic and gender differences. This analysis approach allows readers to consider the degree of improvement of student performance for all populations of students in our public schools.

Summary of Race/Ethnic Trends

- **Long-term Trends, 1982 to 1994.**

The figures in the following table show black and Hispanic students' proficiency at all ages rose significantly — for example black students at age 9 scores improved 17 points (195 to 212) and Hispanic students' age 9 scores improved 6 points (204 to 210). Science scores for black students at age 17 improved dramatically over 12 years, over 20 points for blacks (235 to 257), as compared to 13 points for white 17 year olds.

Trends in Average Mathematics and Science Proficiency by Race/Ethnicity, NAEP 1982 and 1994

MATHEMATICS	1982	1994	SCIENCE	1982	1994
Black			Black		
Age 9	195	212*	Age 9	187	201*
Age 13	240	252*	Age 13	217	224
Age 17	272	286*	Age 17	235	257*
Hispanic			Hispanic		
Age 9	204	210	Age 9	189	201
Age 13	252	256	Age 13	226	232
Age 17	277	291*	Age 17	249	261
White			White		
Age 9	224	237*	Age 9	229	240*
Age 13	274	281*	Age 13	257	267*
Age 17	304	312*	Age 17	293	306*

* Statistically significant difference from 1982.

NAEP trends reported on a scale of 0 to 500; trend scores are reported by age groups rather than grades.

Source: Campbell et al., 1996.

A 20-point improvement on NAEP is substantial—it can be interpreted as the equivalent of an improvement of almost two years of school (given the differences in average for 9 versus 13 year olds). Scores for white students improved also during the period, so substantial differences in performance remain on the original NAEP trends assessment. Improved scores on the NAEP trend assessment shows that U.S. public school students *are* performing better than they were in the early 1980's in mathematics and science. This finding presents solid evidence to the contrary of some public opinion and media discussion about the poor performance, or lack of improvement, in the basics in math and science in public schools.

- **Main NAEP Mathematics, 1990 to 1996.**

Black and Hispanic students made improvement on the new NAEP math assessment over six years, but only significant improvements were for grade 4 and grade 12 students (e.g., 11 points improvement for grade 12 Hispanics). White students made significant improvements in scores at all three grade levels (e.g., 12 point improvement in grade 8 whites).

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NAEP Trends by Gender

- *Long-term NAEP, 1982 to 1994.* The analysis of 1994 results and trends by student gender over 12 years in mathematics show no gender differences in average mathematics proficiency at age 9 and age 13. The average proficiency for males is slightly higher than females at the 12th grade in mathematics. There is little change in NAEP math scores by gender over the period.

The science NAEP results show that in 1994 females continue to score slightly lower than males at age levels—13, and 17, but age 9 scores are almost the same. Females have made statistically significant improvement in science performance at grade 13 since 1987. The difference in NAEP science scores for males and females at age 17 is the equivalent of about one year of high school.

- *Main NAEP, Mathematics 1990 to 1996.* On the new version of NAEP beginning in 1990, gender differences on math scores have almost disappeared. There is less difference in grade 12 scores between males and females on the new main NAEP than there is on the long-term trend NAEP (reported above).

Main NAEP Trends in Mathematics Proficiency by Race/Ethnicity, NAEP 1990 to 1996

	1990	1996
Black		
Grade 4	189	200*
Grade 8	238	243
Grade 12	268	280*
Hispanic		
Grade 4	198	206*
Grade 8	244	251
Grade 12	276	287*
White		
Grade 4	220	232*
Grade 8	270	282*
Grade 12	301	311*

* Statistically significant difference 1990 to '96.

Source: Reese, et al, 1997.

Main NAEP Trends in Mathematics Proficiency by Gender, NAEP 1990 to 1996

	1990	1996
Male		
Grade 4	214	226*
Grade 8	263	272*
Grade 12	297	305*
Female		
Grade 4	213	222*
Grade 8	262	272*
Grade 12	291	303*

* Significant difference from 1990 to 1996.

Source: Reese, et al., 1997.

Students Taking Advanced Placement Examinations

- **Advanced Placement Exams in Mathematics and Science.**

  Nationally, 5 percent of grade 12 students took AP mathematics examinations in 1998, and 6 percent took science examinations. Eight states increased participation in AP Math exams by three percentage points or more from 1992 to 1998. In science, eight states increased the percent of students taking AP Science (Biology, Chemistry or Physics) exams by three or more percentage points from 1992 to '98.

⊳ Eight states increased the percent of grade 12 students taking AP Mathematics exams (calculus) more than 2 percentage points from 1992 to 1998 (District of Columbia, New Jersey, Maryland, Massachusetts, New Hampshire, North Carolina, Indiana, and Wisconsin).

⊳ Ten states increased the percent taking AP Science exams more than 2 percentage points from 1992 to 1998 (DC, New York, New Jersey, Maryland, Massachusetts, Delaware, Hawaii, Connecticut, California, and Florida).

⊳ Nationally, 5 percent of high school grade 12 students graders took AP Mathematics exams in calculus, six percent took Science exams in 1998.

Each year the College Board offers Advanced Placement (AP) examinations in a range of academic subjects for public and private school students in each state. If students receive a composite score of 3, 4, or 5 they can receive a college credit for the subject. Many high school students enroll in courses that follow the AP curriculum. The number of high school students in a state taking AP examinations and the proportion who receive a qualifying (passing) score, provide an indicator of high-level student achievement. Caution should be used in interpreting this indicator since AP exams represent a voluntary group of students, and states and districts may differ significantly in how students are enrolled in AP courses and apply to take the exams.

Table 5 provides state-by-state data on the percentage of grade 12 students (public and private schools) in each state that took 1998 AP exams in Mathematics/calculus and in Science fields of biology, chemistry, or physics; the percentage of 1998 exam-takers who receive a qualifying score; and the percentage points increase/decrease in AP exams from 1992 to 1998 (the period reported by state by CCSSO).

- From 8 to 11 percent of grade 12 students took the 1998 Math/Calculus AP exam in Massachusetts, Maryland, New Jersey, New York, and the District of Columbia;
- Over eight percent of grade 12 students took a Science AP exam in DC, New York, New Jersey, Maryland, Massachusetts, Utah, Delaware, Hawaii, Connecticut, California, and Florida.

Nationally, the 5 percent of grade 12 students taking AP calculus in 1998 (total of 123,000 students), is an increase from 4 percent in 1992. In science, the 6 percent taking an AP exam in 1998 (total of 137,000), is an increase from 4 percent in 1992. These totals include both public and private schools. Nationally, 80 percent of AP exams in all subjects are taken by public school students. Please note that the percentage of grade 12 students is used for statistical comparison across states—AP exams are not limited to only grade 12 students.

Scores that qualified students for college credit were awarded to 68 percent of students, nationally, in Mathematics (calculus) and to 62 percent in Science (biology, chemistry, or physics). The state percentages for qualified scores in AP math varied from 48 percent of exam-takers (in Indiana, where six percent of 12th grade students took the exam) to 85 percent in North Dakota, where two percent took the exam).

AP Exams by Race/Ethnicity and Gender

An important feature of this indicator is measuring progress in minority and female participation in AP exams, as shown in Table 6. The percentage female among students taking AP Calculus varied from 37 percent in Idaho to 53 percent in Wyoming. In 1998, nationally 45 percent of AP math exam-takers were female, which is an increase of two percentage points from 1992. Nationally, 46 percent of students taking AP Science exams in 1998 were female.

The math and science totals by state are reported in Table 6 according to the percentage of exam-takers who were from race/ethnic minority groups. Nationally, 25 percent of students taking AP Calculus exams were minority students, and 26 percent taking AP science exams were minority students. These statistics show no change from 1992 for minority student participation.

TABLE 5 Students Taking Advanced Placement Examinations in Mathematics and Science, 1998, and Trends 1992 to 1998

	AP CALCULUS			AP SCIENCE*		
STATE	% of Grade 12 Students Taking Exam, 1998	% Receiving Qualified Score	Change 1992 to '98 % of Grade 12	% of Grade 12 Students Taking Exam, 1998	% Receiving Qualified Score	Change 1994 to '98 % of Grade 12
Dist. of Columbia	11%	79%	+3%	17%	78%	+4%
New York	10	65	+2	14	65	+4
Maryland	9	72	+3	9	67	+2
Massachusetts	8	75	+2	10	69	+3
New Jersey	8	73	+2	12	68	+3
Virginia	8	65	+2	8	62	+2
Utah	8	76	+2	8	64	-1
Hawaii	8	75	+2	11	62	+4
South Carolina	8	58	+2	7	56	+1
Connecticut	8	77	+3	11	72	+4
New Hampshire	8	72	+3	7	67	+3
Delaware	8	76	+2	10	68	+2
California	7	70	+2	9	62	+3
North Carolina	7	64	+3	8	55	+2
Florida	6	66	+1	8	49	+2
Illinois	6	77	+1	7	72	+1
Indiana	6	48	+2	6	39	0
Minnesota	6	65	+4	3	55	+2
Colorado	5	71	+1	6	65	+2
NATION	**5**	**68**	**+1**	**6**	**62**	**+1**
Vermont	5	63	+1	7	62	+2
Georgia	5	61	+2	6	60	0
Alaska	5	72	+2	5	59	+2
Pennsylvania	5	69	+2	5	61	+1
Michigan	5	73	+2	6	63	+2
Wisconsin	5	77	+3	4	65	+2
Maine	5	68	+2	5	61	+2
Rhode Island	4	71	0	5	66	+1
Ohio	4	70	+1	4	67	+1
Texas	4	63	+2	4	52	+2
Kentucky	4	57	+2	4	44	+1
Tennessee	4	72	+1	4	62	+1
Washington	4	74	+2	3	70	+1
Arizona	3	68	0	3	56	-1
New Mexico	3	59	0	4	56	+1
Nevada	3	74	+1	4	49	+1
South Dakota	3	63	+3	3	42	+2
Oklahoma	3	60	+1	3	51	+1
Oregon	3	76	+1	3	66	+1
Alabama	2	63	0	3	55	0
Iowa	2	76	+1	2	67	+1
West Virginia	2	64	0	2	54	0
Missouri	2	77	+1	3	70	+1
Idaho	2	73	0	3	67	+1
Mississippi	2	51	+1	2	42	+1
Arkansas	2	51	+1	2	46	+1
Wyoming	2	74	0	2	46	+1
Montana	2	72	+1	2	58	+1
Nebraska	2	71	+1	1	63	0
North Dakota	2	85	+1	2	65	+1
Louisiana	1	63	0	1	62	0
Kansas	1	77	0	1	62	0

EXAMPLE: 8% of the grade 12 students in New Jersey took the AP Calculus exam in 1998 and 73% of those students received a 3, 4, or 5 score; in 1992, 6% of grade 12 students took the exam.

NOTE: State totals include public and private schools.
* AP Science = students taking AP Biology, Chemistry, or Physics.

SOURCE: The College Board (1998). Advanced Placement Program, National and 50 States Summary Reports.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE 6 Minority and Female Students Taking Advanced Placement Examinations in Mathematics and Science, 1998; Change 1992 to 1998 in Minority Participation

	AP CALCULUS			AP SCIENCE		
STATE	% Minority of Students Taking AP Calculus, '98	Change '92 to '98 % Minority	% Female of Students Taking Exam, '98	% Minority of Students Taking AP Science, '98	Change '94 to '98 % Minority	% Female of Students Taking Exam, '98
Hawaii	78%	+2%	51%	71%	-6%	47%
California	51	-2	46	48	-1	45
Texas	37	+6	46	37	+17	46
New Jersey	30	+3	44	28	-1	44
Florida	29	0	46	31	+3	46
New Mexico	27	+2	46	28	-2	45
New York	27	0	49	26	-7	49
Maryland	25	0	47	29	-2	47
NATION	**25**	**-1**	**45**	**26**	**0**	**46**
Dist. of Columbia	25	-4	45	26	-9	41
Illinois	24	-3	46	28	-1	43
Georgia	24	+4	49	26	0	49
Oklahoma	23	+5	43	24	+2	44
Nevada	21	-3	43	19	-2	43
Washington	21	+1	42	19	+1	44
Virginia	21	+1	47	23	-1	49
Louisiana	19	-5	49	24	+1	43
Massachusetts	18	0	43	19	+3	43
South Carolina	18	-1	50	16	0	54
Arizona	18	-4	44	19	-3	46
Alabama	17	-2	46	18	-7	50
Mississippi	17	+4	44	16	-2	48
Delaware	17	-1	44	15	-4	45
Arkansas	17	+2	47	12	-1	49
Connecticut	16	0	45	16	-3	46
Alaska	16	0	41	15	+7	44
Tennessee	16	-2	44	20	0	50
Oregon	15	+2	40	16	0	43
Michigan	14	-2	44	16	-4	45
New Hampshire	14	0	38	14	+1	36
North Carolina	14	0	48	16	-3	51
Kansas	13	-2	42	18	-7	41
Missouri	13	-3	41	13	0	43
Pennsylvania	12	-3	44	13	-1	46
Colorado	12	-10	44	15	-1	45
Rhode Island	12	-6	40	11	0	39
Ohio	12	-3	44	14	-3	46
West Virginia	10	-1	39	10	+1	42
Indiana	9	-2	43	11	-1	46
Minnesota	9	0	44	8	-3	43
Kentucky	8	+2	47	8	+2	49
Wyoming	7	+3	53	3	0	59
Wisconsin	7	0	43	9	-1	44
North Dakota	7	-2	47	7	0	49
Idaho	7	+2	37	7	+1	36
Iowa	6	-1	42	8	-2	42
Nebraska	6	-1	46	5	-3	47
Utah	5	-1	38	7	+2	40
Vermont	5	-2	41	6	-3	56
South Dakota	5	+2	51	5	-2	52
Maine	4	-1	38	3	+1	48
Montana	3	-4	43	2	-1	51

NOTE: State totals include public and private schools. Minority students = sum of black, Hispanic, Asian/Pacific Islander, American Indian, etc. % AP Science = Students taking AP Biology, Chemistry, or Physics.

SOURCE: The College Board (1998). Advanced Placement Program, National and 50 States Summary Reports.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

- States with more than 30 percent minority participation in AP Calculus were: Hawaii, California, Texas, New Jersey, and Florida. Texas, New Mexico, and Oklahoma increased the percent minority in AP math by four percentage points. In 13 states, the percent minority taking the AP math declined by more than two percentage points.
- States with over 30 percent minority participation in AP Science were: Hawaii, California, Maryland, Texas, New Jersey, Florida, and Illinois. Texas, Florida, Connecticut, and Alaska had the largest increases in minority participation.

Race/ethnic data for each of the four minority groups by state are available from CCSSO on diskette or hard copy.

Chapter Two

Indicators of Mathematics and Science Content and Instruction

Course Enrollments in High School Mathematics and Science

State Policies and Course Enrollment Trends

Middle Grades Mathematics and Science Course Enrollments

Course Enrollments by Race/Ethnicity and Gender

Instructional Practices in Mathematics and Science

State policy makers and science and math educators need to know about curriculum content and instructional practices in schools. A system of education indicators typically focuses first on student achievement as the primary measure of the outcome of schooling. Then, educators, policy makers, and the public would like to be able to understand differences in student achievement in terms of how and what students are taught. These kinds of indicators could help to inform efforts to develop teachers' knowledge and skills, and to improve the design and delivery of mathematics and science curriculum.

Four types of state indicators are likely to be most useful to our target audiences. In the following paragraphs we describe these types of indicators and then present state indicators being reported for 1997-98.

1. Curriculum Content in Mathematics and Science Taught in Classrooms.

In the 1990s almost all states have developed new content standards for core academic subjects, including science and mathematics (CCSSO, *Key State Education Policies for K-12 Education*, 1998). As these standards are being applied in developing curriculum, professional development strategies, and new approaches to student assessment, educators and policy makers are likely to need consistent, reliable information on subject content of what is taught in math and science and what students are expected to know and be able to do. National surveys involving a sample of teachers, such as NAEP and Schools and Staffing Survey (conducted every four years by NCES) included some question for teachers about what curriculum is taught and practices that are used.

Several recent studies examined the feasibility and validity of various methods of measuring "opportunity to learn" (Porter, 1995; McDonnell, 1995). The most comprehensive and detailed data on the "implemented curriculum" have been collected and analyzed in international studies. The Third International Mathematics and Science Study (TIMSS) measured student achievement in 41 countries based on mathematics and science assessment frameworks developed by consensus of the participating countries (NCES, 1996a, 1997a, 1998). The study included surveys with teachers and students that had a goal of collecting reliable, comparable data on the "implemented curriculum" in math and science classrooms across the participating countries. Teachers were asked to complete a survey with questions on teacher preparation, teaching practices, and amount of time spent on curriculum topics. The data show variation by country in the content of the actual curriculum that is taught, as well as the degree of variation in curriculum within a country. For example, the results show the proportion of class time in grade 8 mathematics that teachers report classes spend on topics such as algebra, geometry, number sense, operations, and measurement. Grade 8 mathematics can be analyzed by 30 mathematics content topics or categories using the TIMSS data.

A similar approach to measuring curriculum in mathematics and science classrooms is being developed and tested with a collaborative of states that are analyzing state initiatives and curriculum reforms using a set of "Surveys of Enacted Curriculum" (see www.ccsso.org/Project Summary, 1999; also, see prior reports, CCSSO, 1998; Martin, Blank, & Smithson, 1996). The CCSSO surveys are available to states and districts to collect, analyze, and report data on enacted curriculum and instructional practices at elementary, middle, and high school levels.

2. Secondary Student Course Enrollments in Mathematics and Science.

CCSSO aggregates data from state information systems on student course enrollments for grades 7-12. These data provide an important indicator for several reasons. Research on patterns of student achievement in math and science has consistently shown that the amount of time in instruction and number and level of secondary courses students take is strongly related to achievement (Husen, 1967; Jones, L.R., Mullis, Raizen, Weiss, & Weston, 1992; Jones, L.V., Davenport, Bryson, Bekhuis, & Zwick, 1986; Rock, Braun, & Rosenbaum, 1985; Sebring, 1987; Walberg, 1984). Analyses of recent NAEP results show that high mathematics proficiency has a high correlation with level of mathematics courses students have completed (Mullis et al., 1993, Reese, et al., 1997; Shaughnessy, et al., 1998; Wilson & Blank, 1999). We also know that instructional time and course taking in math and science vary widely across U.S. schools, and that they are correlated with the socioeconomic status of students in our schools (Goodlad, 1984; Horn & Hafner, 1992; McKnight et. al., 1987; Oakes, 1990; Lee, Bryk, & Smith, 1993; Weiss, 1994).

States have an interest in determining the proportion of students that progress through the secondary science and mathematics curriculums to different course levels—for example, algebra 2, trigonometry, precalculus or chemistry, physics, advanced courses or AP math and science—because they indicate the proportion of students being offered more challenging content that meets high state content standards. Course taking patterns can be analyzed by state policies on high school graduation requirements, which have shown significant increases since the mid-1980s. The course enrollments by state also are useful for tracking how states and schools are progressing in offering opportunities for science and math to students from all race/ethnic groups and for female and male students.

3. Instructional Practices in Mathematics and Science Classrooms.

States have found the data from NAEP teacher and student questionnaires that accompany the mathematics and science assessments to be very useful in providing state-by-state information on instructional practices in their states. For example, data on use of math manipulative or calculators in math classes can be analyzed by characteristics of schools and teachers. For many state users, NAEP achievement results become most valuable when analyzed with information on instruction, resources, and teachers. NAEP data can be used to simply describe current instructional practices in a state or for varying characteristics of classrooms and teachers, based on a standard set of items and consistent procedures, and NAEP data can be analyzed to determine the relationship of instructional practices to achievement.

4. Class Time on Mathematics and Science.

A very basic indicator of curriculum and instruction is the amount of time that teachers spend in teaching a subject. At the elementary level, there is wide variation by school, district, and state on how time is used in teaching various subjects. Sample surveys with teachers, such as Schools and Staffing Survey conducted by NCES, can provide basic data on differences in time devoted to mathematics and science and to other subjects.

Course Enrollments in High School Mathematics and Science

Students Taking Higher-Level Mathematics Courses

POLICY ISSUES

What proportion of students take challenging subject content in mathematics and science, indicated by course enrollments in high school curriculum?

What are trends in mathematics and science course taking for students, reported by gender and race/ethnicity?

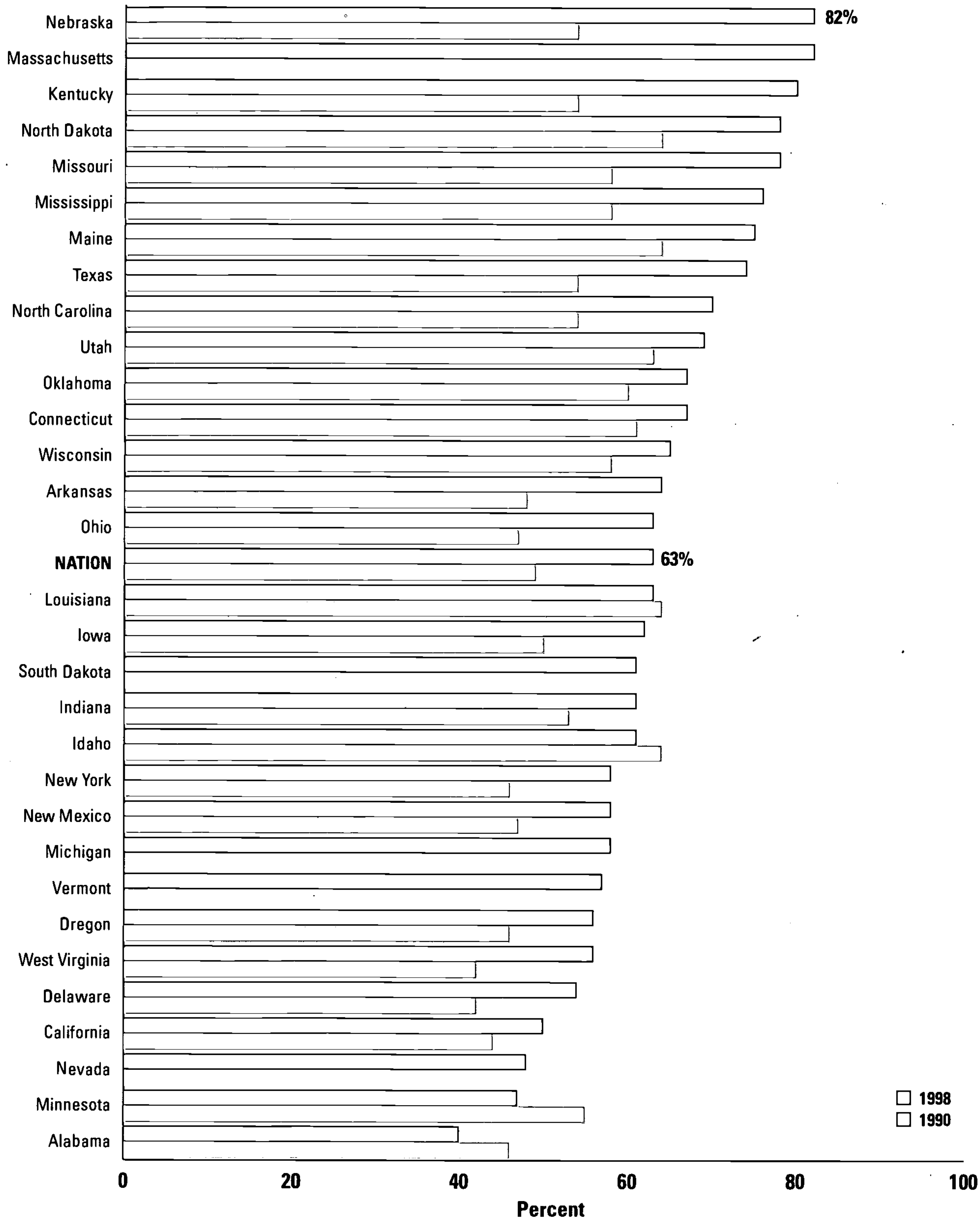
- Seven states had over three-fourths of high school students take three years of high school mathematics (indicated by enrollment in algebra 2 or integrated math 3) in 1998: Nebraska, Massachusetts, Kentucky, North Dakota, Missouri, Mississippi, and Maine.
- Nationally, 63 percent of students took three years of high school mathematics in 1998, as compared to 49 percent in 1990, an increase of 14 percentage points in eight years. Since 1990, the proportion of high school graduates taking four years of high school mathematics increased from 28 percent to 39 percent of graduates.

Many states have set three years of high school mathematics as a requirement for graduation, following the recommendations from *A Nation at Risk* (National Commission on Excellence in Education, 1983). Figure 4 reports the percentage of high school students in each state that take three high school mathematics courses by graduation, as of the 1997-98 school year and the change in enrollments from 1990 to 1998. The states are ordered by the percentage of students taking *algebra 2 or integrated math 3* by graduation (generally, the third year of mathematics in the high school curriculum). The percentage of students reaching three years of high school mathematics varies from 82 percent (Nebraska and Massachusetts) to less than 50 percent (Nevada, Minnesota, and Alabama).

Figure 4 also shows the change from 1990 to 1998 by state in the percent of students taking *algebra 2 or integrated math 3* in high school. The national average is an increase of 14 percentage points over eight years. Eleven states increased enrollments in algebra 2/integrated math 3 by 15 percentage points or more: Nebraska, Kentucky, Missouri, Mississippi, Texas, North Carolina, Wisconsin, Arkansas, Ohio, Indiana, and Nevada. Trends are shown for only those states reporting data for 1990 and 1998. States were excluded that changed their course codes or definitions.

Table 7 reports the percent of high school students taking each of five levels of mathematics by graduation for 1998 along with the change in percent of students taking these courses over eight years. The states are ranked by the percent taking algebra 2 or integrated math 3 (level 3). Nationally, 95 percent of high school students take *first-year algebra or integrated mathematics 1* by the time they graduate, and most states have enrollments over 95 percent. The state percentages for algebra 1/integrated mathematics 1 include enrollments during high school, as well as in grade 8.

FIGURE 4 ***Percent of High School Students Taking Algebra 2/ Math Level 3 by Graduation, 1990 to 1998***



SOURCE: State Departments of Education, Data on Public Schools, 1997–98.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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TABLE 7 **Students Taking Higher-Level Mathematics Courses by Graduation, 1998; Change 1990 to 1998**

	Algebra 2/ Integrated Math 3 (Level 3)		Algebra 1/ Integrated Math 1 (Level 1)		Geometry/ Integrated Math 2 (Level 2)		Trigonometry/ Precalculus (Level 4)		Calculus/ AP Calculus (Level 5)	
STATE	**% 1998**	**Change 1990 to '98**	**% 1998**	**Change 1990 to '98**	**% 1998**	**Change 1990 to '98**	**% 1998**	**Change 1990 to '98**	**% 1998**	**Change 1990 to '98**
Nebraska	82%	+28%	82%	+7%	91%	+24%*	60%	+38%*	15%	+9%
Massachusetts	82	–	95+	–	87	–*	55	–*	22	–
Kentucky	80	+26	95+	+14	75	+8*	45	+15*	11	+5
North Dakota	78	+14	95+	0	78	-3*	43	-6*	5	+2
Missouri	78	+20	95+	0	72	+8*	36	+20*	18	+10
Mississippi	76	+18	95+	+10	86	+22*	41	+12*	6	+3
Maine	75	+11	95+	+11	86	-2*	–	–*	–	–
Texas	74	+20	95+	+13	77	+12*	41	+15*	10	+5
North Carolina	70	+19	95+	+28	95+	+28*	75	+35*	13	+5
Utah	69	+6	95+	+13	77	+6*	39	+5*	14	+1
Oklahoma	67	+7	95+	0	70	+17*	32	+9*	11	+3
Connecticut	67	+6	95+	+21	77	+14*	43	+5*	21	+7
Wisconsin	65	+29	95+	+16	87	+6*	50	+16*	26	+17
Arkansas	64	+16	84	-4	85	+25*	29	+2*	8	+3
Louisiana	63	-1	95+	0	82	–*	30	–*	8	+4
NATION	**63**	**+14**	**95+**	**+14**	**72**	**+11***	**39**	**+10***	**12**	**+3**
Ohio	63	+16	95+	+15	74	+12*	48	+13*	10	+2
Iowa	62	+12	85	-7	65	-11*	45	+13*	9	0
South Dakota	61	–	78	–	73	–*	35	–*	15	–
Indiana	61	+16	85	+25	66	+8*	43	+13*	15	+7
Idaho	61	-3	95+	0	66	+3*	28	+4*	14	+8
Michigan	58	–	95+	–	70	–*	43	–*	13	–
New Mexico	58	+11	95+	0	53	-3*	22	-1*	8	0
New York	58	+12	95+	+26	74	+18*	34	+6*	15	+3
Vermont	57	+4*	95+	+25*	63	+6*	38	+8*	14	+3*
West Virginia	56	+14	95+	+22	57	+2*	50	+23*	9	+7
Oregon	56	+10*	94	+14*	68	+17*	29	+6*	10	0*
Delaware	54	+11	83	+10	55	+18*	45	+17*	12	-5
California	50	+6	95+	+3	61	+14*	28	+7*	11	+2
Nevada	48	+16	84	-6	53	+2*	22	+3*	6	+1
Minnesota	47	-8	73	-17	54	-17*	38	+4*	16	+4
Alabama	40	-6	78	+8	48	-8*	18	-1*	9	+3

EXAMPLE: 69% of Utah students took Algebra 2 or Integrated Math 3 (3rd year of high school math) prior to graduation, based on data from 1997-98 school year. This represents an increase of 6 percentage points since the 1998–90 school year.

NOTES: – Data not available.

Each state percent is a statisical estimate of course-taking of public high school students by the time they graduate based on the total course enrollment in grades 9–12 in fall 1996 divided by the estimated number of students in a grade cohort during four years of high school.

The statistical estimating method is imprecise above 95%.

Nation = Percent of all public high school students estimated to take each course, including imputation for nonreporting states (see Appendix C for explanation).

Algebra 1 percentages include grade 8 Algebra 1, except Iowa and Texas.

* Change 1992 to 1998.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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The percentage of students taking *geometry or integrated math 2* varies by state from 95 percent (North Carolina) to less than 48 percent (Alabama), with the national average at 72 percent. Two years of high school mathematics has been shown to be an important door to success in college, particularly for minority students. Analysis of college attendance and completion rates show that taking two years of high school mathematics is a strong predictor of whether minority students complete a college degree (Pelavin & Kane, 1990). From 1992 to 1998, the percent of students taking geometry increased from 61 to 72 percent.

Many states and districts established a goal of increasing the proportion of students that take algebra 1, or integrated mathematics 1, as well as more advanced high school mathematics courses, to meet their graduation requirements. One approach states have used in working toward this goal is developing state curriculum frameworks for districts and schools to use in planning and organizing the mathematics curriculum. States also set specific policies. As of 1998, Georgia, Louisiana, Mississippi, North Carolina, and Texas require that students pass algebra 1. Arkansas requires algebra 1 or applied math 1 and DoDEA requires algebra and geometry. See Appendix A for graduation requirements by subject in each state.

Integrated Mathematics

Integrated mathematics and science curricula at the high school level have been developed in several states. Some districts and states have begun to use the integrated mathematics curriculum texts and materials that are modeled after the NCTM mathematics curriculum standards (1989), and the development was supported by NSF. Integrated courses help teachers organize curriculum and instructional strategies that bring together key concepts often taught in separate high school courses, such as algebra, geometry, and functions.

Table 8 highlights the proportion of students taking integrated math 1, which is often taken in place of first-year algebra, in the 21 states that collected detailed data on this course. In 1997-98 school year, over 15 percent of grade 9 students took integrated math 1 in California, Massachusetts, New York, and Oregon. Integrated math as the initial high school course is predominant in the state of New York (85%).

Mathematics Enrollments by Grade

- Enrollments in higher level mathematics differ by state: From 10 to 25 percent of grade 10 students take algebra 2 or integrated math 3, and from 25 to 45 percent of grade 11 students take this third year of high school mathematics.

Many educators and policy makers are interested in tracking the specific grade at which high school students take certain math and science courses. Enrollments in two levels of high school math courses are reported by grade in Table 9—algebra 1 or integrated math 1, and, algebra 2 or integrated math 3. Fifteen states were able to report their enrollment data by the grade at which students took the course in 1997-98. The data show divergent patterns in *algebra 1/integrated math 1.* For example, New York, North Carolina, North Dakota, Texas, and Wisconsin enroll over 60 percent of students in this course level in 9th grade. Other states tend to have a distribution of students taking algebra 1/integrated math 1 across grades 9, 10, and 11, such as Missouri, Utah, Vermont, and West Virginia.

TABLE 8

Integrated Mathematics Course Enrollments as a Percentage of Grade 9 Students, 1998

STATE	Integrated Math 1 % of grade 9
California	29
Connecticut	13
Idaho	1
Indiana	1
Iowa	14
Kentucky	6
Louisiana	10
Massachusetts	19
Minnesota	4
Nevada	2
New Mexico	9
New York	85
Ohio	9
Oregon	23
South Dakota	3
Texas	0.2
Utah	0.3
Vermont	11
West Virginia	1

NOTES: – Data not available. New York students enrolled in grades 9, 10, or 11.

SOURCE: State Departments of Education, Data on Public Schools, 1997-98; NCES, CCD Fall Membership 1996.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

The largest enrollments in *algebra 2/integrated math 3* (indicator of three years of high school math) are in grade 11, varying from 25 to 45 percent of students. Also, the results show that from 10 to 25 percent of students take the third year of high school mathematics in grade 10, and most states have from 10 to 15 percent taking their third year of math in grade 12.

TABLE 9 Students Taking Algebra 1/Integrated Math 1 and Algebra 2/Integrated Math 3 as a Percent of Students in Each High School Grade, 1998

ALGEBRA 1 OR INTEGRATED MATH 1

STATE	% Grade 9	% Grade 10	% Grade 11	% Grade 12
Alabama	40%	19%	5%	1%
California	54	28	5	2
Connecticut	46	21	9	3
DoDEA	43	22	9	3
Indiana	59	12	2	1
Missouri	34	17	18	20
New York	73	15	2	1
North Carolina	66	45	16	5
North Dakota	63	16	4	1
South Dakota	45	9	3	1
Texas	73	30	10	3
Utah	37	20	7	2
Vermont	46	24	6	2
West Virginia	50	22	11	5
Wisconsin	68	23	7	2

ALGEBRA 2 OR INTEGRATED MATH 3

STATE	% Grade 9	% Grade 10	% Grade 11	% Grade 12
Alabama	1%	10%	23%	7%
California	3	11	29	6
Connecticut	3	17	34	14
DoDEA	1	23	34	14
Indiana	2	21	34	2
Missouri	16	19	21	20
New York	0.2	10	45	5
North Carolina	1	23	30	16
North Dakota	2	23	43	10
South Dakota	1	15	34	5
Texas	2	20	36	15
Utah	6	28	25	10
Vermont	3	18	26	10
West Virginia	3	21	21	10
Wisconsin	4	20	30	10

SOURCE: State Departments of Education, Data on Public Schools, 1997-98; NCES, CCD Fall Membership 1996.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Students Taking Higher-Level Science Courses

- Ten states had over 60 percent of students taking three years of high school science (indicated by chemistry enrollments) as of 1998, and 11 states raised the enrollment in science at this level by more than 15 percentage points from 1990 to 1998.
- Nationally, 54 percent of students took 3 years of high school science as of 1998, as compared to 45 percent in 1990, an increase of 9 percentage points in eight years. In nine states, more than 30 percent of students took four years of science, as indicated by physics enrollments. The national average for physics was 24 percent.

Figure 5 reports the percentage of high school students in each state that take three years of high school sciences courses by graduation, based on data from the 1997-98 school year. States are ordered by the percentage of students taking *chemistry 1* (generally, the third year of science in the high school curriculum). The percentage of students reaching this level of science varies from over 71 percent (e.g., Massachusetts, Maine) to 34 percent (e.g., Alabama). Six states have over 65 percent of students taking three years of science: New York, Nebraska, Kentucky, Wisconsin, Massachusetts, and Maine.

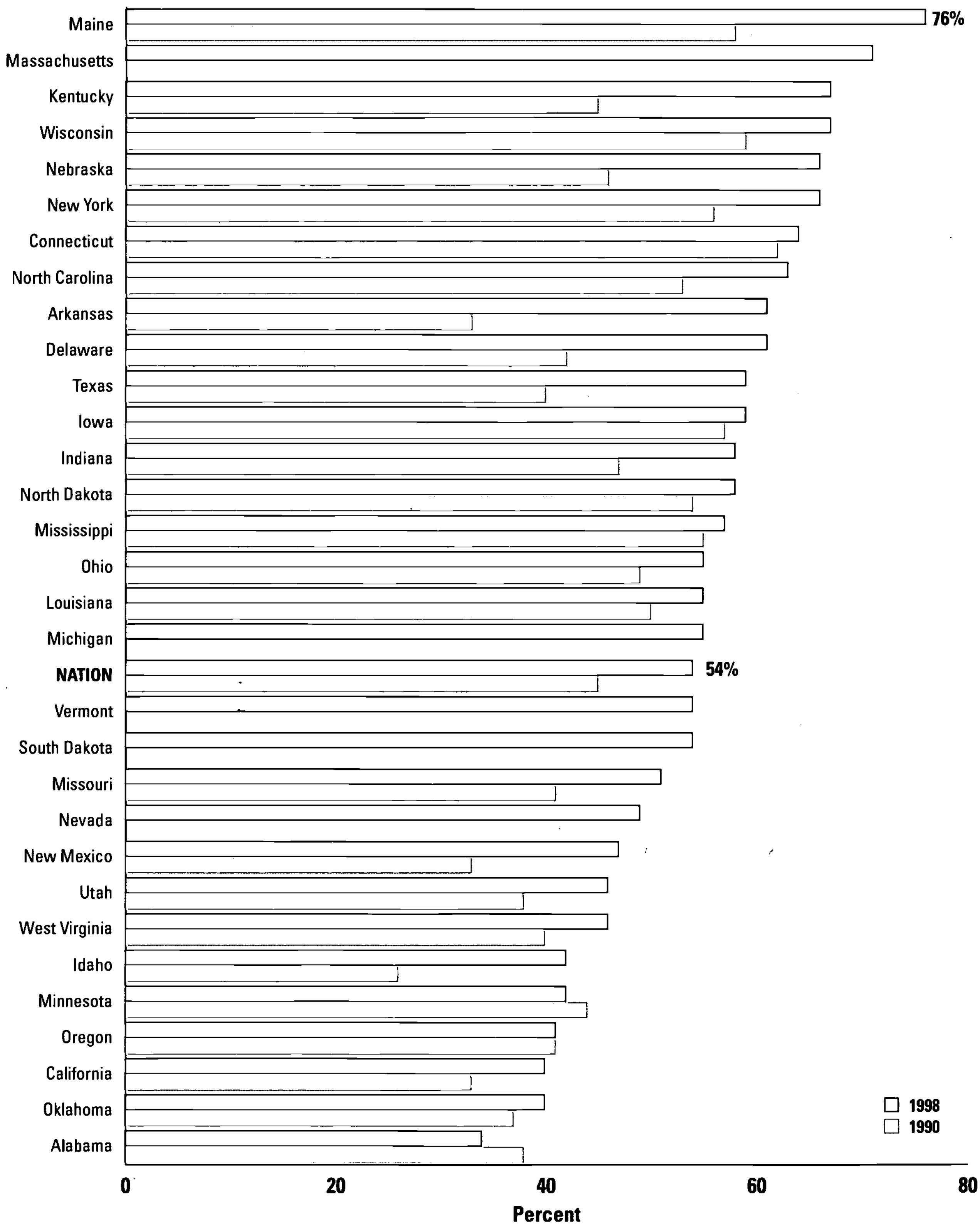
Figure 5 also shows the change by state from 1990 to 1998 in students attaining three years of high school science. Twelve states increased enrollments in chemistry more than 12 percentage points over eight years: Maine, Wisconsin, Kentucky, Nebraska, North Carolina, Delaware, Arkansas, Texas, Indiana, Nevada, New Mexico, and Idaho.

Table 10 shows the percent of high school students in each state that take courses in several levels of science by graduation: chemistry, physics, and biology. These percentages are based on data from the 1997-1998 school year. The table also includes a column showing the change in percent of students taking these courses over eight years. The states are ordered by the percent of students that take *chemistry* by graduation. It is possible for students to take three years of science without taking chemistry (e.g., two years of biology and one year of earth science); but as an indicator across states, course enrollment in chemistry is the indicator that is most consistent.

All states have a very high proportion of students taking first-year *biology* by graduation, and nationally 92 percent of high school students take biology. In many states, the increase to two or three graduation requirements for science in the 1980s means that the typical student now takes an introductory science course, e.g., earth, physical, general, or integrated science, and a course in biology. In a few states, such as Mississippi, biology is the first science course in high school.

Physics enrollments vary by state from 55 percent in Maine, 40 percent in Massachusetts, and 38 percent in Connecticut and Vermont to under 11 percent in Oklahoma and Alabama. The national average is 24 percent of students taking physics by graduation, and this is an increase of four points from 20 percent in 1990. This percentage is an estimate of the proportion of students taking four years of high school science.

FIGURE 5 **Percent of High School Students Taking Chemistry by Graduation, 1990 to 1998**



SOURCE: State Departments of Education, Data on Public Schools, 1997–98.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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TABLE 10 Students Taking Higher-Level Science Courses by Graduation, 1998; Change 1990 to 1998

	CHEMISTRY		PHYSICS		BIOLOGY	
STATE	% 1998	Change 1990 to '98	% 1998	Change 1990 to '98	% 1998	Change 1990 to '98
Maine	76%	+18%	55%	+5%*	95+%	+1%
Massachusetts	71	–	40	–	90	–
Wisconsin	67	+16	34	+9	95+	0
Kentucky	67	+22	22	+8	95+	0
Nebraska	66	+20	34	+13	95+	0
New York	66	+10	34	+6	95+	0
Connecticut	64	+2	38	+2	95+	0
North Carolina	63	+16	20	+5	95+	0
Delaware	61	+13	20	+1	88	-7
Arkansas	61	+28	32	+19	92	-3
Texas	59	+19	21	+9	95+	0
Iowa	59	+2	29	+2	88	-7
North Dakota	58	+4	25	+1	95+	0
Indiana	58	+16	25	+6	95+	0
Mississippi	57	+2	17	0	95+	0
Michigan	55	–	28	–	73	–
Louisiana	55	+5	25	+4	94	+4
Ohio	55	+6	23	+3	92	-3
NATION	**54**	**+9**	**24**	**+4**	**92**	**-3**
South Dakota	54	–	22	–	86	–
Vermont	54	+2*	38	+7*	88	+6*
Missouri	51	+10	17	+1	95+	+9
Nevada	49	+16	23	+10	95+	+30
New Mexico	47	+14	14	-1	95+	0
West Virginia	46	+6	14	+3	13	-82
Utah	46	+9	33	+13	95+	+15
Minnesota	42	-2	20	-3	65	-30
Idaho	42	+16	14	-1	95+	+15
Oregon	41	0*	21	0*	82	-2*
California	40	+7	20	+4	76	-15
Oklahoma	40	+3	11	+1	92	-1
Alabama	34	-4	11	-10	82	-13

EXAMPLE: 67% of Kentucky students took Chemistry (i.e., three years of high school science) prior to graduation, based on data from 1997–98 school year. This represents an increase of 22 percentage points since the 1998–90 school year.

NOTES: – Data not available.
See Appendix C for computation of percentages.
* = Change 1992 to 1998.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Initial Science Courses in High School

Table 11 shows enrollments of high school science courses in earth science, physical science, general science, and integrated science for 1998 along with the change in percent of students taking these courses since 1996. Not all students take these courses in grade 9, but this is a common pattern, and using grade 9 enrollment as the denominator improves state comparisons. These data are useful to educators interested in tracking the patterns and trends in science course-taking across states. There are marked differences in course enrollments by state.

- *Integrated Science*: In 1997-98, over 15 percent of grade 9 students in California, DoDEA, Kentucky, Massachusetts, Michigan, Oregon, Utah, and West Virginia were taking an integrated or coordinated science course. In West Virginia almost all students take integrated science in grade 9, and most students also take integrated science in grade 10 (thus, WV biology, in Table 10, is only 13% of students).
- *Earth Science:* The states of Arkansas and New York have over 60 percent of grade 9 students taking earth science.
- *Physical Science:* Arkansas, Louisiana, Missouri, North Carolina, North Dakota, Oklahoma, and South Dakota have over 60 percent taking this initial course, and Arkansas has many students taking both earth science and physical science for science credits.
- *General Science:* The predominant initial high school science course in Virgin Islands, Ohio, and Nevada is general science. About half the states have over 15 percent of students taking this course in high school.

Several states now have a substantial percentage of students taking an integrated or coordinated science curriculum, often starting in grade 7 and continuing through grade 9 or 10.

A *coordinated* science curriculum treats the disciplines of biology, chemistry, physics and earth/space science individually and equitably and focuses on an overarching idea in the sciences that can be explained in terms of all four disciplines. An *integrated* science curriculum intentionally blurs the traditional disciplinary lines and treats science as a whole, under the assumption that the disciplines should not be separated in the secondary curriculum (California Scope, Sequence & Coordination Project, 1995). CCSSO has available on the CCSSO website additional, more detailed data on science and mathematics course enrollments by state, including enrollments in "general" versus "applied" biology, chemistry, and physics; data on review and informal high school mathematics courses and computer science courses; as well as enrollments by state in advanced/second year courses and advanced placement (AP) courses. See Appendix D for a complete list of the course categories collected by state.

TABLE 11 Students Taking Earth Science, Physical Science, General Science, and Integrated Science as a Percent of Grade 9 Students, 1996 to 1998

PERCENT OF GRADE 9 STUDENTS

	Earth Science:		Physical Science		General Science		Integrated or Coordinated Science	
STATE	% 1998	Change 1996 to '98	% 1998	Change 1996 to '98	% 1998	Change 1996 to '98	1998	Change 1996 to '98
Alabama	3%	+1%	50%	-17%	5%	0%	– %	– %
Arkansas	78	-5	75	-5	53	+53	–	–
California	9	0	27	-4	7	-3	32	+14
Connecticut	36	-4	25	0	26	+2	7	+3
Delaware	15	-11	57	-2	–	–	2	0
DoDEA	3	+1	–	–	–	–	84	0
Idaho	57	-6	38	+2	6	+1	–	–
Indiana	33	+5	19	-3	7	-3	3	0
Iowa	35	+9	55	+10	–	–	13	–
Kentucky	5	+2	42	-3	–	–	38	+3
Louisiana	11	-1	74	+8	8	-8	–	–
Maine	58	+1	–	–	–	–	–	–
Massachusetts	30	+2	31	0	9	-3	21	+14
Michigan	26	–	30	–	17	–	28	–
Minnesota	7	-3	1	-39	–	–	4	+1
Mississippi	2	0	35	+1	0.1	-0.9	–	–
Missouri	15	0	63	-1	11	-4	–	–
Nebraska	34	-9	52	0	24	+1	–	–
Nevada	13	–	9	–	27	–	0.2	–
New Mexico	7	0	36	-5	18	-2	–	–
New York	67	0	6	-2	7	-2	3	-2
North Carolina	37	-2	75	-2	–	–	–	–
North Dakota	3	0	101	-5	–	–	–	–
Ohio	18	-3	23	-3	43	+2	–	–
Oklahoma	4	0	65	-4	5	-1	–	–
Oregon	12	-1	36	+1	9	0	26	+5
South Dakota	17	-1	67	+6	8	+5	–	–
Texas	9	+1	59	-3	–	–	6	+4
Utah	30	-4	10	-10	–	–	42	+9
Vermont	48	–	14	–	8	–	11	–
Virgin Islands	0	–	–	–	82	–	2	–
West Virginia	3	+1	3	-11	1	-2	93	+12
Wisconsin	24	-2	47	-11	15	-6	–	–

NOTES: – Data not available.
Some students take these courses beyond grade 9; West Virginia students take Integrated Science in grade 9, 10, or 11.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98; NCES, CCD Fall Membership 1996.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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Science Enrollments by Grade

As with selected mathematics courses, CCSSO aggregated data from states on science course enrollments by specific grade at which high school students take a course. Enrollments in first-year biology are reported by grade in Table 12. Sixteen states were able to report their enrollment data by the grade at which students took the course in 1997-98. The data show divergent patterns in *first-year biology* course taking patterns. For example, Indiana enrolls two-thirds of students in biology in grade 9, and New York, Utah, and Wisconsin have about one-third of students taking biology in grade 9. DoDEA, Idaho, North Dakota, South Dakota, and Wisconsin have most students taking biology in grade 10, while Missouri schools enroll many students in biology across all four grades.

TABLE 12 **Students Taking First-Year Biology as a Percent of Students in Each High School Grade, 1998**

	BIOLOGY, 1ST YEAR			
STATE	**% Grade 9**	**% Grade 10**	**% Grade 11**	**% Grade 12**
Alabama	26%	45%	7%	2%
California	17	48	7	3
Connecticut	19	66	9	7
DoDEA	14	75	8	2
Idaho	4	86	9	7
Indiana	66	22	3	3
Missouri	24	30	18	20
New York	39	66	3	2
North Carolina	23	69	7	2
North Dakota	4	85	9	4
South Dakota	4	69	3	1
Texas	43	43	8	3
Utah	36	57	16	9
Vermont	18	63	5	3
West Virginia	0.2	5	6	3
Wisconsin	30	71	11	7

NOTE: — Data not available.

SOURCE: State Departments of Education, Data on Public Schools, 1997-98; NCES, CCD Fall Membership 1996.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

POLICY ISSUES

Have enrollments in higher-level courses increased since many states raised graduation requirements?

Do states with policies setting higher course requirements for graduation have higher rates of course taking in science and mathematics?

State Policies and Course Enrollment Trends

Current efforts toward science and math reform are aimed at high standards for the content of what students know and can do. State policies aimed at raising requirements for time of instruction or number of courses have recently been viewed as insufficient to provide strong incentives for improving instruction or for determining the effectiveness of curriculum.

Even though content and performance standards are currently the favored approach to education reform, it is still important to monitor and report on the effects of major policy initiatives, such as raising course requirements, because such initiatives continue to be used widely as a strategy for encouraging higher-level content for more students.

In the 1980s, over 40 states raised the number of credits in science and mathematics required for graduation (Blank & Espenshade, 1988; Blank & Dalkilic, 1992). A survey of states in 1998 showed the following state totals for required credits in mathematics and science (CCSSO/State Education Assessment Center, 1998):

- 22 states require three credits of mathematics and one requires four credits;
- 16 states require three credits of science and one requires four credits;
- 25 states require two mathematics credits, and 28 states require two science credits; and
- Five states leave graduation requirements to local districts.

Graduation requirements have gone up in almost all states. As of 1998, 45 states require at least two years of math and science. In 1980, only nine states had this requirement. There has been recent change as well—in 1992, 13 states required 2.5 or more credits of math, as compared to 24 in 1998; and in 1992 six states required 2.5 credits in science, as compared to 16 in 1998.

National trends on course taking can be tracked from 1982 through the NCES Condition of Education reports (1997b), and we use the state data reported to CCSSO to compare to the results for the 1997-98 school year.

- In 1982, 37 percent of high school graduates took algebra 2 (NCES, 1997b). State data for 1998 show that the rate is up to 63 percent of graduates taking second-year algebra.
- In 1982, 32 percent of graduates took chemistry (NCES, 1997b). In 1998, state data show that 54 percent of graduates took chemistry.

Higher science and math course enrollments have increased significantly in the same period of increasing course credit requirements. We have found that the states with the highest requirements have had slightly higher overall course enrollments in science and mathematics. However, because rates have gone up in almost all states, it is hard to determine specific effects of different policies on course taking. Porter's recent study of effects of state requirements at the local level did show that students were taking more mathematics and science courses in high school, and key courses such as algebra, biology, and chemistry did not have their curriculum content reduced as a result (Porter, et al., 1994).

Mathematics Trends by State Policies

- Twenty-four of 27 states reporting on trends since 1990 show an increase in the proportion of high school students taking higher level mathematics.
- Nationally, 45 percent of high school students took higher higher-level math courses in 1998, an increase of eleven points from 1990; and, 88 percent of high school students took a math course during the 1997-98 school year.

CCSSO can now track the amount of change in course enrollments in relation to an individual state's requirements. Table 13 shows change from 1990 to 1998 in the percent of high school students taking higher-level mathematics, i.e., geometry (level 2) through calculus (level 5), according to a state's graduation requirements. The states with Statewide Systemic Initiatives (SSI) supported by NSF are identified.

Among the 12 states that had higher math requirements (2.5 to 4 credits) in 1998, 8 of the 12 raised enrollments in higher-level math courses by six or more percentage points. Arkansas, Connecticut, DoDEA, Kentucky, Mississippi, North Carolina, Texas, and West Virginia showed the greatest increases of over 10 points.

Among the 15 states requiring two credits in 1998, 11 states increased the percentage of students in higher-level math six or more points over eight years. The percentage enrolled in higher-level math in 1998 varied from 32 percent (Nevada) to 55 percent (Wisconsin).

In the third column of Table 13, we show the proportion of students in each state taking mathematics at any level in 1998. The national total is 88 percent of high school students, an increase of five points from 83 percent in 1990. The high-requirement states vary in total enrollment from 64 percent in Alabama to 97 percent in Kentucky and 99 percent in North Carolina. In two-credit states, the total percent of students taking mathematics varies from 77 percent in Idaho to 99 percent in Wisconsin.

Science Trends by State Policies

- Twenty-five of 27 states reporting on trends in science enrollments since 1990 show an increase in the proportion of high school students taking higher level science.
- Nationally, 26 percent of high school students took higher higher-level science courses in 1998, an increase of five points from 1990; and, 78 percent of high school students took a science course during the 1997-98 school year.

Table 14 shows change from 1990 to 1998 in the percent of high school students taking higher-level science, i.e., chemistry, physics, or advanced/second-year courses, from 1990 to 1998, according to a state's graduation requirements.

In the eight states that had higher science requirements (2.5 to 4 credits) in 1998, all but one raised enrollments in higher-level science courses by three or more percentage points since 1990. Arkansas, DoDEA, Kentucky, and North Carolina all increased higher-level science by 10 points.

TABLE 13 Change in Higher-Level Mathematics Enrollments by State Graduation Requirements, 1990 to 1998

STATE (*By Requirements*)	PERCENT OF GRADES 9–12 STUDENTS % Students Taking Math at Level 2, 3, 4, or 5 1998	Change 1990 to'98	% Students Taking Math (any course) 1998
2.5 to 4 Credits (as of 1998)			
Alabama	27%	-1	64%
Arkansas (SSI '93)	46	+15	82
Connecticut (SSI '91)	49	+11	96
DoDEA	51	+11	89
Kentucky (SSI '92)	50	+15	97
Louisiana (SSI '91)	43	0	81
Mississippi	49	+11	93
New Mexico (SSI '92)	34	+4	81
North Carolina (SSI '91)	59	+22	99
Texas (SSI '92)	46	+11	92
Vermont (SSI '92)	42	+5	83
West Virginia	42	+12	89
2 Credits (as of 1998)			
California (SSI '92)	36	+7	81
Delaware (SSI '91)	39	+11	86
Idaho	41	+3	77
Indiana	45	+12	82
Missouri	49	+13	91
Nevada	32	+6	81
New York (SSI '93)	43	+9	93
North Dakota	51	+7	85
Ohio (SSI '91)	47	+11	88
Oklahoma	43	+9	86
Oregon	40	+8	81
South Dakota (SSI '91)	45	–	84
Utah	50	–	84
Virgin Islands	42	–	85
Wisconsin	55	+8	99
1 Credit or Local Board Policies			
Iowa	45	+2	89
Massachusetts (SSI '92)	59	–	99
Michigan (SSI '92)	44	–	84
Minnesota	38	-3	65
Nebraska (SSI '91)	61	+25	99
NATION	**45**	**+11**	**88**

EXAMPLE: 46% of Arkansas' 9–12 students took higher level math courses in 1998, while in 1990 only 31% took these courses.

NOTES: Math Level 2-5 = Geometry, Algebra 2, Trigonometry, Pre-Calculus, or Calculus.
Delaware, DoDEA, Oregon, Vermont, Wisconsin: change from 1992 to 1998.
SSI = State with Statewide Systemic Initiative under NSF grant, five years starting 1991, '92, or '93.
Other SSI = Florida, Georgia, Maine, Montana, New Jersey, Puerto Rico, South Carolina, Virginia.
– Data not available.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE 14 Change in Higher-Level Science Enrollments by State Graduation Requirements, 1990 to 1998

	PERCENT OF GRADES 9–12 STUDENTS		
	Students Taking Chemistry, Physics, or Advanced Science		Students Taking Science (any course)
STATE (*By Requirements*)	%, 1998	Change 1990 to 1998	%, 1998
2.5 to 4 Credits (as of 1998)			
Alabama	19%	+1	59%
Arkansas (SSI '93)	27	+16	99
DoDEA	32	+11	90
Kentucky (SSI '92)	34	+11	86
Louisiana (SSI '91)	21	+3	84
Mississippi	41	+6	85
North Carolina (SSI '91)	31	+15	98
Vermont (SSI '92)	29	+3	80
West Virginia	26	+5	87
2 Credits (as of 1998)			
California (SSI '92)	20	+5	67
Connecticut (SSI '91)	33	+3	88
Delaware (SSI '91)	25	+7	82
Idaho	16	-1	70
Indiana	31	+7	76
Missouri	31	+4	89
Nevada	25	+11	67
New Mexico (SSI '92)	21	+7	68
New York (SSI '93)	28	+4	92
North Dakota	32	+7	86
Oklahoma	25	+12	77
Oregon	20	+1	72
South Dakota (SSI '91)	34	–	81
Texas (SSI '92)	26	+9	78
Utah	30	–	82
Virgin Islands	12	–	82
Wisconsin	37	+7	99
1 Credit or Local Board Policies			
Iowa	35	+12	89
Massachusetts (SSI '92)	37	–	99
Michigan (SSI '92)	29	–	81
Minnesota	23	0	48
Nebraska (SSI '91)	33	+17	99
Ohio (SSI '91)	24	+4	74
NATION	**26**	**+5**	**78**

NOTES: Delaware, DoDEA, Oregon, Vermont, Wisconsin — change from 1992 to 1998.
SSI = State with Statewide Systemic Initiative under NSF grant, five years starting 1991, '92, or '93.
Other SSI = Florida, Georgia, Maine, Montana, New Jersey, Puerto Rico, South Carolina, Virginia.
– Data not available.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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Among the 17 states requiring two credits in 1998, 12 states increased the percentage of students in higher-level science by three or more points over eight years. The percentage enrolled in higher-level science in 1998 varied from 12 percent (Virgin Islands) to 37 percent (Wisconsin).

In the third column of Table 14, we show the proportion of students in each state taking science at any level in 1998. The national total is 78 percent of high school students, an increase of 6 points since 1990. The range for high-requirement states is 59 percent in Alabama to 99 percent in Arkansas, and the range for two-credit states is from 67 percent in California and Nevada to 99 percent in Wisconsin.

The group of six states that rely on local board policies on graduation requirements have enrollments as high as some states with high state requirements. Data on policies by district from the 1994 SASS (NCES, 1996b) show that local district policies often exceed state requirements. States such as Iowa, Massachusetts, and Nebraska may have local requirements that lead to high rates of science and mathematics course taking.

This brief summary of CCSSO's analysis of course enrollments by state policies could be elaborated further. States may want to analyze enrollments by local requirements, or, enrollments could be analyzed by other policy differences within states, such as integrated science or mathematics curriculum versus a traditional sequence of courses.

Middle Grades Mathematics and Science Course Enrollments

- First-year algebra courses were taken by over 20 percent of grade 8 students in ten states; and nationally, 18 percent of grade 8 students took algebra 1 in 1998.
- Science courses taught in grades 7-8 vary widely by states. Across the states, 31 percent of grades 7 and 8 students took a general science course in 1997-98, 15 percent took life science, and 12 percent took earth science. The data also show that in nine states integrated science had the highest middle grades enrollments.

The mathematics and science curricula for middle school students are highly varied both between states and within states. In mathematics, many states and districts are moving towards grade 8 curricula with greater emphasis on algebra. Table 15 shows that in 1998, 18 percent of students were taking *algebra* in grade 8, as compared to 11 percent in 1990. The percent taking algebra in grade 8 varied from 8 percent in Arkansas, Indiana, and Oklahoma to 34 percent in DoDEA and 54 percent in Utah. *Pre-algebra* courses were taken by 21 percent of students in 1998. Almost two-thirds of the states reporting grade 7-8 data had less than half their students taking "regular math" courses in grade 8.

The course titles provide only a rough estimation of the content students are receiving. Content analyses show wide variation in the content in courses of "algebra," "pre-algebra," and "regular grade 8 math," but these categories do provide useful distinctions in the general level of math content that is taught (McKnight, et. al., 1987; Shaughnessy, 1998).

The curriculum in grades 7 and 8 science is highly varied across states, as shown in Table 16. *Life science* is taught to over a third of students in these grades in four states. In nine states, over a third of students take a course called general science courses. Thirteen states have more than 15 percent of grade 7-8 students enrolled in *integrated* or *coordinated science* courses. In three states, over one-fourth of students take *earth science* in grades 7-8.

TABLE 15 Grade 8 Mathematics Course Enrollments, 1990 to 1998

MATHEMATICS GRADE 8: PERCENT ENROLLED

STATE	Algebra Grade 8 % 1998	Algebra Grade 8 Change 1990 to '98	Regular Math % 1998	Enriched/ Pre-Algebra % 1998
Alabama	12%	+5%	49%	5%
Arkansas	8	+5	55	0
California	21	+8	43	26
Connecticut	28	+12	36	30
Delaware	25	+5	43	22
DoDEA	34	+16*	5	57
Idaho	19	+7	42	26
Indiana	8	-1*	76	11
Kentucky	17	+6	66	23
Louisiana	10	+5	30	33
Maine	–	–	100	–
Massachusetts	33	–	41	19
Michigan	27	–	52	19
Minnesota	12	+6	32	–
Mississippi	13	+6	47	40
Missouri	19	+9	39	–
Nebraska	–	–	22	19
Nevada	17	+10	56	14
New Mexico	18	+10	52	18
New York	14	+3*	70	0.2
North Carolina	27	+9*	53	21
North Dakota	13	-7*	48	26
Ohio	19	+10	41	15
Oklahoma	8	+1	42	36
Oregon	22	+6*	49	17
South Dakota	12	–	42	4
Utah	54	+19*	5	42
Vermont	20	–	59	7
Virgin Islands	18	–	43	–
West Virginia	19	+11	0.1	66
Wisconsin	17	+5*	54	6
NATION	**18**	**+7**	**47**	**21**

NOTES: – Data not available.
In several states, e.g., Louisiana, Minnesota, and Nebraska, data from self-contained classrooms are not included in the totals.
* = Change 1992 to 1998.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98; NCES, CCD Fall Membership 1996.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE 16 Grades 7–8 Science Course Enrollments, 1998

STATE	SCIENCE GRADE 7–8: PERCENT ENROLLED Highest 3 Courses: Earth, Life, Physical, General, or Integrated Science					
Alabama	Gen.	70%	Earth	13%	Life	3%
Arkansas	Life	36	Earth	35	Gen.	17
California	Gen.	58	Integ.	8	Life	7
Connecticut	Gen.	40	Life	21	Phy.	16
Delaware	Earth	40	Life	33	Integ.	18
DoDEA	Integ.	95				
Idaho	Life.	37	Phy.	21	Earth	15
Indiana	Gen.	93	Earth	0.4	Life	0.3
Kentucky	Integ.	85	Earth	9	Life	7
Louisiana	Life	24	Earth	18	Gen.	10
Massachusetts	Integ.	30	Life	25	Phy.	16
Michigan	Gen.	47	Integ.	26	Life	11
Minnesota	Life	26	Earth	24	Phy.	11
Mississippi	Integ.	93				
Missouri	Gen.	42	Life	29	Earth	22
Nebraska	Gen.	21	Life	9	Earth	8
Nevada	Phy.	27	Integ.	22	Gen.	7
New Mexico	Life	30	Earth	23	Gen.	22
New York	Phy.	31	Life	28	Earth	12
North Carolina	Integ.	96	Earth	0.1	Life	0.01
North Dakota	Earth	47	Life	46		
Ohio	Gen.	50	Earth	11	Life	9
Oklahoma	Integ.	65	Earth	17	Gen.	6
Oregon	Life	23	Integ.	23	Earth	18
South Dakota	Gen.	40	Earth	20	Life	16
Utah	Integ.	90	Life	6	Earth	3
Vermont	Life	26	Gen.	23	Phy.	22
Virgin Islands	Gen.	93				
West Virginia	Integ.	91	Life	1	Earth	1
Wisconsin	Gen.	32	Life	21	Earth	16
NATION	**Gen.**	**31%**	**Life**	**15%**	**Earth**	**12%**

NOTES: In several states, e.g., Minnesota, Nebraska, data from self-contained classrooms are not included in the totals.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98; NCES, CCD Fall Membership 1996.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Course Enrollments by Race/Ethnicity and Gender

POLICY ISSUES

Are minority students increasing their participation in higher-level science and mathematics?

Is the gender gap closing in higher-level science and mathematics?

Reforms in science and math education aim to increase opportunities among female and male students, and among minority and white students. States are trying to improve the knowledge and skills of all students in mathematics and science, and to raise student confidence by helping them reach challenging levels of course work. The goal of efforts toward equity is to prepare students for further study or to apply knowledge in careers. Course enrollments show patterns of progress in science and mathematics for females, minorities, and students from lower SES families. This progress is also important because we know that opportunities represented by course-taking levels are strong predictors of student learning in mathematics and science.

Higher Level Mathematics and Science by Race/Ethnicity

- Thirteen states reported enrollments by student race/ethnic group. Black and Hispanic enrollments in higher level math and science courses lagged enrollments for whites and Asians in all the states. From 1990 to 1998, only four of eight states raised the enrollments of Black and Hispanic students.

State enrollments by race/ethnicity for two course levels (chemistry and algebra 2/integrated math 3) as of 1997-98 are reported in Table 17, and we also report change in the percentage of students taking these courses from 1996. CCSSO requested data by race/ethnicity from states for the first time in 1993-94, and eight reported. Now, 13 states have education data systems based on student-level records that allow states to aggregate and report enrollments by race/ethnicity.

The state percentages by race/ethnicity for students taking chemistry and algebra 2/integrated math 3 in 1998 can be compared with the percent of each group in the K-12 enrollment shown at the bottom of the page. Our analysis focuses on the major minority groups in each state because some groups in these states are very small. Following are some examples of the kinds of analyses that can be carried out:

- Black students' chemistry and algebra 2 enrollments in Delaware are more than 15 percentage points below the enrollment of white students. The rate of enrollment went up since 1996 in chemistry for Hispanic students, and went up for all groups in algebra 2. Connecticut's black students are more than 30 points below the enrollment of white students in these two courses. The enrollments of blacks went up slightly in two years, but the rate for Hispanics declined.

- In Texas, Hispanic students' chemistry enrollment is 30 points below that for whites, and the algebra 2 enrollment is 31 points below the rate for whites. Enrollments have gone up Hispanic and white students since 1996. In Massachusetts, Hispanic enrollment is 23 points below the enrollment of whites in chemistry, and 36 points below the rate for whites for algebra 2. Enrollments are improving for Hispanic and black students.

- Black students in Ohio are 18 points below the enrollment for white students in chemistry, and the rate of change is the same since 1996. In North Carolina, black students are 25 points behind whites in chemistry and algebra 2, and there is almost no change since 1996.

TABLE 17 Race/Ethnic Differences in Students Taking Chemistry and Algebra 2/Integrated Math 3, 1996 to 1998

PERCENT OF HIGH SCHOOL STUDENTS TAKING CHEMISTRY BY GRADUATION

STATE	All Students % 1998	White % 1998	White Change 1996 to '98	Black % 1998	Black Change 1996 to '98	Hispanic % 1998	Hispanic Change 1996 to '98	Asian % 1998	Asian Change 1996 to '98	Am. Indian % 1998	Am. Indian Change 1996 to '98
Arkansas	61%	65%	-5%	52%	+3%	34%	-31%	87%	+22%	46%	-3%
Connecticut	64	74	+4	42	+2	27	-5	77	-18	43	-52
Delaware	61	69	-3	45	-5	43	+11	99	+35	31	-66
Idaho	42	45	+2	24	-17	19	+1	35	-6	13	-8
Massachusetts	71	75	+3	51	+6	52	+15	89	0	36	+2
Nevada	49	56	–	36	–	23	–	85	–	26	–
North Carolina	63	72	+4	47	+1	27	-35	99	0	42	-20
Ohio	55	57	-3	43	-3	39	-19	99	0	55	-3
South Dakota	54	59	–	54	–	27	–	68	–	27	–
Texas	59	74	+9	45	-1	44	+5	98	-1	39	-16
Utah	46	48	-1	33	+24	31	+12	38	-9	31	+7
Vermont	54	54	–	14	–	41	–	54	–	36	–
West Virginia	46	46	–	23	–	18	–	99	–	46	–

NOTE: – Data not available.

PERCENT OF HIGH SCHOOL STUDENTS TAKING ALGEBRA 2/INTEGRATED MATH 3 BY GRADUATION

STATE	All Students % 1998	White % 1998	White Change 1996 to '98	Black % 1998	Black Change 1996 to '98	Hispanic % 1998	Hispanic Change 1996 to '98	Asian % 1998	Asian Change 1996 to '98	Am. Indian % 1998	Am. Indian Change 1996 to '98
Arkansas	64%	67%	-4%	54%	-2%	36%	-31%	91%	+24%	48%	-2%
Connecticut	67	78	+7	39	+2	28	-13	80	-18	45	-20
Delaware	54	60	+4	45	+15	38	+14	60	+13	54	-17
Idaho	61	64	+1	87	-12	27	-8	99	+38	19	-12
Massachusetts	82	87	+13	68	+14	51	+12	99	+6	82	+47
Nevada	48	56	–	30	–	23	–	83	–	25	–
North Carolina	70	79	+3	55	+1	30	-40	93	-6	47	-23
South Dakota	61	69	–	61	–	31	–	76	–	13	–
Texas	74	89	+7	62	-10	57	+4	99	0	49	-23
Utah	69	71	-10	99	+83	46	+15	86	+47	46	+7
Vermont	57	54	–	99	–	43	–	57	–	48	–
West Virginia	56	56	–	42	–	22	–	99	–	56	–

NOTE: – Data not available.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98 school year.

RACE/ETHNICITY OF K–12 STUDENTS

STATE	% White	% Black	% Hispanic	% Asian	% Am. Ind.
Arkansas	73.5%	23.5%	1.8%	0.7%	0.4%
Connecticut	71.7	13.6	11.9	2.5	0.3
Delaware	63.9	29.9	4.3	1.8	0.2
Idaho	88.0	0.7	8.9	1.2	1.3
Massachusetts	77.9	8.4	9.6	4.0	0.2
Nevada	65.1	9.6	18.8	4.6	1.9
North Carolina	63.9	30.8	2.3	1.5	1.5
Ohio	82.0	15.4	1.4	1.0	0.1
South Dakota	83.7	1.0	0.8	0.8	13.8
Texas	45.6	14.3	37.4	2.4	0.3
Utah	89.5	0.7	6.0	2.4	1.5
Vermont	97.3	0.8	0.4	1.0	0.6
West Virginia	95.2	4.0	0.5	0.3	0.1

SOURCE: NCES, Common Core Data, Fall 1996.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

National high school transcripts studies conducted by NCES are useful for analyzing long term national trends in math and science course-taking by student race/ethnicity and by student gender (NCES, 1997b). The national averages below show that minority students are making some progress in participation in higher-level mathematics and science courses. We have selected algebra 2 and chemistry to trace minority students' progress as compared to that of white students.

Race/Ethnic Differences in Students Taking Algebra 2 and Chemistry, 1982 to 1994

PERCENT TAKING ALGEBRA 2

Student Race/ Ethnicity	1982	1994
White	41	62
Black	26	44
Hispanic	23	51
Asian	55	67
American Indian	20	39

PERCENT TAKING CHEMISTRY

Student Race/ Ethnicity	1982	1994
White	35	59
Black	23	44
Hispanic	17	47
Asian	52	69
American Indian	34	41

Source: NCES, Condition of Education, 1997b.

The enrollment of black students taking algebra 2 increased significantly over the 1982 to 1994 period—from 26 percent to 44 percent of graduates. At the same time, however, the white-black gap in participation widened by four percentage points over 12 years (whites: 44% to 62%). Hispanic and American Indian students made the largest increases in algebra 2 enrollments—with both groups' enrollments doubling over 12 years. Asian American students continue to enroll in Algebra 2 at a higher rate than any other group—67 percent in 1994.

In science, chemistry enrollments increased significantly from 1982 to 1994 for all groups. Black and Hispanic enrollments in chemistry doubled over 12 years—23 to 44 percent, 17 to 47 percent; white enrollments increased 24 percentage points, and Asian American enrollments increased by 17 points.

Course Enrollments by Gender

- Female students have greater enrollments in three years of high school math and science in all 20 states reporting by gender in 1998.
- In 13 of 20 states, female enrollments have increased from 1 to 9 percentage points in trigonometry/pre-calculus since 1990, and in 12 states female enrollments have increased 2 to 8 percent in physics since 1990.

In analyzing course taking trends by student gender since 1990, we focus on the higher levels of math and science. In 1998, a total of 20 states reported course taking in math and science by gender. Tables 18 and 19 show trends by state on the percent of females among students taking higher level math and science, i.e., algebra 2/integrated math 3, trigonometry/precalculus, chemistry and physics.

TABLE 18 Gender Differences in Students Taking Higher-Level Mathematics Courses, 1990 to 1998

	PERCENT FEMALE					
	Algebra 2/Integrated Math 3		Trigonometry/Precalculus		Algebra 1/ Integrated Math 1	Geometry/ Integrated Math 2
STATE	% 1998	Change 1990 to '98	% 1998	Change 1990 to '98	% 1998	% 1998
Arkansas	55%	+1%	55%	+6%	52%	48%
California	52	+1	52	+3	49	52
Connecticut	52	+1	54	+6	50	51
Delaware	52	–	53	–	49	53
DoDEA	50	-1	53	+7	49	51
Idaho	52	+5	51	+3	50	50
Iowa	53	+1	50	+3	51	52
Massachusetts	51	–	55	–	49	51
Nevada	53	+1	53	+9	52	52
North Carolina	55	-1	55	+1	47	52
North Dakota	52	–	51	–	47	49
Ohio	52	+1	52	+2	50	52
Oregon	52	–	50	–	49	51
South Dakota	52	–	52	–	49	50
Texas	52	–	53	–	47	52
Utah	50	-1	49	+3	48	51
Vermont	52	+3	52	+2	47	51
Virgin Islands	58	–	68	–	55	57
West Virginia	55	0	54	+4	47	55
Wisconsin	53	+2	51	+5	50	52

NOTES: – Data not available. DoDEA, North Carolina, Ohio, Utah, Vermont = change from 1992 to 1998.

SOURCE: State Departments of Education, Data on Public Schools.

Council of Chief State School Officers, State Education Assessment Center, Washington, OC, 1999.

All 20 states had more females than males taking algebra 2/integrated math 3 in 1998, varying from 50 percent (DoDEA, Utah) to 58 percent female (Virgin Islands). In fourth year math (trigonometry/precalculus courses), 19 states had more females than males enrolled. The percent female taking higher-level mathematics increased since 1990 in 13 of 20 states reporting trend data. For example, in Nevada, the percent female enrolled in level 4 math went up nine percentage points in eight years.

In science, all 19 states had more females taking chemistry than males, as of 1998, varying from 51 percent in DoDEA, Oregon, and Utah to 57 percent female in the Virgin Islands. Eighteen states (of 19) have more males than females taking physics. From 1990 to 1998, the percent female among students taking physics increased in all 12 states with trend data, with increases from 2 to 8 percentage points. The proportion female of students taking physics varies from 39 percent in Idaho, 41 percent in Utah, to 48 percent in California and DoDEA, 71 percent in the Virgin Islands.

TABLE 19 Gender Differences in Students Taking Science Courses, 1990 to 1998

	PERCENT FEMALE			
	Chemistry		Physics	
STATE	% 1998	% Change 1990 to '98	% 1998	% Change 1990 to '98
Arkansas	53%	+1%	46%	+3%
California	53	+2	48	+6
Connecticut	52	+3	44	+8
Delaware	56	–	46	–
DoDEA	51	0	48	+8
Idaho	52	+1	39	+8
Iowa	54	+3	47	+7
Massachusetts	52	–	46	–
Nevada	52	+1	47	+7
North Carolina	56	0	47	+2
North Dakota	53	–	43	–
Ohio	53	+1	44	+2
Oregon	51	–	42	–
South Dakota	55	–	47	–
Texas	53	–	47	–
Utah	51	+5	41	+8
Vermont	53	+2	45	+2
Virgin Islands	57	–	71	–
Wisconsin	54	+2	46	+6

NOTES: – Data not available.
DoDEA, North Carolina, Ohio, Utah, Vermont: change from 1992 to 1998.

SOURCE: State Departments of Education, Data on Public Schools.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

POLICY ISSUES

To what extent are teaching practices consistent with national professional standards on teaching in mathematics and science?

Are there major differences in instructional practices in mathematics and science across the states?

Are differences in teaching practices related to higher student achievement in mathematics or science?

Instructional Practices in Mathematics and Science

The NCTM *Mathematics Curriculum Standards* and *Teaching Standards* (1989, 1991) and the NRC *Science Education Standards* (1995) and AAAS *Benchmarks* (1993) recommend approaches to instruction that increase students' direct involvement in learning through doing mathematics and science and constructing ways of reasoning and solving problems. Many states have completed their own state standards and curriculum frameworks in mathematics and science that suggest teaching strategies or provide examples of classroom practices that are consistent with challenging content standards (Blank, et. al., 1997). In the present report, we have selected data reported from the NAEP mathematics and science teacher surveys from the 1996 assessments to provide indicators of teaching practices useful for analyzing teaching in relation to standards. This information will be updated with results from the NAEP 2000.

Mathematics Instructional Practices, Grades 4 and 8

- **Discuss Solutions to Math Problems with Other Students.** In 12 states, over 50 percent of students in grade 4 discuss solutions to math problems with other students in class once per week or more. At grade 8, 36 percent of students report they discuss math problems in class almost every day, and 65 percent discuss math problems in class at least once a week.

This instructional practice is very prevalent across the nation. Often these students may be working with other students in small groups. This indicator addresses the problem solving and reasoning theme of the NCTM standards for mathematics education. Nationally, 48 percent of grade 4 students report discussing problems with other students at least weekly.

- **Use of Calculators.** In 1992, only 18 percent of grade 4 students across the United States reported using calculators in math class once per week or more, according to teacher reports. By 1996, the rate has increased to 34 percent of students using calculators at least weekly.

Eight states had over 40 percent of grade 4 students using calculators weekly or more, according to their teachers. By comparison, 49 percent of grade 8 students report they use calculators in math class almost every day, and 76 percent use them at least once a week in class.

- **Write about solving math problems.** One-third of students in grade 8, nationally, write about how to solve math problems in class once per week or more.

Table 20 shows data by state on four instructional practices in mathematics in grade 4 classrooms: (a) Students discuss math problems in class with other students at least weekly, (b) Students write a few sentences about how to solve math problems at least weekly, (c) Students use calculators in math instruction weekly, and (d) Homework assigned per day in math. The first two items are from student surveys, the next two from teacher surveys. The percentages represent the percent of students in each state affected by the practice—for example, teachers of 62 percent of Alabama's grade 4 students report they assign 30 minutes or more homework each day.

Table 21 reports the same four instructional practices for grade 8 math classes. The only difference in the items is that calculator use is reported by students in grade 8.

Applying mathematics to real-life needs and problems is a major emphasis of NCTM standards. Many states have recommended in their standards that instruction should develop students' abilities to communicate mathematically, such as by writing about how to solve a math problem. Three states have over 50 percent of grade 8 students writing about math problems weekly.

The fairly high frequency of students reporting they discuss solutions to math problems with other students may be somewhat surprising, given the common perception of U.S. math instruction as teacher-centered or individuals working on their own math assignments in class. One-third of grade 8 math classes involve some student interaction and cooperation almost daily, and half of grade 4 classes have students discussing their work at least weekly. These findings may indicate there is change taking place in methods of math instruction in our schools.

Writing about solving mathematics problems is used more often in grade 4 math classes than in grade 8, according to NAEP surveys with students. At grade 4, 49 percent of students report they write about solving math problems once a week or more, while at grade 8 only 35 percent report writing about math as often as once per week. Writing about math in grade 8 classes varied from 23 percent in Indiana, Utah, and West Virginia to 58 percent in Kentucky and 50 percent in California.

Calculator use in math instruction has risen significantly since 1992. Now, half of grade 8 students are using calculators almost daily, and 10 states have over 60 percent of students using calculators this often. At grade 4, about one-third of math classes use calculators once or twice a week. No state has over half their classes using calculators weekly, but all states have over one-fifth of classes using calculators once or twice per week.

TABLE 20 Instructional Practices in Mathematics, Grade 4, 1996 NAEP

STATE	Students Discuss Math Problems % Once a Week or More	Write About Math Problems % Once a Week or More	Calculator Use % At Least Once a Week 1996	Calculator Use % At Least Once a Week 1992	Homework Assigned % 30 Minutes or More
Alabama	47	44	17	22	62
Alaska*	49	43	33	–	–
Arizona	49	46	22	15	32
Arkansas*	39	37	25	8	37
California	55	53	41	34	50
Colorado	50	48	34	31	36
Connecticut	54	55	36	29	44
Delaware	51	48	34	24	42
Dist. of Columbia	60	55	48	59	83
DDESS	48	42	43	–	–
DoDDS	66	61	73	–	–
Florida	48	46	32	21	57
Georgia	51	49	30	14	53
Guam	50	52	16	10	71
Hawaii	50	57	23	35	76
Indiana	47	41	24	12	33
Iowa*	46	39	26	18	18
Kentucky	53	54	52	47	41
Louisiana	48	45	21	18	54
Maine	49	57	51	23	34
Maryland	54	58	48	39	58
Massachusetts	56	52	37	18	47
Michigan*	48	48	56	38	32
Minnesota	48	46	52	28	24
Mississippi	49	50	21	16	55
Missouri	43	37	12	14	44
Montana*	43	42	38	–	–
Nebraska	45	40	37	22	30
Nevada*	46	51	32	–	–
New Jersey*	54	49	45	26	56
New Mexico	44	44	30	9	46
New York*	51	49	22	14	59
North Carolina	51	53	62	21	54
North Dakota	35	32	34	14	42
Oregon	46	46	40	–	–
Pennsylvania*	52	44	30	18	46
Rhode Island	50	49	40	18	45
South Carolina*	47	44	24	15	52
Tennessee	45	40	18	7	59
Texas	48	45	20	24	42
Utah	46	45	43	21	27
Vermont*	53	68	50	–	–
Virginia	45	42	30	14	49
Washington	46	40	31	–	–
West Virginia	46	45	50	24	28
Wisconsin	44	40	38	34	33
Wyoming	45	40	28	24	19
NATION	**48**	**49**	**34**	**18**	**41**

NOTES: – Data not available.

* Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

SOURCE: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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TABLE 21 Instructional Practices in Mathematics, Grade 8, 1996 NAEP

STATE	Students Discuss Math Problems % Almost Every Day	Write About Math Problems % Once a Week/More	Calculator Use % Almost Every Day 1996	Calculator Use % At Least Once a Week 1996	Calculator Use % At Least Once a Week 1992	Homework Assigned % 30 Minutes or More
Alabama	36	25	30	57	49	73
Alaska*	37	29	58	83	–	–
Arizona	39	34	52	76	49	64
Arkansas*	32	22	36	64	42	66
California	39	50	48	76	56	69
Colorado	40	33	52	78	70	73
Connecticut	35	34	44	73	53	74
Delaware	34	36	51	78	53	69
Dist. of Columbia	45	42	20	48	56	79
DDESS	38	36	26	64	–	–
DoDDS	43	50	63	88	–	–
Florida	33	26	42	70	46	66
Georgia	39	30	47	74	47	64
Guam	42	34	36	63	30	64
Hawaii	36	37	26	57	46	78
Indiana	34	23	36	65	41	66
Iowa*	31	28	60	85	67	70
Kentucky	29	58	52	84	66	64
Louisiana	35	26	26	52	39	61
Maine	37	34	53	82	73	72
Maryland*	34	36	37	66	49	70
Massachusetts	35	32	47	74	35	84
Michigan*	42	39	67	87	68	71
Minnesota	33	27	65	86	75	70
Mississippi	38	34	33	60	31	66
Missouri	32	25	60	82	75	70
Montana*	39	35	60	85	–	–
Nebraska	38	25	60	83	69	65
New Mexico	37	26	38	66	46	64
New York*	32	32	36	64	29	73
North Carolina	40	37	47	76	44	67
North Dakota	37	25	71	86	72	78
Oregon	39	33	59	83	–	–
Rhode Island	29	25	40	68	47	80
South Carolina*	36	36	35	64	46	60
Tennessee	33	25	27	57	42	69
Texas	37	29	35	64	62	66
Utah	37	23	63	84	67	68
Vermont*	35	45	52	81	–	–
Virginia	34	26	37	65	43	65
Washington	40	25	51	76	–	–
West Virginia	32	23	35	63	43	44
Wisconsin*	30	30	62	86	71	65
Wyoming	35	23	55	79	71	56
NATION	36	35	49	76	53	67

NOTES: – Data not available.

* Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

SOURCE: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Science Instructional Practices

The NAEP 1996 Science Assessment included a teacher and student survey, and results were reported by state on instructional practices in science classrooms at grade 8. The results from the survey provide some basic information about the degree to which activities in eighth grade science classes do emphasize hands-on, active learning.

Science Demonstrations. The statistics in Table 22 show first that a majority of grade 8 science teachers report that they lead demonstrations about science at least once per week. Nationally, 59 percent of classes have demonstrations for students once a week or more often. The percentages by state vary from 50 percent of classes (e.g., Tennessee) to 70 percent of classes having teacher-led demonstrations at least once per week.

Hands-On Activities/Investigations. Second, teachers report that hands-on activities or investigations are used at least once a week in over three-fourths of grade 8 science classes (83% in nation). The state percentages vary widely, from under 50 percent of classes (e.g., Alabama, Tennessee) to almost 90 percent (e.g., California, Colorado, Nebraska, Wyoming) doing hands-on science at least once a week. The category gives teachers room for including many different kinds of activities in this practice. Student results for the same question indicate that 51 percent of classes had weekly hands-on science or investigations.

Long-term Projects. The third column in Table 22 shows the percent of students in each state that report they have done individual or group science projects or investigations in school that take a week or more. About two-thirds of students (63%), nationally, report doing a long-term science project at grade 8. The state percentages vary from 46 percent of students (e.g., Arkansas) to 77 percent of students (Maine) and 81 percent (Vermont).

A national sample of elementary, middle, and high school science and mathematics teachers were surveyed in fall 1993 about their instructional practices, preparation, classroom resources, and school conditions (Weiss, 1994). The survey results are an excellent resource on a broad range of national indicators. The survey is being repeated in 1999–2000.

TABLE 22 *Instructional Practices in Science, Grade 8, 1996 NAEP*

STATE	Science Demonstrations by Teacher % Once a Week/More (per teachers)	Hands-On Activities/ Investigations % Once a Week/More (per teachers)	Long-Term Science Projects % Yes (per students)
Alabama	60	47	58
Alaska*	58	78	73
Arizona	70	84	68
Arkansas*	56	44	46
California	65	85	71
Colorado	65	88	71
Connecticut	63	75	68
Delaware	53	63	63
Dist. of Columbia	57	67	77
DDESS	54	82	68
DoDDS	83	86	61
Florida	64	64	63
Georgia	67	58	62
Guam	61	55	74
Hawaii	60	75	55
Indiana	64	74	58
Iowa*	63	79	67
Kentucky	56	66	67
Louisiana	53	50	50
Maine	62	80	77
Maryland*	67	83	68
Massachusetts	60	81	69
Michigan*	69	74	63
Minnesota	62	85	62
Mississippi	67	61	52
Missouri	59	65	57
Montana*	70	79	63
Nebraska	68	89	62
New Mexico	54	75	62
New York*	69	70	60
North Carolina	61	73	63
North Dakota	44	60	57
Oregon	63	82	72
Rhode Island	62	76	65
South Carolina*	60	63	70
Tennessee	50	38	53
Texas	66	79	63
Utah	82	67	53
Vermont*	66	84	81
Virginia	71	86	65
Washington	65	82	68
West Virginia	66	85	54
Wisconsin*	58	82	65
Wyoming	69	88	59
NATION	**59**	**83**	**63**

NOTES: Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

SOURCE: NCES, NAEP 1996 Science Cross-State Data Compendium for the Grade 8 Assessment, May 1998.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Chapter Three

Indicators of Teacher Preparation and Supply

Number of Teachers in Mathematics and Science

Teachers Certified in Assigned Field

Teachers with a Major in Assigned Field

Teachers' Professional Development

Indicators of Race/Ethnicity and Gender in the Teaching Force

Age Distribution of Science and Mathematics Teachers

New Teachers in Mathematics and Science

POLICY ISSUES

What proportion of current teachers have knowledge and teaching skills in their field at the level outlined by professional standards?

Do we have a sufficient number of teachers currently, and are new teachers coming into math and science that would allow us to improve the quality of teaching?

What improvement in the knowledge and skills of teachers are needed?

What efforts are currently being made to improve teachers' knowledge and skills?

National professional standards in mathematics and science, as well as the standards in many states, call for change in teaching and classroom practices to emphasize active learning by students, deep understanding of concepts, and developing skills in problem-solving and reasoning (NCTM, 1989, 1991; AAAS, 1993; NRC, 1995; Blank, et al, 1997). The standards for teaching in mathematics and science de-emphasize teacher lectures, memorizing facts and terminology, and curriculum aimed at briefly covering many topics. One implication of challenging content standards for all students is that teachers need in-depth knowledge and understanding of the discipline and skills in a variety of classroom practices that actively engage students in mathematics and science.

The issues of teacher preparation and teacher supply are critical for education quality in every states. The National Commission on Teaching & America's Future (1996) found that the related problems of insufficient numbers of well-prepared teachers, current shortages of teachers in some urban areas and poorer communities which typically have difficulty attracting teachers, and impending retirements of many teachers mean that indicators of teachers and teaching are critical measures for our education systems.

Indicators for mathematics and science education in the area of teacher preparation and teacher supply should be able to inform educators, policy makers, and the public about conditions and trends concerning current teachers and needs for improving the teaching force.

The currently available state-by-state indicators regarding teachers and teaching provide some answers to these issues. From state education information systems, we can report state-level statistics on the proportion of teachers with state certification in their assigned teaching field; the number of teachers by race, gender, and age; and the number of new teachers entering math and science teaching. We can report statistics by state on the level of preparation of teachers in their assigned teaching field, based on representative data by state from the Schools and Staffing Survey (SASS) and from the National Assessment on Educational Progress (NAEP). Finally, state indicators on the amount and types of professional development received by secondary teachers are available from NAEP teacher surveys associated with the student assessments.

Number of Teachers in Mathematics and Science

- The total number of mathematics teachers in U.S. public high schools increased by 29,000 teachers from 1990 to 1998, and the number of mathematics teachers in grades 7-8 increased by 18,000 teachers from 1994 to 1998.
- In science, the total number of teachers in U.S. public high schools assigned to teach biology increased by 13,000 teachers from 1990 to 1998, the number of chemistry teachers increased by 6,000, physics teachers went up by 2,700 and earth science teachers went up by 5,800. The number of science teachers in grades 7-8 increased by 9,000 teachers from 1994 to 1998.

Tables 23 and 24 show the trends in size of the mathematics and science teaching force during the 1990s. The statistics for each state and the nation represent the total number of teachers in each subject, i.e., teachers assigned one or more period/class in the subject.

Almost every state increased the number of math teachers from 1990 to 1998. There are notable changes in the size of the teaching force in several states. In high school mathematics, Texas more than doubled the number of teachers (9,800 to 21,200), and Michigan and North Carolina increased by over a thousand teachers. Some change can be accounted for by increasing use of multiple assignments for teachers. For example, in Texas only 32 percent of the total assigned in math have their primary assignment in math. In Michigan, 90 percent have their primary assignment in mathematics, and in North Carolina 65 percent have their primary assignment in the field. (Details on teachers by assignment are available on the CCSSO website: www.ccsso.org/ science&math indicators/detailed data.) Nationally, 70 percent of mathematics teachers have their primary assignment in the field. In Table 24, the states with the largest increase in middle grades math teachers (over 10%) are Idaho, Kentucky, Massachusetts, Minnesota, North Carolina, Oklahoma, Texas, Utah, and West Virginia.

In high school science, the numbers of teachers have increased in all four fields reported in Table 23. The total number of high school science teachers with assignments (some being multiple assignments) have gone up by about 10,000 teachers. Earth science has increased the most, almost 5,000 teachers, or a 35 percent increase since 1990. The numbers of teachers assigned in physics, chemistry, and biology have all increased by 20 to 30 percent. In middle grades science, in Table 24, the states with the largest increases in teachers (over 10%) are California, Connecticut, Minnesota, Kentucky, Massachusetts, New Mexico, North Carolina, Texas, Utah, and West Virginia.

Teachers Certified in Assigned Field

State certification in the assigned teaching field indicates that teachers have a basic level of preparation in the subject they are teaching. Using teacher personnel files and teacher assignment data, states reported the number of teachers of high school mathematics and science who are certified. States reported on certification status by specific science fields, such as biology, and by percent of time assigned to the field. For example, more than 50 percent of time assigned to a field, such as biology, represented the teacher's main or primary assignment. The proportion of teachers who are certified in the subjects they are teaching is an important policy indicator for state and local educators because state certification is often used as a basic

TABLE 23 All Teachers in Mathematics and Science, Grades 9–12, 1990 to 1998

STATE	MATH 1998	MATH 1990	BIOLOGY 1998	BIOLOGY 1990	CHEMISTRY 1998	CHEMISTRY 1990	PHYSICS 1998	PHYSICS 1990	EARTH SCIENCE 1998	EARTH SCIENCE 1990
Alabama	1,836	1,597	960	809	394	380	236	305	44	18
Alaska	–	–	–	–	–	–	–	–	–	–
Arizona	–	1,304	–	1,093	–	–	–	–	–	–
Arkansas	3,048	650	604	518	357	283	245	220	56	91
California	10,467	9,684	3,835	3,733	1,798	1,308	1,138	868	618	616
Colorado	–	1,297	–	1,161	–	–	–	–	–	–
Connecticut	1,700	1,453	775	620	416	373	271	243	266	258
Delaware	224	240	60	55	28	17	31	41	11	13
Dist. of Columbia	–	–	–	–	–	–	–	–	–	–
DoDEA	169	–	14	–	10	–	4	–	–	–
Florida	–	–	–	3,832	–	1,096	–	632	–	2,008
Georgia	2,915	–	1,258	–	–	–	–	–	–	–
Hawaii	–	831	–	153	–	49	–	39	–	76
Idaho	861	649	300	270	138	129	98	104	189	105
Illinois	–	3,745	–	1,312	–	654	–	293	–	185
Indiana	2,440	2,298	1,144	1,003	644	491	405	368	363	283
Iowa	1,373	1,487	669	700	432	427	436	390	174	334
Kansas	–	1,179	–	653	–	370	–	262	–	82
Kentucky	1,978	1,659	1,166	689	551	345	260	220	54	43
Louisiana	1,436	3,565	614	816	227	442	106	241	53	108
Maine	652	796	312	357	193	203	164	173	126	174
Maryland	–	2,298	–	2,050	–	–	–	–	–	–
Massachusetts	2,893	3,513	1,322	764	828	466	529	269	328	323
Michigan	5,941	3,339	935	839	423	434	255	261	214	130*
Minnesota	1,951	1,811	744	715	509	475	350	366	79	122
Mississippi	1,148	719	753	398	311	141	209	46	70	1
Missouri	2,297	1,999	1,278	986	660	574	394	361	185	167
Montana	585	535	277	236	167	154	141	132	193	106
Nebraska	1,270	–	579	–	326	–	289	–	263	–
Nevada	682	673	362	213	101	69	67	41	90	88
New Hampshire	727	600	272	228	90	59	41	32	45	34
New Jersey	4,619	4,375	1,368	887	770	337	393	82	450	372
New Mexico	767	643	401	301	163	121	88	78	67	55
New York	8,277	7,853	5,586	5,180	2,144	1,864	1,270	1,158	3,316	2,931
North Carolina	4,027	2,966	1,407	1,181	622	553	361	331	668	171
North Dakota	464	471	271	262	173	174	125	125	11	9
Ohio	3,781	4,254	1,638	1,695	937	985	670	751	336	394
Oklahoma	1,983	1,674	1,051	901	501	481	258	240	64	86
Oregon	1,120	1,222	348	338	–	158	–	106	–	–
Pennsylvania	–	5,704	–	1,755	–	1,016	–	670	–	728
Puerto Rico	–	1,582*	–	414*	–	231*	–	119*	–	94*
Rhode Island	442	418	179	155	96	77	68	44	7	10
South Carolina	–	1,853	–	615	–	324	–	210	–	6
South Dakota	508	707	259	230	174	151	135	125	42	26
Tennessee	–	1,872	–	709	–	357	–	238	–	39
Texas	21,225	9,834	8,447	3,951	2,709	1,562	1,488	909	3,108	366
Utah	1,099	1,114	609	505	168	105	102	69	46	109
Vermont	347	278*	153	127*	97	80*	76	73*	84	77*
Virgin Islands	48	–	24	–	5	–	5	–	–	–
Virginia	–	3,114	–	994	–	543	–	323	–	789
Washington	–	–	–	–	–	–	–	–	–	–
West Virginia	1,174	906	353	386	183	182	120	122	29	67
Wisconsin	2,217	1,960	1,015	838	606	522	407	374	155	113
Wyoming	256	464	111	180	63	125	–	98	22	94
NATION	**140,243**	**111,184**	**59,812**	**46,277**	**27,158**	**21,196**	**16,731**	**14,070**	**18,241**	**13,425**

NOTES: – Data not available.
All Teachers = one or more period assigned to subject.
* = 1992
Arizona, Colorado, Maryland: 1990 biology = all science; Arkansas: 1990 math = main assignment only;
Delaware: 1990, 1998 main assignment only; Maryland, New Jersey, Rhode Island: 1990 main assignment only.

SOURCE: State Departments of Education, Data on Public Schools, 1997-98.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE 24 All Teachers in Mathematics and Science, Grades 7–8, 1994 to 1998

STATE	NUMBER OF MATH TEACHERS 1998	1994	NUMBER OF SCIENCE TEACHERS 1998	1994
Alabama	1,340	1,374	1,203	1,243
Alaska	–	–	–	–
Arizona	–	–	–	–
Arkansas	–	–	–	–
California	7,477	7,635	6,730	5,558
Colorado	–	1,071	–	1,001
Connecticut	1,106	928	969	823
Delaware	151	136	152	125
Dist. of Columbia	–	272	–	130
DoDEA	86	–	67	–
Florida	–	–	–	–
Georgia	1,350	–	1,028	–
Hawaii	–	297	–	204
Idaho	559	396	451	346
Illinois	–	2,748	–	2,587
Indiana	1,475	1,535	1,386	1,430
Iowa	–	–	–	–
Kansas	–	–	–	–
Kentucky	1,948	1,159	1,169	1,007
Louisiana	541	522	447	493
Maine	457	463*	396	278*
Maryland	–	–	–	–
Massachusetts	2,039	1,570	1,828	1,478
Michigan	–	–	–	–
Minnesota	946	796	832	732
Mississippi	914	951	806	836
Missouri	1,408	1,334	1,361	1,288
Montana	455	415	379	367
Nebraska	177	212	165	194
Nevada	312	310	234	232
New Hampshire	–	103	–	–
New Jersey	562	2,516	72	1,508
New Mexico	470	437	522	423
New York	6,425	6,964	5,013	5,481
North Carolina	3,352	2,779	2,774	2,492
North Dakota	422	470	371	381
Ohio	2,524	2,787	2,270	2,375
Oklahoma	1,400	1,185	1,281	1,100
Oregon	665	667	563	497
Pennsylvania	–	–	–	–
Puerto Rico	–	1,513	–	796
Rhode Island	224	244	–	232
South Carolina	–	–	–	–
South Dakota	448	338	395	319
Tennessee	–	1,476*	–	1,480*
Texas	20,674	8,826	11,873	6,196
Utah	576	293	541	251
Vermont	303	266	70	235
Virgin Islands	38	–	41	–
Virginia	–	–	–	–
Washington	–	–	–	–
West Virginia	932	801	711	536
Wisconsin	944	1,050	940	999
Wyoming	144	231	155	199
NATION	**99,040**	**80,966**	**74,426**	**65,023**

NOTES: – Data not available. All Teachers = one or more period assigned to subject.
* = 1996. Delaware: main assignment only.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

measure of teacher qualification and as an indicator of teacher supply and shortage. It is not, however, an adequate measure of quality of teacher preparation, particularly in cross-state comparisons, because of the differing state standards for certification. State certification requirements for secondary, middle grades, and elementary teachers are reported in *Key State Education Policies on K-12 Education* (CCSSO, 1998)

In the following analysis, "certification" in a field means the teacher holds a state's regular, standard, advanced, or probationary certificate in the assigned field/subject. In science, the teacher holds a "specific-field" certification (e.g., biology) or a "broad-field" certification (multiple fields of science). "Not certified" means the teacher holds an emergency or temporary certificate or holds a certification in a field other than the assigned field.

High School Teachers Certified in Field

- State teacher certification statistics as of 1997-98 school year show widely divergent patterns by state. Over half the states have over 95 percent of high school teachers certified their assigned fields. But, one-fourth of states have more than 10 percent of teachers uncertified in mathematics and one or more science fields of biology, chemistry, physics and earth science.
- From 1990 to 1998, the national percentage of high school mathematics and science teachers certified in their field declined from two to six percentage points (varying by field). However, in the same period, the number of high school teachers of mathematics went up over 20 percent and the number of high school teachers of science also increased by over 20 percent.

Mathematics: The certification data in Table 25 show that of 32 states reporting, exactly half have 95 percent or more of math teachers that are certified in math. Six states (New Jersey, North Dakota, Ohio, Oklahoma, Rhode Island, Wisconsin) reported 100 percent of math teachers as certified. Ten states have less than 90 percent certified, with Texas the low state at 77 percent. For Texas, this means that almost 5000 mathematics teachers are not certified in math. The national figure shows 88 percent certified among all high school teachers of math, or a decline of 2 percentage points between 1990 and 1998. The states of California, Kentucky, Louisiana, Michigan, Massachusetts, Mississippi, and Texas have notable shortages of certified math teachers.

Biology: Fifteen of the reporting states have over 95 percent of biology teachers certified in field. This includes teachers certified in biology and "broad-field" science certification, where applicable (see Appendix A). The states of Texas, New York, Mississippi, Louisiana, Georgia, and California have less than 88 percent of biology teachers certified in field. The national average for certified teachers in biology declined by six percentage points over eight years from 1990 to 1998.

Chemistry: In 1998, 15 states reported 95 percent or more of their chemistry teachers as certified in field. Nine states have less than 89 percent certified chemistry teachers, which is the national average as of 1998. Nationally, there was a 3 percent decline in the certified chemistry teachers over the eight year period of study.

TABLE 25 Certification of Grade 9–12 Mathematics and Science Teachers, 1998; Change 1990 to 1998

% CERTIFIED IN ASSIGNED FIELD

STATE	Mathematics % Cert. 1998	Mathematics Change 1990 to '98	Biology % Cert. 1998	Biology Change 1990 to '98	Chemistry % Cert. 1998	Chemistry Change 1990 to '98	Physics % Cert. 1998	Physics Change 1990 to '98	Earth Science % Cert. 1998
Alabama	92%	-3%	94%	-4%	90%	-3%	83%	+6%	68%
Alaska	–	–	–	–	–	–	–	–	–
Arizona	–	–	–	–	–	–	–	–	–
Arkansas	96	+1	94	+28	94	+23	88	+7	89
California	81	0	83	-1	80	-3	83	-1	61
Colorado	–	–	–	–	–	–	–	–	–
Connecticut	98	-2	96	-4	94	-6	89	-11	77
Delaware	91	-4	93	+4	96	+2	74	-2	82
Dist. of Columbia	–	–	–	–	–	–	–	–	–
DoDEA	–	–	–	–	–	–	–	–	–
Florida	–	–	–	–	–	–	–	–	–
Georgia	95	–	55	–	–	–	–	–	–
Hawaii	–	–	–	–	–	–	–	–	–
Idaho	97	0	99	0	100	+3	99	+3	92
Illinois	–	–	–	–	–	–	–	–	–
Indiana	97	+1*	98	+2*	98	+4*	95	+9*	97
Iowa	–	–	–	–	–	–	–	–	–
Kansas	–	–	–	–	–	–	–	–	–
Kentucky	81	-8	98	-1	94	-2	83	-4	43
Louisiana	87	–	81	–	79	–	66	–	57
Maine	–	–	–	–	–	–	–	–	–
Maryland	–	–	–	–	–	–	–	–	–
Massachusetts	88	–	93	–	94	–	93	–	90
Michigan	84	–	93	–	82	–	33	–	59
Minnesota	91	-6	95	-2	86	-4	84	-6	37
Mississippi	88	-5	81	-8	67	-6	49	+1	76
Missouri	95	-4	80	-17	77	-17	73	-12	58
Montana	96	+11	99	+4	99	+3	96	+8	94
Nebraska	88	–	88	–	77	–	66	–	66
Nevada	97	+14	99	+1	99	-1	99	+1	91
New Hampshire	–	–	–	–	–	–	–	–	–
New Jersey	100	0	100	0	100	0	100	0	100
New Mexico	91	-7	92	-8*	97	-3*	92	-7*	93
New York	89	-3	85	-6	86	-6	81	0	61
North Carolina	89	-6	92	-5	93	-7	89	-7	85
North Dakota	100	0	100	0	100	0	100	0	100
Ohio	100	+2	92	-7	95	-4	94	-5	72
Oklahoma	100	+6	100	+3	100	+5	100	+15	97
Oregon	–	–	–	–	–	–	–	–	–
Pennsylvania	–	–	–	–	–	–	–	–	–
Puerto Rico	–	–	–	–	–	–	–	–	–
Rhode Island	100	0	100	0	100	0	100	0	100
South Carolina	–	–	–	–	–	–	–	–	–
South Dakota	96	+48	97	+22	95	+41	84	+45	95
Tennessee	–	–	–	–	–	–	–	–	–
Texas	77	–	70	–	85	–	80	–	50
Utah	95	+1	94	+5	96	0	89	-5	85
Vermont	93	-4*	96	–	95	–	95	–	99
Virgin Islands	–	–	–	–	–	–	–	–	–
Virginia	–	–	–	–	–	–	–	–	–
Washington	–	–	–	–	–	–	–	–	–
West Virginia	94	-2*	95	+1*	92	+2*	81	-7*	79
Wisconsin	100	–	100	–	100	–	100	–	100
Wyoming	–	–	–	–	–	–	–	–	–
NATION	**88**	**-2**	**86**	**-6**	**89**	**-3**	**86**	**-2**	**68**

NOTES: – Data not available; Certified = Teachers assigned one or more period to subject who have state certification in subject. Science Certified = specific-field or broad-field certification. Delaware: Main assignment only.
* = Change 1996 to 1998.

SOURCE: State Departments of Education, Data on Public Schools, Fall 1997.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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Physics: Ten of the reporting states in 1998 had 95 percent or more of physics teachers that were certified. On the other hand, six states level of certification fell below 80 percent, and 12 states fell below 86 percent, the national average. Critical shortages were found in Mississippi (49%), Michigan (33%), and Louisiana (66%). The national average for certified physics teachers fell by two percentage points over eight years.

Earth Science: Certification of teachers in earth science was not tracked by CCSSO in 1990. Currently there are severe shortages of certified teachers with only 68 percent of teachers across the nation being certified in 1998. In Table 25, eight states have 95 percent or more certified teachers. Of 32 reporting states, 18 states had certification levels below 90 percent. As with other science fields and mathematics, high school earth science had a rapid increase in the numbers of assigned teachers in the 1990s, and many states and districts are having difficulty hiring and assigning well-prepared teachers in the field of earth science.

The following summary table shows the percentages of high school teachers that were assigned to teach a subject in which they were certified, and the change between 1990 and 1998.

High School Teachers Certified in Assigned Field

	Math	Biology	Chemistry	Physics	Earth Sci.
1990	90%	92%	92%	88%	n.a.
1994	88	90	92	86	81
1998	88	86	89	86	68

Source: State Departments of Education, 1990– 1998.

Broad-field Science Certification

Two-thirds of the states have a certification for "broad field" secondary science certification that covers teaching in biology, chemistry, physics, and other science subjects. Most states also have certification in the specific fields of biology, chemistry, physics, etc. See Appendix A for differences in state certification requirements.

Our analysis of state data by type of science certification revealed that almost one-third of all high school science teachers are certified through a broad field certification. Many schools must hire teachers to teach two or three science subjects, and they tend to hire teachers who have received state certification through a broad-field, or "non-specialist," method of science certification.

Middle Level Teachers Certified in Field

- In 1998, 72 percent of middle grades mathematics teachers in the U.S. were certified in mathematics, which represented a significant gain over the certification rates in 1994. Nationally, 5 percent of middle level math teachers were certified with elementary certification, and 22 percent of all math teachers were not certified.
- In science, very similar rates of certification are found, with 73 percent of science teachers certified in science, 5 percent elementary certified, and 22 percent of all science teachers not certified in 1998.

TABLE 26 Certification of Mathematics and Science Teachers, Grades 7–8, 1994 to 1998

	MATHEMATICS				SCIENCE			
STATE	Certified Math	Change Certified Math 1994 to '98	Certified Elementary	Not Certified	Certified Science	Change Certified Science 1994 to '98	Certified Elementary	Not Certified
Alabama	76%	-3%*	17%	7%	74%	-6%*	15%	11%
Alaska	–	–	–	–	–	–	–	–
Arizona	–	–	–	–	–	–	–	–
Arkansas	–	–	–	–	–	–	–	–
California	54	+9	36	10	45	-16	44	11
Colorado	–	–	–	–	–	–	–	–
Connecticut	43	-5	55	2	47	-12	50	3
Delaware	77	+3	17	6	77	-2	14	9
Dist. of Columbia	–	–	–	–	–	–	–	–
DoDEA	–	–	–	–	–	–	–	–
Florida	–	–	–	–	–	–	–	–
Georgia	–	–	–	–	–	–	–	–
Hawaii	–	–	–	–	–	–	–	–
Idaho	52	0	46	2	66	-8	31	3
Illinois	–	–	–	–	–	–	–	–
Indiana	90	+3	7	3	93	+1	4	3
Iowa	–	–	–	–	–	–	–	–
Kansas	–	–	–	–	–	–	–	–
Kentucky	56	+26	0	44	39	+13	52	9
Louisiana	86	0	0	14	75	-4	0	25
Maine	–	–	–	–	–	–	–	–
Maryland	–	–	–	–	–	–	–	–
Massachusetts	53	-14	41	6	55	-15	40	5
Michigan	–	–	–	–	–	–	–	–
Minnesota	94	-2	0	6	–	–	–	–
Mississippi	38	+1	62	0.2	43	-9	57	0.5
Missouri	76	-12	0	24	51	-30	12	37
Montana	45	-5	53	2	66	+23	32	2
Nebraska	93	+1	0	7	76	0	0	24
Nevada	–	–	–	–	–	–	–	–
New Hampshire	–	–	–	–	–	–	–	–
New Jersey	–	–	–	–	–	–	–	–
New Mexico	33	-6	67	0.4	49	-13	50	1
New York	89	-3	0	11	80	-7	0	20
North Carolina	65	-3	3	32	62	-6	2	36
North Dakota	56	-2	44	0	66	-4	34	0
Ohio	42	-9	50	8	–	–	–	–
Oklahoma	48	-6	52	0.4	60	-7	39	0.5
Oregon	–	–	–	–	–	–	–	–
Pennsylvania	–	–	–	–	–	–	–	–
Puerto Rico	–	–	–	–	–	–	–	–
Rhode Island	100	0	0	0	–	–	–	–
South Carolina	–	–	–	–	–	–	–	–
South Dakota	93	-4	6	1	89	-3	11	0
Tennessee	–	–	–	–	–	–	–	–
Texas	65	+42	0	35	65	+10	0	35
Utah	87	+4	13	0.3	94	+22	5	1
Vermont	82	–	13	5	89	–	9	2
Virgin Islands	–	–	–	–	–	–	–	–
Virginia	–	–	–	–	–	–	–	–
Washington	–	–	–	–	–	–	–	–
West Virginia	95	-3	0	5	93	–	0	7
Wisconsin	–	–	–	–	–	–	–	–
Wyoming	–	–	–	–	–	–	–	–
NATION	72	+18	5	22	73	+10	5	22

NOTES: – Data not available. * = Change 1996 to 1998. Certified math (science) = Teachers assigned one or more period to subject who have state certification in secondary math (science) or middle level math (science). Certified Elementary = Certification in Elementary Education, General Secondary/Middle, or subject not assigned. Delaware: Main assignment only; Oklahoma: Gen. Sec. = alternative schools; gds 7-8 teachers in elementary schools not included. Texas: not certified includes elem./middle.

SOURCE: State Departments of Education, Data on Public Schools, Fall 1997.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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Many states find that indicators of middle school science and mathematics teachers are critical indicators for two reasons. First, middle grades classes are often where students develop strong interests and aspirations in science and mathematics, or, their interests shift to other subjects or their interest and achievement in science and math decline. Second, middle grades is often where states, districts, and schools find it is difficult to fill positions with well-qualified teachers in science and mathematics. In the state science-math indicators system, we ask states to report separately on the status of all grade 7 and 8 math and science teachers. We asked to receive data on the total number assigned to each subject, and then we asked states to differentiate between teachers assigned to grades 7-8 math and science that are certified in elementary education and those certified in math or science.

Grade 7-8 Mathematics

Table 26 shows that of the 26 states reporting certification data for grade 7-8 teachers, only six states have 90 percent or more of their middle grades teachers certified in math, and only 10 have more than 80 percent certified. Rhode Island reports all of its 224 strong middle grade 7-8 teachers certified in mathematics, and Nebraska, Minnesota, Indiana, New York, and West Virginia have over 90 percent certified in math. New Mexico had 33 percent of middle grades teachers certified in math, and 67 percent certified as elementary teachers, and several other states have half of their middle grades math teachers certified as elementary teachers.

Grades 7-8 Science

Only three of the 23 states reporting data on middle grades science teachers have 90 percent or more certified middle school science teachers, as shown in Table 26. Only three more states have at least 80 percent certified in science. Utah had the highest level of certified teachers at 94 percent. Kentucky had the lowest rate at 39 percent, and 52 percent of their teachers are certified at elementary level. One fifth of the states have less than 50 percent of their science teaching force certified in science. States with about close to half their science teachers certified in elementary teaching are California, Connecticut, Mississippi, Oklahoma, and North Dakota.

Teachers with a Major in Assigned Field

A second important state-by-state indicator of the preparation of teachers in their assigned teaching field of science or mathematics is the percentage of teachers that earned a major in the field in an undergraduate or graduate degree. A major in the teaching field is a relatively consistent and comparable measure of the extent of knowledge of the subject by teachers. Teacher knowledge of subject is a key to effective teaching along with understanding of how students learn and teaching methods (Darling-Hammond, 1996). Research has shown a positive relationship between amount of course work preparation of teachers in science and mathematics and student learning in those fields (Shavelson et al., 1989). A recent analysis of data from the Longitudinal Study of American Youth showed that each additional mathematics course taken by mathematics teachers above the average for teachers translates into two to four percent higher student achievement (Monk, 1993). The National Commission on Teaching & America's Future (1996) documented the fact that inequity in proportion of teachers with a major in their field shows major differences by school location and socioeconomic status of students, and the patterns of variation in prepared teachers is a major source of inequity in our schools.

Secondary Mathematics Teachers

- Eight states have over 90 percent of secondary math teachers (grades 7-12) with a major or minor in mathematics or math education, based on teacher survey data from 1994. At the same time, 12 states have less than 72 percent of math teachers with a major or minor. Thus, in these states over one-fourth of secondary teachers of mathematics do not have adequate preparation in that field.
- Nationally, 80 percent of all secondary teachers of math (teaching math one or more periods) have a major or minor in math; and, 72 percent of secondary teachers with their main assignment in math had a major in that field. The national figure of 20 percent without adequate math preparation represents a total of over 46,000 secondary teachers of math.

The 1994 Schools and Staffing Survey (SASS) provides the most recent state-by-state statistics on college majors of teachers by their teaching assignments. The survey is conducted with a representative sample of elementary and secondary teachers in each state. Figure 6 shows a graph with states rank-ordered according to the percentage of secondary mathematics teachers (grades 7-12) that have a major in mathematics or math education.

States with *over 90 percent* of their secondary mathematics teachers with a major or minor in math are: Pennsylvania, Minnesota, Missouri, North Dakota, Iowa, Indiana, Montana, and Rhode Island.

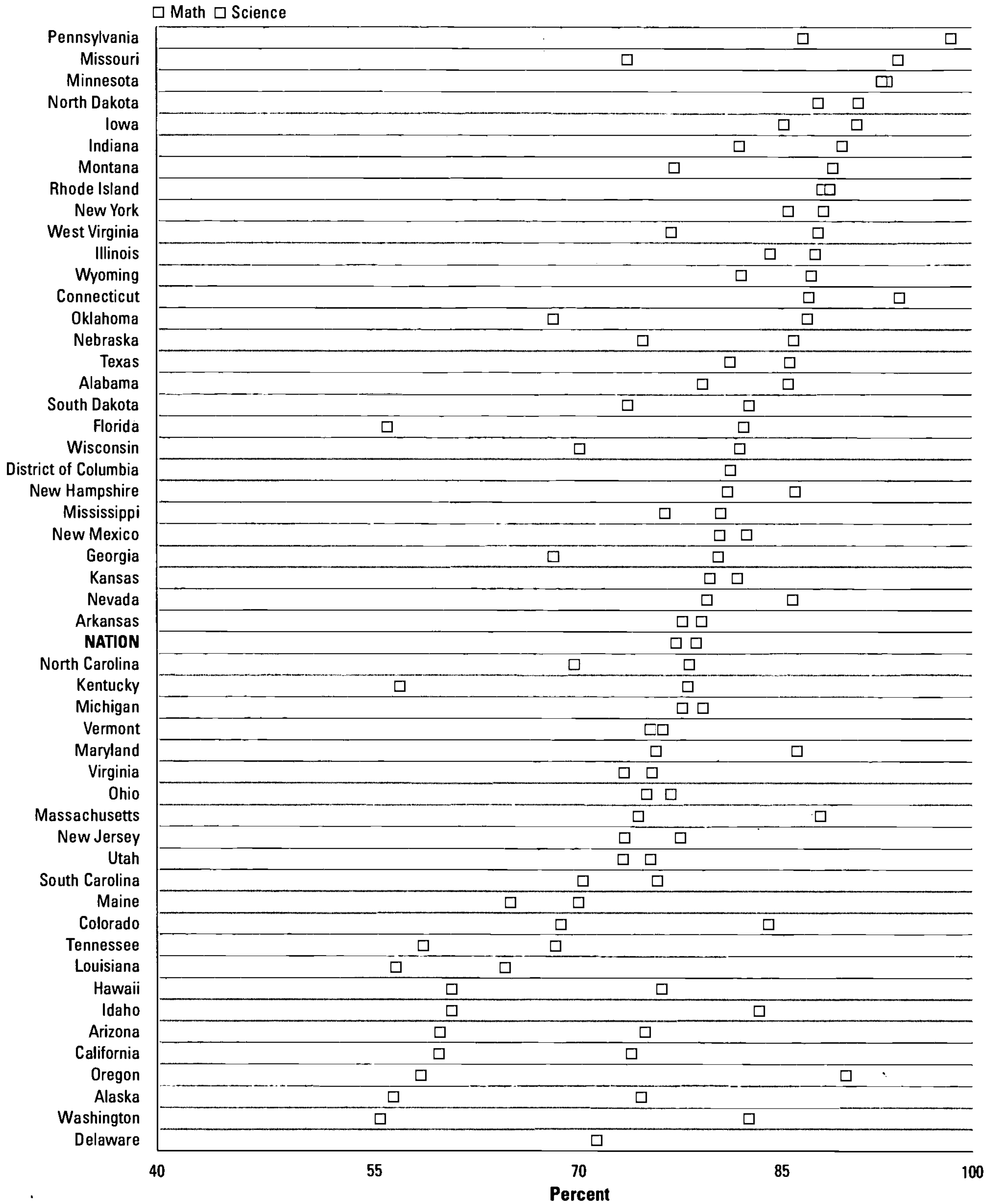
States with *less than 70 percent* of math teachers that are well prepared in the field are: Tennessee, Louisiana, Idaho, Hawaii, Arizona, California, Oregon, Alaska, and Washington.

Table 27 reports states alphabetically and shows the percentage of secondary teachers with their *main assignment* in mathematics or science that majored in their field, and the percent of *all teachers* with 1 or more periods assigned in math and science that majored or minored in their assigned field. The percentage of teachers with their *main assignment in math* that have a major in math or math education varies from 46 percent in Idaho, and 50 percent in Alaska and California, to 98 percent in Pennsylvania and 94 percent in Minnesota. The data indicate that in some rural states and states with sharp increases in enrollments (e.g., California, Utah), it is more difficult to hire math teachers with a major in that field.

Secondary Science Teachers

- Eleven states have over 85 percent of secondary teachers (grades 7-12) with a major or minor in science or science education, based on SASS teacher survey data from 1994. At the same time, seven states have less than 70 percent of science teachers that have a major or minor. Thus, in these states over one-fourth of secondary science teachers do not have adequate preparation in that field.
- Nationally, 78 percent of all teachers with an assignment in science have a science major or minor. Among teachers with their main assignment in science, 74 percent have a major in science.

FIGURE 6 Percent of Mathematics and Science Teachers with Major or Minor in Field, Grades 7–12, 1994



NOTES: Teachers = Public school teachers with main or second assignment in subject in grades 7–12 departmentalized instruction.
Major/minor = Undergraduate or graduate degree major or minor in math or math education (science or science education).

SOURCE: NCES, Schools and Staffing Survey, 1993–94.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE 27 Mathematics and Science Teachers with Major in Assigned Field, Grades 7–12, 1994

	MAIN ASSIGNMENT		MAIN OR SECONO ASSIGNMENT	
STATE	Math % with Major in Math	Science % with Major in Science	Math % with Major or Minor	Science % with Major or Minor
Alabama	89	73	87	80
Alaska	50	79	57	76
Arizona	61	73	61	76
Arkansas	70	66	80	79
California	50	62	61	75
Colorado	65	78	70	85
Connecticut	84	90	88	95
Delaware	–	82	–	72
Dist. of Columbia	82	–	82	–
Florida	76	52	83	57
Georgia	82	68	81	69
Hawaii	69	74	62	77
Idaho	46	77	62	84
Illinois	82	77	89	85
Indiana	81	78	91	83
Iowa	74	86	92	86
Kansas	63	78	81	83
Kentucky	79	55	79	58
Louisiana	63	57	66	58
Maine	68	67	71	66
Maryland	73	86	77	87
Massachusetts	76	89	75	89
Michigan	61	73	79	80
Minnesota	94	97	93	94
Mississippi	72	73	82	77
Missouri	89	70	95	75
Montana	77	76	90	78
Nebraska	83	79	87	76
Nevada	74	88	81	87
New Hampshire	76	91	82	87
New Jersey	69	82	74	79
New Mexico	69	71	81	83
New York	84	85	89	87
North Carolina	79	73	79	71
North Dakota	87	85	92	89
Ohio	64	75	76	78
Oklahoma	74	62	88	69
Oregon	61	93	59	91
Pennsylvania	98	85	99	88
Rhode Island	81	94	90	89
South Carolina	72	74	71	77
South Dakota	67	72	84	75
Tennessee	59	52	69	60
Texas	65	70	87	82
Utah	55	66	74	76
Vermont	75	81	77	76
Virginia	69	67	76	74
Washington	49	83	56	84
West Virginia	80	76	89	78
Wisconsin	76	68	83	71
Wyoming	78	80	88	83
NATION	**72**	**74**	**80**	**78**

NOTES: – Data not available. Percent with major = Percent of assigned teachers with an undergraduate or graduate degree with a major in math (science field) or math education (science education). (See Appendix A of the 1997 report for standard errors.) Public school teachers in departmentalized instruction with main or second assignment in subject in grades 7 through 12.

SOURCE: NCES, Schools and Staffing Survey, 1993–94.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Figure 6 also shows the percentage of all secondary science teachers (grades 7-12) that have a science or science education major or minor. The survey asked teachers with one or more periods assigned to any science subject if they had a major or minor in any field of science (e.g., biology, chemistry, geology) or in science education. States that have over 85 percent of secondary science teachers with a major or minor in a science field or science education are: Connecticut, Minnesota, Oregon, Rhode Island, Massachusetts, North Dakota, Pennsylvania, Maryland, New Hampshire, Nevada, New York, and Iowa.

In Table 27, we can compare the preparation of teachers with *main assignment* in science with the preparation of *all* teachers of science, which includes any teacher assigned to a science subject (earth science, biology, chemistry, etc.) for one or more periods per day. In total, over three-fourths of all U.S. secondary science teachers have college academic preparation in science with a college major or minor. This means that 22 percent, or over 40 thousand teachers, do not have adequate preparation in science.

Teachers with Major/Minor versus Certification

The percentage of teachers with a major or minor in a field is typically significantly smaller than the percentage certified in the field, if we compare Tables 25, 26, and 27. For example, Indiana had 97 percent of grade 9-12 math teachers (Table 25), and 90 percent of grade 7-8 math teachers certified in 1998 (Table 26), but only 81 percent of the Indiana teachers had a major or minor in mathematics or math education (Table 27).

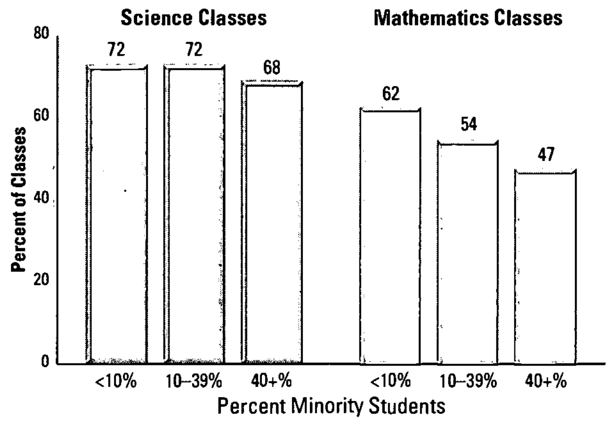
The data on certification reported in Tables 25 and 26 do not differentiate teachers with main assignment in the subject vs. those with second or third assignment to the subject. In many states, the certification rate varies substantially for teachers in their main teaching field as compared to teachers assigned to a second or third field. The rate of certification by field and percent of time assigned is displayed in more detailed tables available from the CCSSO website (www.ccsso.org).

Preparation of Teachers by Student Race/Ethnicity and Poverty Enrollment of School

In reporting indicators of the preparation of teachers in mathematics and science, we need to consider whether variation in teacher preparation is related to the family and community background of students. That is, do certain groups of students get better or less well prepared teachers?

Results from Weiss' 1993 survey of a nationally representative sample of elementary and secondary teachers provide statistics on teacher preparation by student race/ethnicity. Figure 7 shows that only 47 percent of mathematics teachers in classes with high minority enrollments have a degree in math or math education. In mathematics classes with less than 10 percent minority students, over 60 percent of teachers majored in mathematics. Thus, race/ethnicity of students does make a difference in quality of mathematics teachers they are assigned. In science classes, the preparation of teachers differs less according to student race/ethnic composition— in low-minority classes 72 percent of science teachers have science majors, whereas 68 percent of teachers have science majors in high-minority classes (Weiss, 1994).

Figure 7 ***Percentage of Grades 7-12 Science and Mathematics Classes Taught by Teachers with Major in Field, by Percentage of Minority Students in Class***



Source: Weiss, 1994.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Percentage of Secondary Teachers with Major or Minor in Field

	Low Poverty Schools	High Poverty Schools
Mathematics	79%	67%
Science (All)	88	71
Life Science	66	55
Physical Science	50	29

Source: Ingersoll & Gruber (1996); NCES, Schools and Staffing Survey, 1990-91

Data from the 1990-91 Schools and Staffing Survey analyzed by Ingersoll and Gruber (1996) inform us about the differences in preparation of teachers according to the socioeconomic status of students in schools, as measured by the percent of students at or below the poverty level. Overall, 27 percent of students in secondary mathematics classes in 1991 had a teacher without a major or minor in mathematics. In low-poverty schools only 21 percent had a poorly prepared teacher, while 33 percent of students in high-poverty schools had a teacher without a major or minor. In science, the disparity is even greater, with 29 percent of students in high-poverty schools being assigned a teacher without a major or minor in a science field as compared to only 12 percent of students in low-poverty schools.

As a national average, students who are taught in classes with high-minority and high-poverty enrollments have less chance of being taught by a teacher who is well prepared in mathematics or science. Unfortunately, this indicator is not available state by state from SASS due to the limitations on sample size. Many states could provide this kind of indicator of teacher preparation by student background for the districts or schools in a state. This information might be more useful to local educators than simply the state average for teachers with a major in their field.

Teachers' Professional Development

- **Hours of Professional Development in Field:** In 16 states, over 50 percent of eighth-grade students were in mathematics classes with teachers that received 16 or more hours of professional development in mathematics education in 1995-96. In science, 19 states had over 50 percent of eighth grade students in classes with teachers that received 16 or more hours of professional development in science education.
- Nationally, 48 percent of grade 8 math students and 57 percent of science students had teachers that received 16 or more hours of professional development in their teaching fields during the school year of 1995-96.

Professional standards for teaching mathematics (NCTM, 1991) and standards for teaching science (NRC, 1995) recommend that teachers have adequate course work preparation in the content areas they will be teaching, and in addition the professional organizations recommend ongoing professional development in the subject content and methods of teaching their assigned field and grade level. The 1996 NAEP Mathematics and Science Assessment teacher questionnaires ask teachers at grades 4 and 8 to report on their professional development in their teaching field for the previous 12 months.

Our state indicators reported in Table 28 focus on the amount of professional development in mathematics. From the 1996 NAEP data we show the percent of teachers in grades 4 and 8 that received 16 or more hours of professional development in mathematics education in the previous year. An average of 28 percent of teachers in grade 4 received more than 16 hours of professional development in teaching mathematics. Sixteen or more hours is used to indicate the proportion of teachers that received more extensive professional development in teaching mathematics. In five states (Arkansas, California, Nevada, Texas, and Vermont), over 40 percent of grade 4 teachers participated in 16 or more hours of mathematics professional development. The percent of grade 8 math teachers receiving higher levels of professional development varied by state from only 27 percent of New Mexico teachers to 70 percent of teachers in California and 69 percent in Kentucky.

In science education, the typical eighth grade science teacher received more hours of professional development than did mathematics teachers. The states varied from 67 percent of grade 8 teachers receiving 16 or more hours of development in science education to 36 percent of science teachers reporting this level of development in New Mexico.

Indicators of Race/Ethnicity and Gender in the Teaching Force

The current distributions and trends in the number of science and mathematics teachers by gender and race/ethnicity provide a basis for states and the nation to compare the characteristics of the current teaching force with goals of improving the match between students and teachers in terms of gender and race/ethnic characteristics.

National survey data (Weiss, 1994; NCES/SASS, 1996) show that minority science and mathematics teachers and female science teachers are vastly under represented, considering the student population in our schools. Oakes' (1990) analysis of teacher characteristics and student participation and opportunities in science and mathematics demonstrated that the rate of participation of minority and female students in science and mathematics is related to the characteristics of their teachers.

TABLE 28 *Professional Development of Teachers in Mathematics and Science Education (in Last Year), 1996 NAEP*

% RECEIVING 16 OR MORE HOURS PROFESSIONAL DEVELOPMENT

STATE	Grade 4, Mathematics	Grade 8, Mathematics	Grade 8, Science
Alabama	24%	45	57%
Alaska*	27	31	50
Arizona	22	43	44
Arkansas*	25	55	53
California	45	70	63
Colorado	21	42	44
Connecticut	22	47	51
Delaware	22	55	45
Dist. of Columbia	27	60	55
DDESS	14	38	–
DoDDS	28	52	–
Florida	30	61	61
Georgia	25	44	41
Guam	10	5	0
Hawaii	30	55	56
Indiana	13	30	39
Iowa*	18	35	46
Kentucky	34	69	63
Louisiana	31	40	40
Maine	28	41	48
Maryland	23	53	47
Massachusetts	38	68	67
Michigan*	22	44	41
Minnesota	24	50	54
Mississippi	37	60	42
Missouri	29	55	57
Montana*	28	55	53
Nebraska	23	36	42
Nevada*	41	–	–
New Jersey*	22	–	–
New Mexico	26	27	36
New York*	21	40	41
North Carolina	19	37	44
North Dakota	22	44	38
Oregon	24	38	47
Pennsylvania*	17	–	–
Rhode Island	21	37	50
South Carolina*	27	49	49
Tennessee	19	36	40
Texas	46	64	57
Utah	32	46	43
Vermont*	41	58	60
Virginia	30	50	41
Washington	33	47	56
West Virginia	20	46	59
Wisconsin	18	40	54
Wyoming	18	34	49
NATION	**28**	**48**	**57**

NOTES: – Data not available.

* Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

Data from Teacher Survey: During last year, time teachers spent in professional development workshops or seminars in mathematics (science) or mathematics education (science education). Percentages in table are percent of students at the grade taught by teachers giving these responses.

SOURCE: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Race/Ethnicity of Science and Mathematics Teachers

➢ Southeastern states, California, and Hawaii have the highest proportion of science and math teachers that are from minority populations. In most states, the percent minority teachers is one-third or less the percent minority students. The percentages of high school math and science teachers from race/ethnic minority groups have increased by one to two percentage points from 1990 to 1998.

Since our first state indicators report for 1990, CCSSO has reported state data on the race/ethnicity of high school science and mathematics teachers. As of 1998, we can examine state-by-state percentages of white and minority teachers by subject, as compared to their student populations; and we can observe any trends in increase or decrease in the proportion of minority teachers.

Table 29 ranks the states by the percentage of minority students to show comparisons with the percentage of minority teachers in several fields. States with the highest proportions of minority teachers in science and mathematics (over 15 percent) are in the Southeast states and Hawaii. Of 28 states with more than 20 percent minority enrollment, only Hawaii comes close to matching the proportions of minority teachers and students. There are not major differences between fields in the percent of teachers that are minorities, although chemistry and physics have slightly lower proportion of minority teachers in most states. A complete state-by-state disaggregation of teacher race/ethnicity by five race/ethnic groups — Black, Hispanic, Asian, American Indian, white— for each teaching field is available from CCSSO.

Minority Teachers in High School Math and Science: 1990 to 1998

	PERCENT MINORITY TEACHERS		
Field	1990	1994	1998
Mathematics	12%	14%	12%
Biology	11	13	12
Chemistry	7	9	8
Physics	5	6	6

The national trends in four high school fields, left, show small increases since 1990 in the total percent of teachers that are minority teachers.

We know that overall enrollment of minority students has increased in the U.S., and we know that trends are up in minority enrollments in mathematics and science. The number of minority teachers is increasing slowly, i.e., less than the rate of increase in math and science teachers, and not fast enough to match the enrollment of minority students. Currently, 36 percent of K-12 students in our public schools are students from minority populations, which is an increase of four percentage points since 1990.

States that made the most progress in increasing minority teachers since 1990 were: Texas, (up 2% in math, 5% in chemistry); California (up 4% in math and chemistry); Rhode Island (up 2% in math, 6% in biology); and Delaware (up 11% in chemistry).

TABLE 29 Minority Teachers in Mathematics and Science by Minority Students in State, 1990 to 1998

	% MINORITY STUDENTS		% MINORITY TEACHERS					
			Math		Biology		Chemistry	
State	1998	Change 1990 to '98	1998	Change 1990 to '98	1998	Change 1990 to '98	1998	Change 1990 to '98
Maine	3%	+1%	1%	+1%	0%	0%	0%	0%
Vermont	3	+1	0.3	–	1	–	2	–
New Hampshire	4	+1	–	–	–	–	–	–
West Virginia	5	0	1	–	2	–	1	–
Iowa	8	+2	1	+1	1	+1	1	0
Utah	11	+4	3	+1	1	-1	1	0
North Dakota	11	+3	0	0	1	0	0	-1
Wyoming	11	+2	0.4	–	1	–	2	–
Kentucky	11	+1	2	0	3	0	1	0
Idaho	12	+5	1	-1	1	0	0	0
Montana	13	+6	1	0	0.4	-1	0	0
Minnesota	13	+4	2	–	2	–	1	–
Nebraska	14	+4	1	–	2	–	1	–
Indiana	15	+1	3	0	3	0	3	+1
Oregon	15	+4	3	–	5	–	–	–
South Dakota	16	+7	0.4	–	0.4	–	1	–
Wisconsin	17	+3	–	–	–	–	–	–
Ohio	18	+2	4	+1	5	0	4	+2
Kansas	18	+3	–	–	–	–	–	–
Missouri	19	+2	5	–	5	–	3	–
Pennsylvania	20	+3	–	–	–	–	–	–
Rhode Island	22	+6	4	+2	8	+6	6	+1
Massachusetts	22	+4	7	–	7	–	5	–
Washington	23	+6	–	–	–	–	–	–
Michigan	24	+2	–	–	–	–	–	–
Tennessee	25	+2	–	–	–	–	–	–
Arkansas	26	+1	9	-1	10	0	5	-1
Colorado	28	+4	–	–	–	–	–	–
Connecticut	28	+4	5	+2	6	+3	3	+1
Oklahoma	31	+6	5	0	6	+1	4	0
Virginia	32	+5	–	–	–	–	–	–
Nevada	35	+11	8	-1	9	+2	6	+3
NATION	**36**	**+4**	**12**	**+1**	**12**	**+2**	**8**	**+1**
North Carolina	36	+3	14	0	16	0	9	-2
Delaware	36	+5	6	-2	2	-2	11	+11
Alaska	37	+5	–	–	–	–	–	–
Illinois	37	+3	–	–	–	–	–	–
Alabama	38	+1	16	-2	18	-1	14	-3
Georgia	42	+3	19	–	22	–	–	–
Maryland	43	+5	–	–	–	–	–	–
Florida	43	+6	–	–	–	–	–	–
Arizona	43	+7	–	–	–	–	–	–
New York	44	+6	–	–	–	–	–	–
South Carolina	44	+2	–	–	–	–	–	–
Louisiana	50	+3	–	–	–	–	–	–
Mississippi	52	+1	22	-4	25	-5	24	-3
Texas	54	+4	20	+2	21	+4	16	+5
California	61	+8	22	+4	19	+3	16	+4
New Mexico	61	+3	22	+2	17	-2	11	-8
Hawaii	75	-2	–	–	–	–	–	–
Dist. of Columbia	96	0	–	–	–	–	–	–
Virgin Islands	99	-1	94	–	88	–	80	–
Puerto Rico	100	–	–	–	–	–	–	–
DoDEA	–	–	10	–	7	–	0	–
New Jersey	–	–	9	-1	9	+2	5	0

NOTES: – Data not available.
Grades 9–12 teachers assigned one or more period to subject.
Percent minority teachers = Asian/Pacific Islander, Black, Hispanic, and American Indian teachers.

SOURCES: (Teachers 9-12) State Departments of Education, 1997-98; (Students K–12) NCES, Common Core of Data, Fall 1996.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Gender of Science and Mathematics Teachers

➢ Female teachers of high school mathematics and science have significantly increased in numbers since 1990. For example, in 1998, 56 percent of mathematics teachers in grades 9-12 were women, and 44 percent of chemistry teachers were women.

Figure 8 provides a state-by-state bar graph of the change in percentage of mathematics teachers that are female from 1990 to 1998. The distribution of mathematics teachers by gender varies widely by state, from 33 percent female in Oregon to 56 percent in Oklahoma to 70 percent in Mississippi, and almost 70 percent in North Carolina and Alabama.

Over the past eight years, a majority of states have increased the percentage of females in math teaching, with the percentage female going up by 10 percentage points in several states, e.g., Delaware, Rhode Island, Montana, Minnesota.

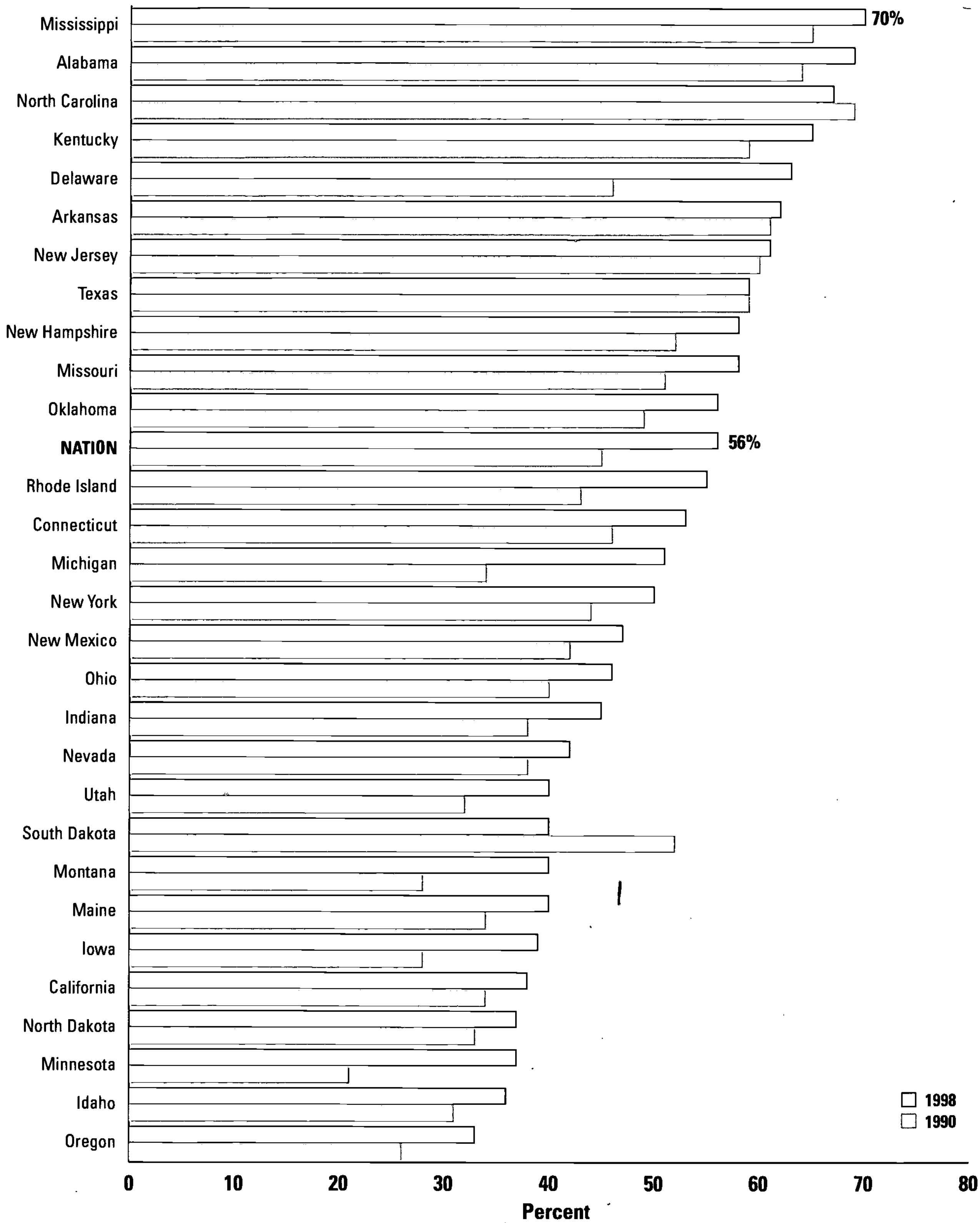
State data aggregated to the nation indicate that female teachers in mathematics and science in high schools have increased significantly in all fields. For example, the percent female among mathematics teachers increased 11 percentage points in eight years and increased 13 points in biology. The gender breakdown of math and science teachers by subject since 1990 shows the following trends.

Female Teachers in High School Math and Science: 1990 to 1998

Field	1990	1994	1998
Mathematics	45%	49%	56%
Biology	37	42	50
Chemistry	34	37	44
Physics	22	24	29

The gender distribution of mathematics and science teachers by state shows that geographic region is associated with the pattern across states. Fourteen of the 35 reporting states have more female than male mathematics teachers, and eight are southeastern states. Across all fields, southeastern states have the highest proportion of female high school teachers, and states in the Midwest have the lowest proportion. The state map of chemistry teachers by gender in Figure 9 shows the regional pattern. Five states that reported over 55 percent female chemistry teachers are all are in the southeast. Sixteen states have from 35 to 54 percent female chemistry teachers, and all are in the southeast or northeast regions of the U.S. Data on high school teachers in other fields by state confirm this pattern of regional differences in math and science teachers.

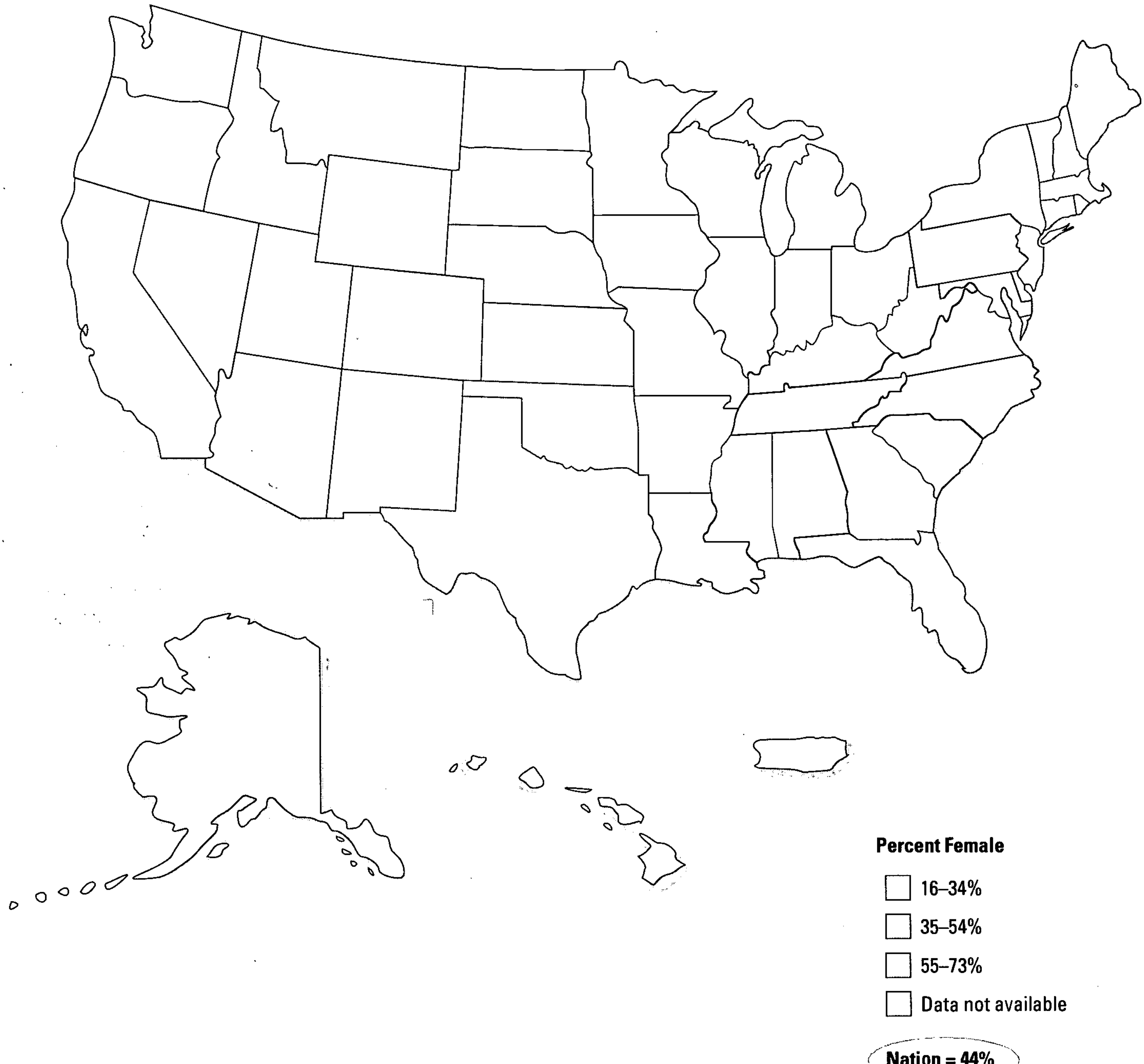
FIGURE 8 Gender of Mathematics Teachers (Percent Female), 1990 to 1998



NOTE: Grades 9-12 teachers assigned one or more period to subject.

SOURCE: State Departments of Education, Data on Public Schools, 1997-98.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

FIGURE 9 **Gender of Chemistry Teachers, Percent Female by State, 1998**



NOTES: Washington, D.C. = n/a
DoDEA = 60%
Virgin Islands = 40%

Grades 9–12 teachers assigned one or more period to chemistry.

SOURCE: State Departments of Education, Data on Public Schools, 1997-98.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Age Distribution of Science and Mathematics Teachers

> The percentage of mathematics teachers and physics teachers that are over age 50 has gone up five points since 1990. At the same time, several states have significantly increased the percent of teachers under age 30 in mathematics and science.

With 1997-98 data, we have eight-year trends in teacher age by field by state. Teacher data are from state education information systems and comprise the universe of teachers. Percentages by age categories provide useful information for estimating possible shortage fields as teachers near retirement age or leave teaching, and reviewing the flow of new, younger teachers into these fields.

Field	1990	1994	1998
Mathematics	19%	23%	24%
Biology	20	24	25
Chemistry	22	26	28
Physics	23	27	28

Teachers over Age 50 in High School Math and Science: 1990 to 1998

Table 30 shows the percentage of high school mathematics teachers in each state by percent over age 50 and percent under age 30, with the states ordered by percentage under age 30. Nevada, North Carolina, Georgia, Alabama, and Arkansas have over 20 percent of mathematics teachers under 30, and have increased their percentage of younger teachers by more than 4 points since 1990. Other states increasing the proportion of mathematics teachers under 30 are New Jersey, Kentucky, Delaware, Montana, Minnesota, and Rhode Island.

The map in Figure 10 shows the percent of high school mathematics teachers over age 50, and the map reveals that states in the northeast and Midwest have an aging teaching force, with seven states over 30 percent— New Hampshire, Minnesota, California, Massachusetts, New York, Connecticut, and DoDEA have over 30 percent older math teachers. The percentage of teachers over 50 has gone up over five points since 1990 (see Table 30).

According to NCES projections, attrition rates from elementary and secondary teaching average 10 percent per year, but the period 1995 to 2000 will show higher rates of teacher retirement (NCES, 1997). States that have flat or declining populations over the past two decades, particularly northeastern and Midwestern states, have higher proportions of older science and mathematics teachers. Many of the teachers over 50 years of age in these states were hired in the 1960s when school enrollments were increasing.

Table 31 shows the percentage of high school physics teachers in each state over age 50 and under age 30, with the states ordered by percentage under age 30. Five states have over 20 percent of teachers under 30, and six states have less than 10 percent under 30. Several states have increased the proportion of younger teachers since 1990, including Hawaii, Delaware, Arkansas, Mississippi, New Mexico, and Minnesota.

Twelve states have over one-third (33 percent) of their physics teachers over age 50 including Indiana, Utah, North Dakota, Minnesota, New Hampshire, New York, Connecticut, Massachusetts, and Maine. The percentage of physics teachers over age 50 has gone up over 10 points since 1990 in most states, and the highest rates are in Utah, North Dakota, Montana, New York, Ohio, Rhode Island, Connecticut, and Maine. These states are facing shortages of physics teachers due to impending retirements of many of their teachers.

TABLE 30 Age of Mathematics Teachers, 1990 to 1998

STATE	% Under Age 30 % 1998	% Under Age 30 Change 1990 to '98	% Age 50 & Over % 1998	% Age 50 & Over Change 1990 to '98
Nevada	26%	+15%	18%	-4%
North Carolina	24	+4	25	+15
Georgia	24	–	19	–
Alabama	22	+9	20	+7
Arkansas	21	+7	19	+4
Indiana	19	+4	28	+11
New Jersey	19	+9	19	0
South Dakota	19	+1	29	+7
Missouri	19	0	29	+14
Nebraska	19	–	28	–
Delaware	18	+9	30	+2
Kentucky	18	-1	21	+11
Iowa	18	+3	30	+12
Utah	17	+1	26	+4
Ohio	17	+1	28	+15
Wyoming	17	–	25	–
Montana	17	+4	29	+10
Oklahoma	16	-1	18	+7
Minnesota	16	+6	35	+6
NATION	**15**	**+2**	**24**	**+5**
Mississippi	15	+1	29	+12
New Hampshire	14	–	36	–
Idaho	14	-3	28	+9
North Dakota	14	-8	25	+12
Massachusetts	14	–	39	–
California	13	0	32	+6
Virgin Islands	13	–	27	–
Oregon	12	0	28	+6
New York	12	+3	37	+17
Maine	12	-2	30	+15
Rhode Island	12	+9	29	+14
Vermont	12	–	29	–
New Mexico	10	-2	26	+6
Connecticut	9	+3	41	+21
West Virginia	7	–	28	–
DoDEA	3	–	53	–

NOTES: – Data not available. Grades 9-12 teachers assigned one or more period to subject.

SOURCE: State Departments of Education, Data on Public Schools, 1997-98.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

FIGURE 10 Mathematics Teachers Age 50 and Over, by State, 1998

NOTES: Washington, D.C. = n/a
DoDEA = 53%
Virgin Islands = 27%

Grades 9–12 teachers assigned one or more period to mathematics.

SOURCE: State Departments of Education, Data on Public Schools, 1997-98.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE 31 *Age of Physics Teachers, 1990 to 1998*

STATE	% Under Age 30		% Age 50 & Over	
	% 1998	Change 1990 to '98	% 1998	Change 1990 to '98
Nevada	31%	+24%	9%	-11%
Delaware	26	+9	29	0
Virgin Islands	20	–	40	–
North Carolina	19	+4	28	+11
Kentucky	19	+3	24	+12
New Jersey	19	+12	22	-6
Arkansas	18	+5	17	-5
Alabama	17	+1	22	+4
Nebraska	16	–	30	–
Indiana	16	+3	35	+10
New Mexico	15	+5	18	+1
Utah	15	+5	35	+16
Iowa	14	-2	31	+10
North Dakota	14	0	34	+18
Montana	14	-2	31	+14
South Dakota	14	-8	31	+13
Missouri	14	0	26	+5
NATION	**14**	**+3**	**28**	**+5**
Minnesota	13	+5	35	+2
Mississippi	13	+4	33	+13
New Hampshire	12	–	46	–
Oklahoma	12	+5	28	+10
California	11	-3	28	+6
Massachusetts	11	–	45	–
New York	10	+3	42	+15
Idaho	9	-4	29	-2
Ohio	9	-4	34	+20
Rhode Island	9	+7	38	+20
West Virginia	7	–	29	–
Connecticut	5	-2	47	+18
Maine	5	-8	41	+20
Vermont	4	–	32	–
DoDEA	0	–	25	–

NOTES: — Data not available.
Grades 9-12 teachers assigned one or more period to subject.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

New Teachers in High School Math and Science

- Of the 27 reporting states for 1998, five states had more than 10 percent of their high school mathematics teaching force that are new, inexperienced teachers. Another 14 states reported that new teachers comprised from five to nine percent of the math teachers in the state. The national figure was eight percent new mathematics teachers in high schools.
- In high school science, only two states (Idaho and North Carolina) reported more than 10 percent of science teachers were new and inexperienced. Eleven states had between five and nine percent new science teachers. The national figure was seven percent new science teachers in high schools.

An important indicator of teacher supply in science and mathematics is the number of new teachers entering teaching. The data on age of the current teaching force by state show that almost half the states will have a third to more of their high school science and math teachers retiring in the next few years. The data also show that several states have significant numbers of younger teachers under age 30. With the current increases in student enrollments experienced by most states additional new teachers will be needed in science and mathematics. In 1997-98, 27 states were able to report data on the number of new teachers in science and mathematics. Table 32 provides an indicator of the proportion of high school science and mathematics teachers that are new, first-year teachers with no experience teaching.

States with high percentages of new teachers in *mathematics* last year were: Alabama (11%), Idaho (15%), Kentucky (11%), Nevada (11%), and North Carolina (20%). In terms of numbers of teachers, districts in the states of Texas, North Carolina, and California hired the most new teachers. Overall growth in the teaching force is an important factor in numbers of new teachers, and several of the states with more new teachers were among the states with sharply increased size of the teaching force in the 1990s, as reported in Table 23.

States with the highest percentages of new high school science teachers in 1997-98 were Idaho, North Carolina, and Nevada. In numbers of new science teachers, Texas (almost 1,000), New York, and California had the most new teachers.

TABLE 32 New Teachers in High School Science and Mathematics, 1996 to 1998

	NEW FIRST-YEAR TEACHERS					
	MATH			SCIENCE		
STATE	Total, 1998	% New	% Change 1996 to '98	Total, 1998	% New	% Change 1996 to '98
Alabama	193	11%	+2%	94	6%	+1%
Alaska	–	–	–	–	–	–
Arizona	–	–	–	–	–	–
Arkansas	153	5	-3	71	6	0
California	833	8	+2	427	6	+2
Colorado	–	–	–	–	–	–
Connecticut	48	3	+1	41	2	0
Delaware	13	6	+4	5	4	-1
Dist. of Columbia	–	–	–	–	–	–
DoDEA	0	0	–	0	0	–
Florida	–	–	–	–	–	–
Georgia	–	–	–	–	–	–
Hawaii	–	–	–	–	–	–
Idaho	132	15	0	87	12	0
Illinois	–	–	–	–	–	–
Indiana	97	4	0	102	4	+1
Iowa	46	3	-1	45	3	0
Kansas	–	–	–	–	–	–
Kentucky	217	11	+4	82	4	0
Louisiana	–	–	–	–	–	–
Maine	17	3	0	18	2	+1
Maryland	–	–	–	–	–	–
Massachusetts	140	5	+1	92	3	0
Michigan	–	–	–	–	–	–
Minnesota	119	6	+2	98	6	+2
Mississippi	89	8	-6	80	6	0
Missouri	–	–	–	–	–	–
Montana	–	–	–	–	–	–
Nebraska	–	–	–	–	–	–
Nevada	76	11	–	49	8	–
New Hampshire	–	–	–	–	–	–
New Jersey	–	–	–	–	–	–
New Mexico	40	5	0	17	2	0
New York	399	5	+3	463	4	+2
North Carolina	789	20	+6	356	12	+2
North Dakota	21	5	+4	18	3	0
Ohio	243	6	+2	167	5	+2
Oklahoma	115	6	0	87	5	+1
Oregon	32	3	0	8	2	-1
Pennsylvania	–	–	–	–	–	–
Puerto Rico	–	–	–	–	–	–
Rhode Island	–	–	–	–	–	–
South Carolina	–	–	–	–	–	–
South Dakota	18	4	-14	25	4	-1
Tennessee	–	–	–	–	–	–
Texas	1,790	8	0	988	6	-1
Utah	54	5	-9	45	5	-8
Vermont	21	6	–	18	5	–
Virgin Islands	2	4	–	–	–	–
Virginia	–	–	–	–	–	–
Washington	–	–	–	–	–	–
West Virginia	22	2	–	8	1	–
Wisconsin	121	5	+2	75	3	0
Wyoming	–	–	–	–	–	–
NATION		8	+1		7	+2

NOTES: – Data not available
New = No experience

SOURCE: State Departments of Education, Data on Public Schools, 1997–98.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Chapter Four

Indicators of Context and Conditions for Teaching

Number of Students per Teacher in Mathematics and Science

Average Class Size in Mathematics and Science

Science and Mathematics Instructional Resources and Materials

State data on course enrollments show that nationally the proportion of public high school students taking a mathematics course increased from 87 percent in 1992 to 88 percent in 1998. The 88 percent enrollment figure represents a total of 11.3 million high school students taking mathematics. The total is an increase of 1.3 million students taking mathematics, while the high school teaching force in mathematics increased by 10,300 teachers (FTE) over the four-year period.

In science, total enrollments increased from 75 percent of high school students taking science in 1992 to 78 percent in 1998, which is an increase of 1.33 million students. During the period, the total number of teachers in high school science increased from 91,300 to 114,600 teachers (FTE). The following table summarizes change in numbers of teachers and students over six years.

POLICY ISSUES

Do school systems have a sufficient number of science and mathematics teachers to provide high quality teaching to students?

Do teachers have adequate resources and materials to meet standards for science and mathematics instruction?

	1992		1998	
Grades 9-12	Math	Science	Math	Science
Students Enrolled	10.0 mil.	8.65 mil	11.3 mil.	9.98 mil.
Teachers (FTE)	98,400	91,300	108,700	114,600

These data give us a picture of the overall size of mathematics and science education at the high school level, and inform us that the total enterprise is increasing significantly each year. To provide useful information to policy-makers and educators, we would like to have more specific indicators about the conditions for teaching in science and mathematics in our states, districts, and schools.

Number of Students per Teacher in Mathematics and Science

- In high school mathematics, six states have student/teacher ratios of over 125 to 1, while 10 states have ratios of less than 100 to 1.
- In chemistry teaching, six states have student/teacher ratios of over 125 to 1, and 13 states have ratios of less than 100 to 1.

An indicator of conditions for teaching and learning mathematics and science is a ratio of the number of students in each subject to the number of teachers. This indicator, shown in Table 33, provides a basic picture of how many students the average teacher in a state must work with during a given school day or week, and the state gains a general estimate of the current supply of teachers for the enrollment demands from students. To estimate the ratio, we use the number of FTE teachers and the total number of students taking mathematics and science courses in high school.

Table 33 reports state students per teacher ratios for math and three science subjects for 1997-98. A high ratio (e.g., California, 139 students per math teacher) means that teachers have to work with more students on a daily basis than teachers in a state with a lower ratio (e.g., Alabama, 82 students per math teacher). Several states have high students per teacher in each science field, including Michigan, California, Kentucky, and Utah, while several have low ratios Oklahoma, Texas, New York, and Massachusetts. In chemistry, the student teacher ratios vary from a high of 184 students per FTE teacher in Michigan to a low of 72 students per teacher in Oklahoma.

TABLE 33 Students per Teacher in Mathematics and Science, Grades 9–12

STATE	STUDENTS/FTE TEACHER Mathematics	Biology	Chemistry	Physics
Alabama	82	82	71	69
Alaska	–	–	–	–
Arizona	–	–	–	–
Arkansas	83	102	100	151
California	139	133	128	120
Colorado	–	–	–	–
Connecticut	91	81	79	77
Delaware	126	155	187	49
Dist. of Columbia	–	–	–	–
DoDEA	–	–	–	–
Florida	–	–	–	–
Georgia	–	–	–	–
Hawaii	–	–	–	–
Idaho	110	111	106	79
Illinois	–	–	–	–
Indiana	107	101	94	82
Iowa	–	–	–	–
Kansas	–	–	–	–
Kentucky	115	126	124	113
Louisiana	125	109	146	176
Maine	–	–	–	–
Maryland	–	–	–	–
Massachusetts	94	67	63	57
Michigan	68	137	184	174
Minnesota	102	103	98	90
Mississippi	121	118	93	70
Missouri	113	103	96	72
Montana	–	–	–	–
Nebraska	86	93	92	66
Nevada	116	101	121	91
New Hampshire	–	–	–	–
New Jersey	–	–	–	–
New Mexico	116	108	119	94
New York	102	59	74	68
North Carolina	118	119	110	90
North Dakota	88	96	91	57
Ohio	133	118	106	93
Oklahoma	79	77	72	50
Oregon	124	123	–	–
Pennsylvania	–	–	–	–
Puerto Rico	–	–	–	–
Rhode Island	–	–	–	–
South Carolina	–	–	–	–
South Dakota	100	95	98	59
Tennessee	–	–	–	–
Texas	91	67	89	72
Utah	128	103	151	177
Vermont	80	68	59	50
Virgin Islands	108	77	88	16
Virginia	–	–	–	–
Washington	–	–	–	–
West Virginia	86	68	99	77
Wisconsin	133	120	115	109
Wyoming	–	–	–	–

NOTES: – Data not available.
Students per teacher ratio based on number of students enrolled in subject divided by estimated number of FTE teachers assigned to subject. Delaware: main assignment only.

SOURCE: State Departments of Education, Data on Public Schools, 1997–98.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

Average Class Size in Mathematics and Science

- ➢ Class size in high school mathematics varies across the states from 18 students per class to 28 students per class, with the average class at 23 students.
- ➢ Science classes in high schools vary by state from 18 students per class to 29 students per class, with the average at 24 students.

Data from the 1994 Schools and Staffing Survey provide a state indicator of average class size in high school mathematics and science. This indicator gives a picture of what the typical teacher deals with in instructing high school science or mathematics classes.

Figure 11 indicates that the average mathematics class size varies by state from 18 students per class in Montana, South Dakota, and Iowa to 28 students per class in Utah and California. Thus, high school mathematics teachers work with over 50 percent larger classes in several high-growth states. Also, Figure 11 indicates that the average science class varies by state from 18 students per class in Wyoming and 19 students in Nebraska and Montana to 29 students in Utah and California.

Instructional Resources for Science and Mathematics

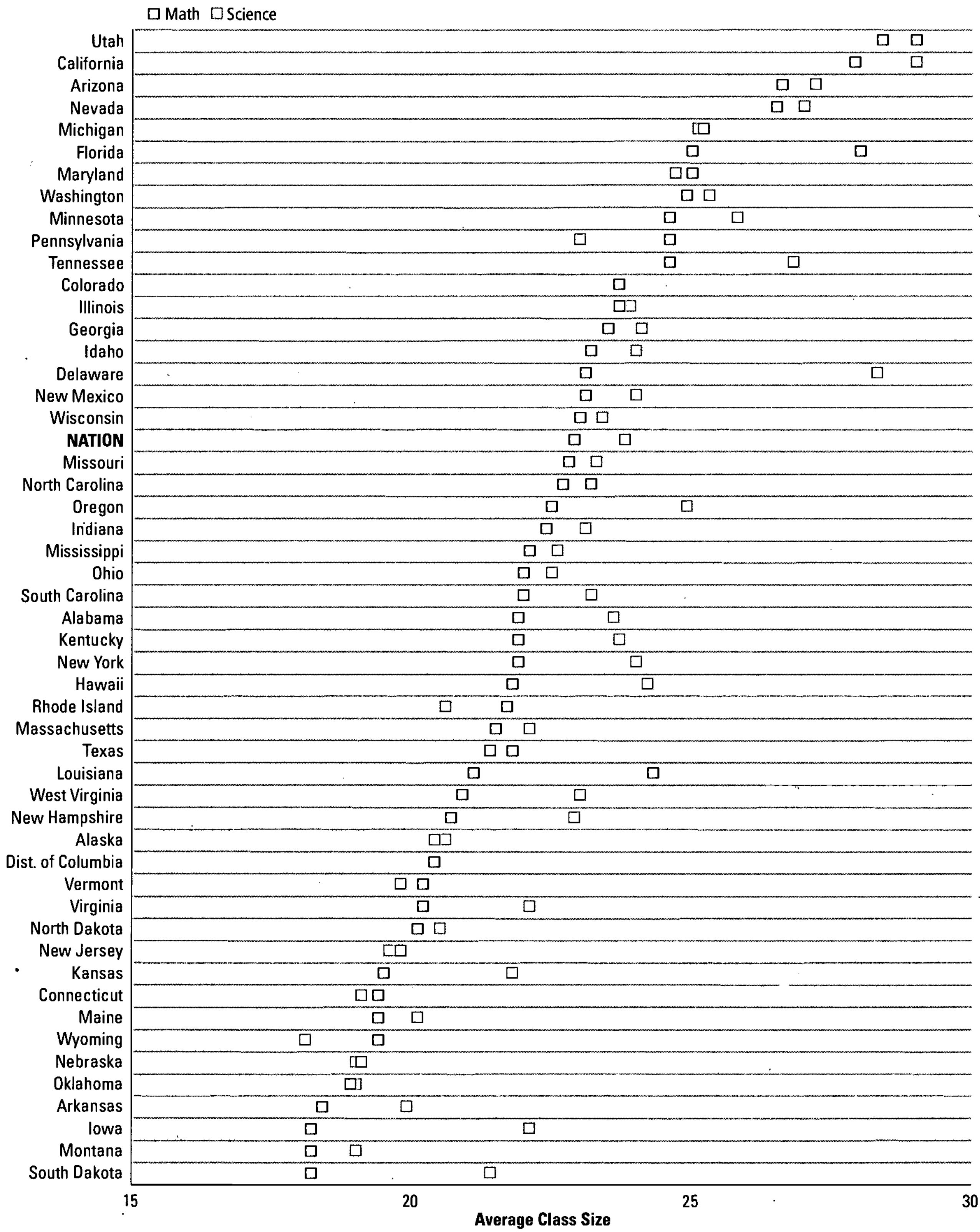
- ➢ In 1996, 64 percent of grade 4 students' classrooms had one or more computer available in the classroom available for mathematics or science instruction. In grade 8 mathematics, only 31 percent of students had a computer available in the classroom. In science at grade 8, 38 percent of students have a computer in the class, but in half the students' classes computers are not used in science instruction.
- ➢ The average elementary school spent about 50 cents per student on science consumable supplies (e.g., chemicals, batteries, glassware) in 1993, and the average middle school spent less than one dollar per student on science supplies.

The NAEP 1996 teacher questionnaire asked teachers to report on the availability of computers for instruction and their primary use in the classroom. The results by state for grade 4 classes are reported in Table 34. A majority of grade 4 classes (64 percent) have one or more computers in the classroom. Another 30 percent of teachers reported computers are available in a computer laboratory room in the school, and in six percent of students' classes no computers were available for student use. In three states, over 20 percent of classes had no computers.

In grade 4 mathematics, over 40 percent of reachers reported the primary use of computers in instruction was in students playing mathematical learning games. Another 27 percent of classes use computers primarily for drill and practice in mathematics.

Data on computers for grade 8 mathematics in Table 35 show that 26 percent of students have no computers available in their classroom, and 31 percent have one or more computers in the classroom. The remaining teachers reported computers are available in a computer lab. Among the teachers reporting some use in instruction, 18 percent of grade 8 classes primarily use them for drill and practice, and 13 use them for simulations and applications.

FIGURE 11 Average Class Size in High School Mathematics and Science, 1994



SOURCE: NCES Schools and Staffing Survey, Public School Teachers, 1993–94.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE 34 Availability and Use of Computers in Mathematics Instruction, Grade 4, 1996 NAEP

	COMPUTER AVAILABILITY % OF STUDENTS			PRIMARY COMPUTER USE % OF STUDENTS	
STATE	None	One per Classroom	Two or More per Classroom	Drill and Practice	Playing Mathematical/ Learning Games
Alabama	10%	42%	30%	40%	40%
Alaska*	7	21	39	21	45
Arizona	12	22	19	30	36
Arkansas*	9	20	18	50	19
California	6	25	30	24	47
Colorado	4	31	29	34	37
Connecticut	7	34	41	28	40
Delaware	18	33	16	18	35
Dist. of Columbia	16	30	19	30	33
DDESS	6	14	51	35	38
DoDDS	1	23	66	13	59
Florida	4	28	52	38	38
Georgia	3	31	45	42	36
Guam	20	0	3	43	8
Hawaii	8	46	30	19	40
Indiana	1	14	42	52	30
Iowa*	3	35	30	38	47
Kentucky	4	24	39	31	36
Louisiana	21	29	14	32	24
Maine	7	42	26	23	45
Maryland	5	17	30	40	29
Massachusetts	6	37	27	22	44
Michigan*	8	34	28	31	39
Minnesota	5	27	16	34	40
Mississippi	20	12	16	35	18
Missouri	12	31	14	28	39
Montana*	5	27	27	21	47
Nebraska	2	35	35	47	40
Nevada*	10	32	14	31	42
New Jersey*	14	43	13	30	33
New Mexico	11	25	34	22	48
New York*	13	27	25	31	35
North Carolina	6	22	35	34	34
North Dakota	2	29	28	34	45
Oregon	8	35	27	26	38
Pennsylvania*	13	21	28	30	29
Rhode Island	13	44	33	22	45
South Carolina*	8	30	19	36	30
Tennessee	9	33	40	32	40
Texas	7	24	22	37	33
Utah	7	15	16	31	39
Vermont*	7	20	47	18	38
Virginia	3	34	32	38	45
Washington	5	27	34	27	42
West Virginia	2	8	70	59	22
Wisconsin	5	24	28	28	46
Wyoming	3	11	24	35	38
NATION	**6**	**35**	**29**	**27**	**41**

NOTES: Other availability = in computer lab; Other use = demonstrate new topics, simulations. Data from teacher reports on computer availability and primary use. * Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

SOURCE: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

In grade 8 science, the data in Table 36 show that one or more computers are available in 38 percent of the students' classrooms. Nationally, 17 percent of students have no computers available, and the state percentages of students with no computers available vary from 50 percent of students in Mississippi to only seven percent of students in Alaska, Kentucky, Maryland, and Nebraska. In science instruction, the primary use is for simulations and modeling, and second for data analysis and other applications. In 46 percent of students classes, the computers are not used for instructional purposes.

A 1993 national survey on science and mathematics education (Weiss, 1994) supported by NSF provided national data on availability of instructional materials and resources for science. The nationally-representative survey asked elementary school principals and middle school and high school department heads to report on school conditions and support for science and math teaching and the availability and use of materials and resources. The survey included specific questions on the amount of money that was spent annually on science and mathematics books, materials, supplies and equipment.

The average elementary school spent only 51 cents per student on science consumable supplies (e.g., chemicals, batteries, glassware), and the typical middle school spent only 88 cents per student. In mathematics, the average elementary school spent only $1.00 per student on math manipulatives and other materials, and middle schools averaged only 40 cents per student on mathematics materials.

The average school spent only $50 on science computer software and $100 on mathematics software, and we know that the price of one piece of software is about $100. These data on average expenditures clearly show why teachers reported that lack of resources and materials is a key problem in science instruction.

Annual Expenditures for Resources and Materials, 1993

		Average annual spending	
Computer software:	Math	$100.00	per school
	Science	50.00	
Science supplies:	Elementary	$0.51	per student
	Middle	0.88	
Math manipulatives:	Elementary	$1.00	per student
	Middle	0.40	

Source: Weiss, 1994

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TABLE 35 Availability and Use of Computers in Mathematics Instruction, Grade 8, 1996 NAEP

	COMPUTER AVAILABILITY % OF STUDENTS			PRIMARY COMPUTER USE % OF STUDENTS	
STATE	None	One per Classroom	Two or More per Classroom	Drill and Practice	Simulations and Applications
Alabama	31%	21%	12%	22%	5%
Alaska*	11	28	22	4	8
Arizona	25	22	10	12	15
Arkansas*	40	12	11	19	5
California	22	21	12	4	12
Colorado	12	19	8	15	15
Connecticut	22	13	7	12	18
Delaware	45	20	11	2	10
Dist. of Columbia	17	10	32	24	26
DDESS	2	12	64	21	21
DoDDS	11	22	36	4	21
Florida	21	26	18	17	12
Georgia	15	27	14	18	10
Guam	53	0	8	25	0
Hawaii	20	26	10	8	5
Indiana	19	12	11	18	14
Iowa*	11	22	10	7	18
Kentucky	5	22	15	15	23
Louisiana	43	10	10	17	3
Maine	13	23	11	6	19
Maryland*	7	8	5	37	16
Massachusetts	23	19	5	5	14
Michigan*	23	19	8	6	14
Minnesota	10	21	8	8	21
Mississippi	37	15	7	24	2
Missouri	18	13	14	16	16
Montana*	6	14	24	7	35
Nebraska	12	24	7	6	14
New Mexico	32	21	9	16	7
New York*	28	5	6	12	15
North Carolina	12	16	11	27	16
North Dakota	13	20	10	14	20
Oregon	22	26	8	2	16
Rhode Island	15	7	0	6	13
South Carolina *	21	20	11	26	5
Tennessee	22	24	30	21	8
Texas	21	21	13	26	14
Utah	32	16	8	13	8
Vermont*	11	27	18	10	25
Virginia	8	20	8	22	21
Washington	18	29	13	7	17
West Virginia	23	12	17	20	2
Wisconsin*	12	19	5	8	19
Wyoming	10	19	22	13	10
NATION	26	19	12	18	13

NOTES: Other availability = in computer lab;
Other use = demonstrate new topics, math/learning games.
Data from teacher reports on computer availability and primary use.
* Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

SOURCE: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

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TABLE 36 *Availability and Use of Computers in Science Instruction, Grade 8, 1996 NAEP*

STATE	COMPUTER AVAILABILITY % OF STUOENTS None	One per Classroom	Two or More per Classroom	PRIMARY COMPUTER USE % OF STUOENTS Simulations and Modeling	Oata Analysis/ Other Applications	Not Used
Alabama	29%	23%	15%	19%	7%	54%
Alaska*	7	34	14	23	25	36
Arizona	21	27	9	24	25	46
Arkansas*	44	25	4	8	10	66
California	18	26	22	32	30	39
Colorado	13	21	4	30	26	32
Connecticut	17	24	7	19	31	45
Delaware	38	14	9	13	13	68
Dist. of Columbia	14	8	42	12	41	23
DDESS	0	14	45	23	38	23
DoDDS	18	25	36	14	30	38
Florida	19	30	19	22	25	41
Georgia	13	35	8	20	18	44
Guam	44	19	0	7	21	58
Hawaii	9	45	22	12	22	45
Indiana	15	17	6	20	23	48
Iowa*	9	34	8	28	22	37
Kentucky	7	29	11	18	33	30
Louisiana	47	19	3	15	11	67
Maine	9	29	6	13	31	32
Maryland*	7	14	4	30	36	36
Massachusetts	16	27	10	17	27	49
Michigan*	24	16	3	12	13	53
Minnesota	10	24	2	30	19	39
Mississippi	50	17	2	6	11	73
Missouri	15	24	10	24	20	47
Montana*	8	26	12	25	31	37
Nebraska	7	35	10	32	26	30
New Mexico	23	25	8	21	16	48
New York*	26	10	10	12	20	51
North Carolina	13	15	11	17	33	33
North Dakota	12	29	8	29	20	31
Oregon	10	32	9	23	26	36
Rhode Island	13	10	11	22	24	44
South Carolina*	31	20	6	14	8	54
Tennessee	24	20	28	24	19	44
Texas	21	30	12	25	21	43
Utah	32	18	8	20	13	58
Vermont*	9	33	16	18	39	35
Virginia	10	20	10	17	24	43
Washington	11	30	16	25	25	38
West Virginia	23	20	15	20	14	55
Wisconsin*	9	29	7	22	20	41
Wyoming	9	29	27	44	42	20
NATION	**17**	**22**	**16**	**26**	**20**	**46**

NOTES: Other availability = in computer lab
Other use = drill and practice, science/learning games, word processing
Data from teacher reports on computer availability and primary use
* Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

SOURCE: NCES, NAEP 1996 Science Cross-State Data Compendium for the Grade 8 Assessment, May 1998 (see for standard errors).
Council of Chief State School Officers, State Education Assessment Center, Washington, OC, 1999.

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Use of Science and Mathematics Indicators to Analyze Policies

Educators and policymakers who read reports providing statistical indicators on education are faced with the question of how to interpret the statistics in relation to current questions about the quality of education and how to use the indicators to examine current and proposed policy initiatives. The science and mathematics indicators outlined in this report can be helpful in analyzing education policies at state, national, and local levels. Following are suggestions for use of the indicators in analyzing education policies.

The intent of the Council and NSF is to provide a report of science and mathematics indicators that would meet a variety of needs for information. At the same time, our decisions on how indicators are selected, designed, and presented in the report does shape how the information can be used.

We chose not to compute and provide a composite indicator that would give a summary score for states across a number of individual indicators. The development of educational indicators has not reached the level of consensus among policymakers, researchers, and educators to make effective use of such a composite indicator. State users of indicators have expressed strong interest in having indicators reported individually to allow for different applications and interpretations.

We continue to hear expressed a need for indicators in at least three broad categories: (a) student achievement and outcomes; (b) school processes, content, and instructional practices; and (c) conditions or context for teaching and learning. Since our work on science and mathematics indicators began in 1986, several individual indicators have developed, changed, or been added, but these broad categories continue to be used.

Uses for analyzing education policies are central to the design for the 1999 report. First, we report state-by-state results on student achievement. The Council voted in 1984 to support state-by-state reporting of state achievement results if they are valid, comparable, and reliable. In this report, the statistics on NAEP 1996 mathematics and science assessments and advanced placement examinations allow the reader to analyze state-to-state differences in achievement and examine trends for individual states. In addition, student scores are reported in relation to standards for performance, that is, the knowledge and skills students should have gained by a given grade level.

Policy reforms in the 1980s aimed to increase the amount of time in elementary and secondary school that students study core academic subjects, such as mathematics and science. High school enrollments in science and mathematics are compared across different levels of state requirements, and trends are reported since 1990. We chose to report the rate at which students are progressing to higher-level courses in science and mathematics, not just the number of credits or courses. This approach to reporting indicators of course taking is consistent with a standard of all students learning challenging subject content in science and mathematics by graduation. This standard reflects the direction many states are now taking toward reform of mathematics and science.

Our analysis of state course enrollments also addresses grade 7 and 8 math and science, where there is currently concern about the lack of focus and extensive breadth of curriculum being taught.

States are currently examining policies and programs concerning initial preparation and professional development of teachers and administrators. An important issue is the use of state standards for content knowledge and instructional skills which are used to guide preparation of educators. This report applies a standard of preparation of whether secondary science and mathematics teachers have a major in their assigned teaching field. We also report on the proportion of teachers that have state certification in their assigned field, and we analyze the rate of certification for middle-level and high school teachers. Finally, we report state indicators from NAEP 1996 on teacher professional development in the amount of time spent on professional development in their assigned teaching field of mathematics or science.

Science and mathematics education reform emphasizes learning through doing and active involvement of students in application of knowledge, hands-on laboratory experiences, and projects. The 1999 indicators provide reliable information on use of calculators and writing in math. We also report data on trends in use of computers and availability of classroom resources and materials in science and mathematics to support active instruction. The indicators can have a role in examining policies that would provide support for science and mathematics reform efforts through key resources and materials.

The format of the 1999 CCSSO report is intended to assist in the use of state indicators, such as inclusion of full-page tables and graphics that can be photocopied as transparencies. We also provide detailed state-level data which are available on diskette. The main report and the detailed data are available in Adobe format on the CCSSO website (publications). Finally, each state has been provided with a diskette providing an archive of their science and math data since 1990, and a convenient spreadsheet-based, graphics program for displaying and reporting state indicators.

List of Abbreviations

AAAS	American Association for the Advancement of Science
AP	Advanced Placement
CCSSO	Council of Chief State School Officers
ECS	Education Commission of the States
ETS	Educational Testing Service
FTE	Full-Time Equivalent
NAEP	National Assessment of Educational Progress
NCES	National Center for Education Statistics, U.S. Department of Education
NCEST	National Council on Education Standards and Testing
NCTM	National Council of Teachers of Mathematics
NEGP	National Education Goals Panel
NGA	National Governors' Association
NRC	National Research Council
NSF	National Science Foundation
NSTA	National Science Teachers Association
OERI	Office of Educational Research and Improvement, U.S. Department of Education
PSA	Policy Studies Associates
SASS	Schools and Staffing Survey
SES	Socioeconomic status
SSI	Statewide Systemic Initiatives
TIMSS	Third International Mathematics and Science Study
USI	Urban Systemic Initiatives

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Appendix A
Student Demographics, State Policies

TABLE A-1 Students Taking Advanced Placement (AP) Exams in Mathematics and Science, 1998

STATE	AP CALCULUS Total Taking Exam	AP CALCULUS % of Grade 12	AP BIOLOGY Total Taking Exam	AP BIOLOGY % of Grade 12	AP CHEMISTRY Total Taking Exam	AP CHEMISTRY % of Grade 12	AP PHYSICS Total Taking Exam	AP PHYSICS % of Grade 12
Alabama	1,013	2%	629	1%	299	1%	391	1%
Alaska	377	5	144	2	192	3	66	1
Arizona	1,465	3	520	1	322	1	592	1
Arkansas	535	2	338	1	233	1	95	0.3
California	21,487	7	12,190	4	6,365	2	7,146	2
Colorado	2,029	5	950	3	589	2	581	2
Connecticut	2,249	8	1,324	5	888	3	915	3
Delaware	488	8	277	4	179	3	161	2
Dist. of Columbia	346	11	236	8	124	4	171	6
Florida	6,601	6	3,741	4	2,454	2	2,383	2
Georgia	3,352	5	1,732	3	1,394	2	873	1
Hawaii	831	8	455	4	403	4	286	3
Idaho	369	2	202	1	93	1	152	1
Illinois	7,198	6	3,089	2	2,289	2	2,858	2
Indiana	3,515	6	1,556	2	1,285	2	743	1
Iowa	848	2	269	1	203	1	114	0.3
Kansas	428	1	129	0.4	142	0.5	85	0.3
Kentucky	1,447	4	845	2	376	1	228	1
Louisiana	618	1	304	1	175	0.4	140	0.3
Maine	584	5	353	3	127	1	160	1
Maryland	3,882	9	1,798	4	1,215	3	1,158	3
Massachusetts	4,449	8	2,543	5	1,373	3	1,601	3
Michigan	4,429	5	2,537	3	1,794	2	1,366	2
Minnesota	3,329	6	917	2	498	1	432	1
Mississippi	501	2	211	1	159	1	80	0.3
Missouri	1,180	2	604	1	442	1	435	1
Montana	197	2	133	1	56	1	32	0.3
Nebraska	317	2	142	1	82	0.4	41	0.2
Nevada	504	3	208	1	278	2	137	1
New Hampshire	859	8	306	3	211	2	258	2
New Jersey	5,603	8	3,614	5	2,223	3	2,142	3
New Mexico	577	3	247	1	171	1	195	1
New York	15,070	10	10,295	7	4,153	3	5,934	4
North Carolina	4,314	7	2,308	4	1,437	2	1,043	2
North Dakota	132	2	109	1	29	0.3	30	0.3
Ohio	5,022	4	1,864	2	1,546	1	1,232	1
Oklahoma	926	3	428	1	389	1	309	1
Oregon	885	3	417	1	273	1	259	1
Pennsylvania	5,614	5	2,641	2	1,734	2	1,607	1
Rhode Island	372	4	252	3	104	1	101	1
South Carolina	2,804	8	1,372	4	704	2	328	1
South Dakota	260	3	154	2	115	1	19	0.2
Tennessee	1,857	4	1,033	2	557	1	506	1
Texas	7,676	4	4,002	2	2,369	1	2,119	1
Utah	2,839	8	1,500	4	705	2	714	2
Vermont	347	5	324	5	78	1	64	1
Virginia	5,302	8	2,614	4	1,544	2	1,220	2
Washington	2,212	4	797	1	452	1	397	1
West Virginia	475	2	217	1	146	1	72	0.3
Wisconsin	2,898	5	1,139	2	731	1	416	1
Wyoming	128	2	91	1	16	0.2	8	0.1
NATION	**140,740**	**5**	**74,100**	**3**	**43,716**	**2**	**42,395**	**2**

NOTE: State totals include public and private schools.

SOURCE: The College Board (1998). Advanced Placement Program, National and 50 States Summary.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE A-2 Minority Students Taking Advanced Placement Examinations in Mathematics and Science, 1998

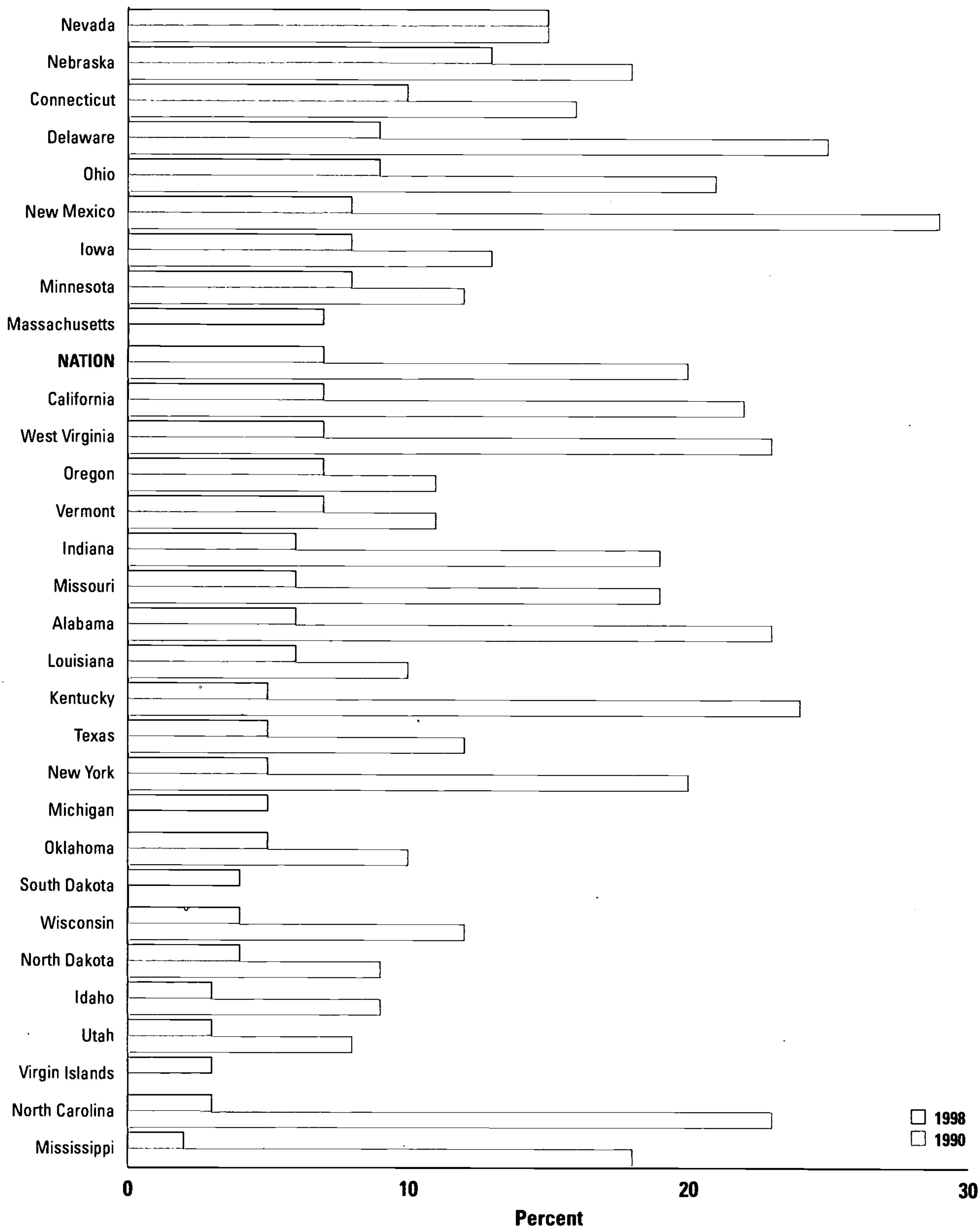
STATE	AP CALCULUS % American Indian	% Asian	% Black	% Hispanic	% Minority of Students Taking AP Calculus	AP SCIENCE % American Indian	% Asian	% Black	% Hispanic	% Minority of Students Taking AP Science
Alabama	1%	8%	7%	1%	17%	1%	9%	7%	1%	18%
Alaska	2	10	1	3	16	3	8	1	3	15
Arizona	1	9	1	7	18	3	8	1	7	19
Arkansas	0.4	10	6	1	17	1	6	4	1	12
California	0.3	39	2	9	51	0.4	38	2	8	48
Colorado	0.4	7	1	4	12	1	9	2	4	15
Connecticut	0.2	12	2	2	16	0.3	12	2	2	16
Delaware	0	12	4	1	17	0	11	4	1	15
Dist. of Columbia	0	5	16	4	25	0	9	12	5	26
Florida	0.3	11	5	12	29	0.2	12	6	13	31
Georgia	0.2	11	12	1	24	0.4	13	11	1	26
Hawaii	0	76	1	1	78	0.3	69	1	1	71
Idaho	0.3	5	0	1	7	0	5	0	2	7
Illinois	0.1	18	2	3	24	0.2	22	3	3	28
Indiana	0.4	5	2	2	9	0.3	6	3	2	11
Iowa	0.4	4	0.5	1	6	0.3	6	1	1	8
Kansas	0.2	12	0	1	13	1	13	1	3	18
Kentucky	0.4	6	1	1	8	0.2	5	1	1	8
Louisiana	0.2	12	6	1	19	0.5	15	7	2	24
Maine	0.2	3	0.3	0.3	4	0.3	2	0	1	3
Maryland	0.2	16	7	2	25	0.3	19	8	2	29
Massachusetts	0.2	15	2	1	18	0.1	16	2	2	19
Michigan	0.2	10	3	1	14	0.2	12	2	1	16
Minnesota	0.03	7	1	1	9	0.2	6	1	1	8
Mississippi	0.2	7	9	1	17	0.2	7	8	1	16
Missouri	0.6	9	2	1	13	0.3	10	3	1	13
Montana	2	1	0	1	3	0.5	0.5	0.5	0.5	2
Nebraska	0	4	1	1	6	0.4	3	1	1	5
Nevada	1	14	3	4	21	1	12	2	4	19
New Hampshire	0.1	12	0.3	2	14	0.3	12	0.3	2	14
New Jersey	0.1	23	4	3	30	0.2	22	3	3	28
New Mexico	4	7	1	15	27	5	6	1	16	28
New York	0.2	18	4	4	27	0.2	17	4	4	26
North Carolina	0.4	7	6	1	14	1	8	7	1	16
North Dakota	0	6	0	1	7	0	5	0	1	7
Ohio	0.3	8	3	1	12	0.4	10	3	1	14
Oklahoma	5	11	4	3	23	5	11	4	3	24
Oregon	1	11	1	2	15	1	14	0.4	1	16
Pennsylvania	0.1	9	2	1	12	0.1	10	2	1	13
Rhode Island	0	9	1	2	12	0.2	6	2	2	11
South Carolina	0.2	5	12	1	18	0.3	6	9	1	16
South Dakota	1	3	0	0.4	5	1	3	0	1	5
Tennessee	0.3	8	7	1	16	0.3	10	9	1	20
Texas	0.3	17	4	16	37	0.4	17	4	15	37
Utah	0.2	4	0.1	2	5	0.3	5	0.1	1	7
Vermont	0	4	1	0.3	5	0.2	5	1	0.2	6
Virginia	0.2	13	6	2	21	0.4	15	6	2	23
Washington	0.5	18	1	2	21	1	15	2	2	19
West Virginia	0.2	8	1	1	10	0.2	8	1	1	10
Wisconsin	0.2	5	1	1	7	0.4	6	1	1	9
Wyoming	2	2	0	3	7	1	3	0	0	3
NATION	**0.3**	**17**	**3**	**5**	**25**	**0.4**	**18**	**4**	**4**	**26**

NOTE: State totals include public and private schools. **Minority students** = sum of black, Hispanic, Asian/Pacific Islander, American Indian, etc. **% AP Science** = Students taking AP Biology, Chemistry, or Physics.

SOURCE: The College Board (1998). Advanced Placement Program, National and 50 States Summary Reports.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

FIGURE A-1 **High School Students Enrolled in General or Consumer Mathematics, Percent of Grades 9–12 Students, 1990 to 1998**



SOURCE: State Departments of Education, Data on Public Schools, 1997-98.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE A-3 **Percent of Public School Students by Race/Ethnicity, by State, 1996–97**

STATE	White	Black	Hispanic	Asian	American Indian	Total Minority
Alabama	61.5%	36.4%	0.7%	0.6%	0.7%	38.4%
Alaska	63.1	4.7	2.9	4.5	24.8	36.9
Arizona	56.6	4.3	30.1	1.8	7.2	43.4
Arkansas	73.5	23.5	1.8	0.7	0.4	26.4
California	39.5	8.7	39.7	11.2	0.9	60.5
Colorado	72.0	5.5	18.8	2.6	1.1	28.0
Connecticut	71.7	13.6	11.9	2.5	0.3	28.3
Delaware	63.9	29.9	4.3	1.8	0.2	36.2
Dist. of Columbia	4.0	87.3	7.2	1.4	0.1	96.0
Florida	56.7	25.4	15.9	1.8	0.2	43.3
Georgia	57.9	37.6	2.6	1.7	0.1	42.0
Hawaii	25.0	3.3	4.9	66.4	0.4	75.0
Idaho	88.0	0.7	8.9	1.2	1.3	12.1
Illinois	62.8	21.2	12.8	3.1	0.1	37.2
Indiana	85.4	11.2	2.4	0.8	0.2	14.6
Iowa	92.2	3.4	2.4	1.6	0.5	7.9
Kansas	81.9	8.6	6.5	1.9	1.1	18.1
Kentucky	88.9	9.9	0.5	0.6	0.1	11.1
Louisiana	50.6	46.4	1.2	1.3	0.6	49.5
Maine	97.2	0.9	0.4	0.9	0.6	2.8
Maryland	56.7	35.6	3.5	3.9	0.3	43.3
Massachusetts	77.9	8.4	9.6	4.0	0.2	22.2
Michigan	75.8	18.8	2.8	1.5	1.0	24.1
Minnesota	86.5	5.2	2.2	4.1	1.9	13.4
Mississippi	47.9	51.0	0.4	0.6	0.2	52.2
Missouri	81.1	16.5	1.1	1.0	0.3	18.9
Montana	87.2	0.6	1.5	0.8	9.9	12.8
Nebraska	86.4	6.0	4.9	1.3	1.4	13.6
Nevada	65.1	9.6	18.8	4.6	1.9	34.9
New Hampshire	96.4	1.0	1.3	1.1	0.2	3.6
New Jersey	—	—	—	—	—	—
New Mexico	38.8	2.4	47.7	1.0	10.2	61.3
New York	56.3	20.3	17.6	5.2	0.5	43.6
North Carolina	63.9	30.8	2.3	1.5	1.5	36.1
North Dakota	89.1	0.9	1.1	0.7	8.1	10.8
Ohio	82.0	15.4	1.4	1.0	0.1	17.9
Oklahoma	68.8	10.5	4.3	1.3	15.1	31.2
Oregon	84.6	2.6	7.4	3.4	2.0	15.4
Pennsylvania	80.2	14.2	3.7	1.8	0.1	19.8
Rhode Island	78.3	7.3	10.7	3.3	0.5	21.8
South Carolina	56.0	42.2	0.8	0.8	0.2	44.0
South Dakota	83.7	1.0	0.8	0.8	13.8	16.4
Tennessee	74.6	23.4	0.9	1.0	0.1	25.4
Texas	45.6	14.3	37.4	2.4	0.3	54.4
Utah	89.5	0.7	6.0	2.4	1.5	10.6
Vermont	97.3	0.8	0.4	1.0	0.6	2.8
Virginia	67.7	25.5	3.3	3.4	0.2	32.4
Washington	77.5	4.8	8.3	6.7	2.7	22.5
West Virginia	95.2	4.0	0.5	0.3	0.1	4.9
Wisconsin	82.6	9.6	3.5	2.9	1.3	17.3
Wyoming	89.0	1.2	6.2	0.8	2.8	11.0
American Samoa	—	—	—	100.0	—	100.0
Guam	5.3	1.2	0.9	92.6	0.1	94.8
Northern Marianas	0.8	—	0.0	99.2	—	99.2
Puerto Rico	—	—	100.0	—	—	100.0
Virgin Islands	1.1	84.6	14.0	0.2	—	98.8
NATION	**64.2**	**16.9**	**14.0**	**3.8**	**1.1**	**35.8**

SOURCE: NCES, Common Core of Data, Fall 1996.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1999.

TABLE A-4 Secondary Teachers: State Requirements for License in English/Language Arts, Mathematics, Science, Social Studies, 1998

STATE	English/ Lang. Arts	Math	Broad Field Science	Biology Chemistry Physics Earth Science	Social Science	History Economics Pol. Sci. Geography
	COURSE CREDITS IN FIELD					
Alabama			*State knowledge/ability rules*			
Alaska			*Institution-specific*			
Arizona	30	30	30	30	30	30
Arkansas			*Major or Minor*			
California	45	45	60	30	45	45
Colorado			*Major required*			
Connecticut	30	30	30	30	30	30(H)
Delaware	36	36	—	42 (b,es) 45 (c,p)	48	—
Dist. of Columbia	36	33	30	30	33	24
DoDEA (1996 data)	24	24	24	24	24	—
Florida			*Major (30 sem. hrs. specific content)*			
Georgia			*Major required*			
Hawaii			*Major required*			
Idaho	20	20	20	20	20	20
Illinois	32	32	32	32	—	32
Indiana	36	36	36	36	—	36
Iowa	24	24	24	24	24	15
Kansas			*Standards-based*			
Kentucky			*Standards-based*			
Louisiana			*15-50 sem. hrs. in subject area*			
Maine	36	36	—	36 (life, phy.)	18	—
Maryland	36	36	—	36	36	26-36
Massachusetts	36	36	36	36	—	24
Michigan	36	30	36	30	36	30
Minnesota			*Major & Approved Program*			
Mississippi			*Credits specific to field*			
Missouri	30	30	30	20	40	—
Montana	30/20	30/20	40	30/20	40	30/20
Nebraska	30	30	59	24	60	36
Nevada	36/24	36/24	36/24	36/24	36/24	36/24
New Hampshire			*Major required in core subjects*			
New Jersey			*Major in subject*			
New Mexico	24-36	24-36	24-36	—	24-36	—
New York	36	36	—	36	36	—
North Carolina			*Approved Program/Competencies in subject*			
North Dakota	30	30	—	30	—	30
Ohio	60	30	60	30	—	30
Oklahoma	24-40	24-40	24-40	24-40	24-40	24-40
Oregon			*24-48 cr. or subject exam*			—
Pennsylvania			*Approved Teacher Ed. Program & Major*			
Puerto Rico			*Major in subject*			
Rhode Island	30	30	30	30	—	30
South Carolina	30	30	30	30/12	30	30
South Dakota	21	18	21	12 (b,c,p) 18 (es)	24	18
Tennessee	36 qtr.	36 qtr.	48	24 qtr.	—	24
Texas	24	24	48	24	24	24
Utah	45 qtr.	45 qtr.	—	69 (b,es) 45 (c,p) qtr.	69	45
Vermont			*Competency-based program*			
Virginia	36	36	—	32	51	—
Virgin Islands	36	36	36	36	36	36
Washington	45/24 qtr.	24 qtr.	45 qtr.	24 qtr.	45	24
West Virginia			*Job-related objectives*			
Wisconsin	34	34	54	34	54	34
Wyoming			*Approv. program & major*			

NOTES: "—" No state course credit requirement. 30/20 = major or minor. "Credits" = semester credits, unless quarter credits specified. States also require professional education credits.

SOURCE: NASDTEC Manual on the Preparation and Certification of Education Personnel, 1998-99.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC. 119

TABLE A-5 Middle Grade Teachers: State Requirements in Academic Fields for Middle Grades License, 1998

STATE	Middle Grades Certification	English/ Lang. Arts	Math	Science	Social Studies	Other
		COURSE CREDITS IN FIELD				
Alabama	4-8			*27-39 cr. in 1 field*		
Alaska	6-9			*Institution-specific*		
Arizona	No					
Arkansas	5-8			*18 cr. in 1 field*		
California	Yes	20	12	16	16	20
Colorado	5-9			*Major in subject*		
Connecticut	4-8			*39 cr. in 5 of 6 areas & major + 3 History*		
Delaware	5-8	9	9	12	9 History, Geog.	6 Arts
Dist. of Columbia	4-8			*Major in subject assigned*		
DoDEA (1996 data)	5-8	18	18	18	18	
Florida	5-9	18	18	18	18	
Georgia	4-8			*30 sem. hrs in subjects*		
Hawaii	Yes					
Idaho	No					
Illinois	5-8			*18 cr. in subject assigned*		
Indiana	5-9			*18 cr. in 1 field*		
Iowa	No					
Kansas	5-9			*Standards-Based*		
Kentucky	5-9			*Standards-Based*		
Louisiana	Yes			*55 semester cr. in general education*		
Maine	K-8	6	6	6	6	60 cr. total
Maryland	No					
Massachusetts	5-9			*Major in 1 field (24 credits)*		
Michigan	Yes			*18 semester cr. in planned program*		
Minnesota	5-9			*Approved Program & Elem. or Sec. License*		
Mississippi	4-8			*18 semester cr. in each of 2 fields*		
Missouri	No					
Montana	No					
Nebraska	No					
Nevada	No					
New Hampshire	Yes			*Major in subject*		
New Jersey	No					
New Mexico	Yes			*24 to 36 sem. cr. in 1 field, 12 in upper div.*		
New York	Yes			*36 semester cr. in subject*		
North Carolina	6-9			*Subject-specific concentration (18 sem. hrs.)*		
North Dakota	No					
Ohio	5-9	30	20	20	20	45 cr. in 2 areas
Oklahoma	7-8			*18 cr. in 1 field*		
Oregon	No					
Pennsylvania	No					
Puerto Rico	No					
Rhode Island	No					
South Carolina	No					
South Dakota	5-8	15	12	12	12	
Tennessee	Yes			*Specific competencies*		
Texas	No					
Utah	Yes			*Major or minor in subject taught*		
Vermont	5-8			*2 academic minors (18 cr. each)*		
Virginia	6-8	21	21	21	21	
Virgin Islands	—					
Washington	Yes					
West Virginia	5-8			*Job-related objectives*		
Wisconsin	5-9			*Major or minor in subject taught*		
Wyoming	5-9			*Integrated program/competencies*		

NOTES: "—" No state course credit requirement. "Credits" = semester credits, unless quarter credits specified. States also require professional education credits.

SOURCE: NASDTEC Manual on the Preparation and Certification of Education Personnel, 1998-99.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC.

Appendix B
NAEP Sample Questions

N stands for the number of stamps John had. He gave 12 stamps to his sister. Which expression tells how many stamps John has now.?

(A) N + 12

(B) N - 12

(C) 12 - N

(D) 12 x N

Algebra and Functions

Overall Correct	67%
Basic	73%
Proficient	90%

Ms. Hernandez formed teams of 8 students each from the 34 students in her class. She formed as many teams as possible, and the students left over were substitutes. How many students were substitutes?

Answer: ______________

Number Sense, Properties, and Operations

Overall Correct	39%
Basic	42%
Proficient	86%

Sam can purchase his lunch at school. Each day he wants to have juice that costs 50¢, a sandwich that costs 90¢, and fruit that costs 35¢. His mother has only $1.00 bills. What is the least number of $1.00 bills that his mother should give him so he will have enough money to buy lunch for five days?

Number Sense, Properties, and Operations

Overall Satisfactory	17%
Basic	14%
Proficient	44%

A car odometer registered 41,256.9 miles when a highway sign warned of a detour 1,200 feet ahead. What will the odometer read when the car reaches the detour?

(A) 42,456.9

(B) 41,279.9

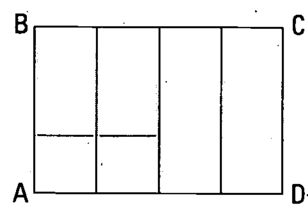
(C) 41,261.3

(D) 41,259.2

(E) 41,257.1

The Measurement Strand

Overall Correct	26%
Basic	25%
Proficient	50%



In the figure above, what fraction of rectangle ABCD is shaded?

(A) $\frac{1}{6}$

(B) $\frac{1}{5}$

(C) $\frac{1}{4}$

(D) $\frac{1}{3}$

(E) $\frac{1}{2}$

Number Sense, Properties, and Operations

Overall Correct	65%
Basic	78%
Proficient	96%

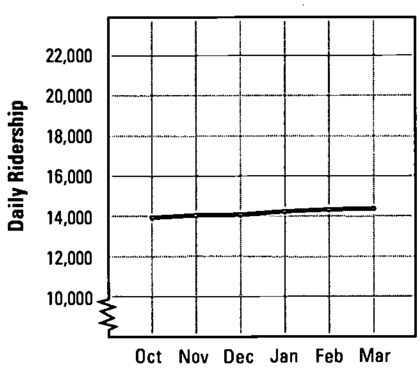
This question requires you to show your work and explain your reasoning. You may use drawings, words, and numbers in your explanation. Your answer should be clear enough so that another person could read it and understand your thinking. It is important that you show *all* of your work.

Metro Rail Company

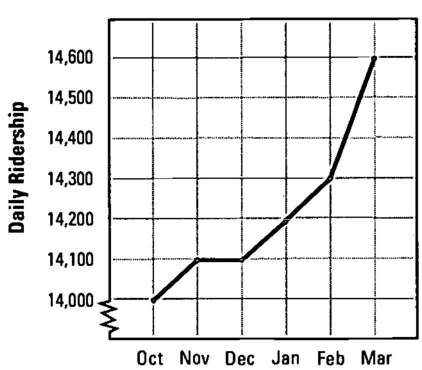
Month	Daily Ridership
October	14,000
November	14,100
December	14,100
January	14,200
February	14,300
March	14,600

The data in the table above has been correctly represented by both graphs shown below.

GRAPH A



GRAPH B



Which graph would be best to help convince others that the Metro Rail Company made a lot more money from ticket sales in March than in October?

Explain your reason for making this selection.

Why might people who thought that there was little difference between October and March ticket sales consider the graph you chose to be misleading?

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Data Analysis, Statistics, and Probability

Overall Satisfactory or Higher	20%
Basic	22%
Proficient	35%

A group of students took potato salad made with mayonnaise to a picnic on a very hot day. Explain how eating the potato salad could cause food poisoning.

____

____

____

____

Describe something that could be done to the potato salad to prevent the people who eat it from getting food poisoning.

____

____

____

____

____

This short constructed-response question measures Life Science and Practical Reasoning. Students' responses were scored using a three-level scoring guide that allowed for partial credit. The sample student response received the highest score, **Complete**. To receive a score of **Complete**, a student's response needed to explain the cause of food poisoning and describe a method of preventing it.

Percentages of Eighth Graders Receiving Complete and Partial Scores

Complete	10%
Partial	61%

Imagine that you could put popcorn kernels into an airtight popcorn popper and measure the mass of the popper with the kernels. After the popcorn has popped, the mass of the popper and the popcorn will be

(A) less than the original mass because popped corn is less dense that the kernels are

(B) equal to the original mass because the container is airtight

(C) greater than the original mass because the volume of the popped corn is greater than that of the kernels

(D) impossible to determine accurately without weighing each piece of popcorn immediately

This multiple-choice question measures Physical Science and Conceptual Understanding and was scored as either correct or incorrect.

The correct answer is B.

Percentage of Eighth Graders Answering Correctly 26%

Figure B-3 NAEP 1996 Science Sample Questions for Grade 8

The question refers to an experiment your teacher asks you to perform to compare the heating rate of soil with that of water. To do this, you are given the following materials: two heat lamps, two bins, two thermometers, one sample of soil, one sample of water, and one timer.

You are instructed to heat a sample of soil and a sample of water with heat lamps, measuring the temperature of each sample once a minute for eight minutes.

Suppose that the experiment yielded the results shown in the table below.

Time (min)	0	1	2	3	4	5	6	7	8
Soil temp (°C)	20.0	21.0	22.5	24.0	26.0	27.5	29.5	30.5	32.0
Water temp (°C)	20.0	21.5	27.0	27.5	24.0	25.5	26.0	27.5	28.5

At a beach that has white sand, you measure the temperature of the sand and the temperature of the seawater at 9:00 a.m. You find that both have a temperature of 16°C. If it is clear and sunny all morning, what do the data from the experiment predict about the temperature of the white sand compared to the temperature of the seawater at noon?

____

Explain your answer.

____

____

____

____

____

Explain why the prediction based on the data might be wrong.

____

____

____

____

____

____

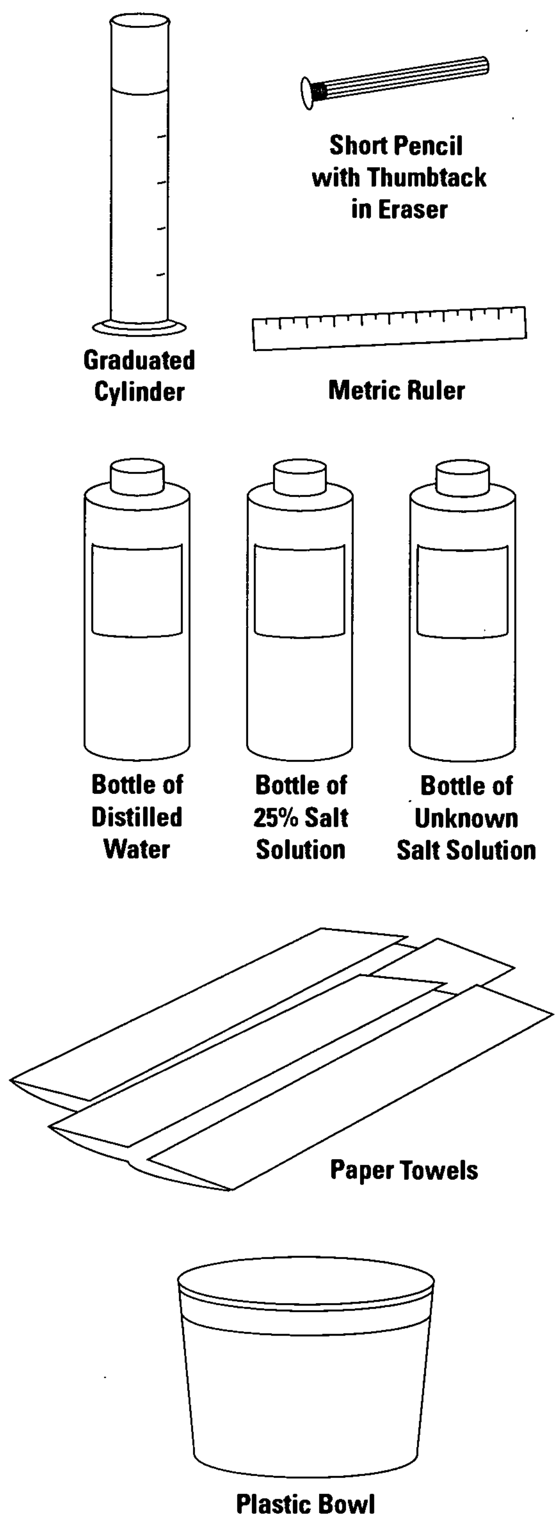
____

This extended constructed-response question measures Earth Science and Scientific Investigation. Students' responses were scored using a four-level scoring guide. The first sample student response received the highest score, **Complete**. To receive a score of **Complete**, a student's response needed to predict the relative temperature of the sand and water at noon and explain the answer. The student's also needed to give a satisfactory explanation of why the prediction might be wrong.

Percentages of Eighth Graders Receiving Complete, Essential, and Partial Scores

Complete	6%
Essential	6%
Partial	31%

Figure B-3 ***NAEP 1996 Science Sample Questions for Grade 8***



SALT SOLUTIONS:
Estimating the Salt Concentration of an Unknown Salt Solution Using the "Floating Pencil Test"

For this task, you have been given a kit that contains materials that you will use to perform an investigation during the next 30 minutes. Please open your kit now and use the following diagram to check that all of the materials in the diagram are included in your kit. If any materials are missing, raise your hand and the administrator will provide you with the materials that you need.

An instrument constructed from a pencil and thumbtack served as a hydrometer in this task. Students were asked to observe, measure, and compare the lengths of a portion of pencil, marked with calibrations for ease of measurement, that floated above the surface in distilled water and in a 25% salt solution. Based on these observations, the students were asked to predict how the addition of more salt to the salt solution would affect the floating pencil. Students then measured the length of the pencil that floated above the surface of a solution of unknown salt concentration and used the results of their previous observations to estimate the salt concentration of the unknown solution. The task assess students' ability to make simple observations, measure length using a ruler, apply observations to an unknown, draw a graph, interpolate from graphical data, and make a generalized inference from observations. The task also assessed students' understanding of the value of performing multiple trials of the same procedures.

...Now take the pencil out of the water and dry it with a paper towel. Use the ruler to measure the length of the pencil that was *above* the water. Record the length in Table 1 below under Measurement 1.

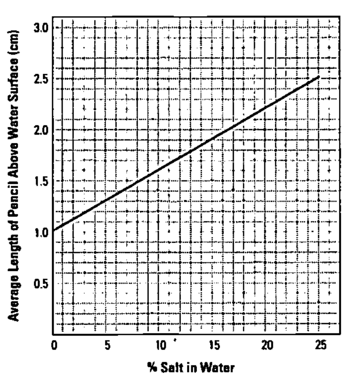
TABLE 1

Type of Solution	Length of Pencil Above Water Surface (cm)		
	Measurement 1	Measurement 2	Average
Distilled Water			
Salt Solution			
Unknown Salt Solution			

Now place the pencil back in the distilled water and repeat steps 2 and 3. Record your measurement in Table 1 under Measurement 2.

Calculate the average Measurements 1 and 2 and record the result in the data table. (You can calculate the average by adding Measurement 1 and Measurement 2 and then dividing by two.)

On the graph below, plot the average values you obtained for the distilled water and the 25% salt solution. Draw a straight line between the two data points. Assume that this line represents the relationship between the length of pencil that is above the water surface and the concentration of salt in the water.



Based on the graph that you plotted, what is the salt concentration of the unknown solution? ____________

Explain how you determined your answer.

____

____

____

____

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Measurement

Students' responses were scored using a four-level scoring guide. The sample student response received the highest score, **Complete**, because the three sets of measurements agreed within tolerance and were in the correct relative order.

Percentages of Eighth Graders Receiving the Following Scores

Complete	Essential	Partial
42%	16%	21%

Average

Students' responses were scored using a three-level scoring guide. The sample student response received a score of **Complete** because the three averages were correctly calculated.

Percentages of Eighth Graders Receiving the Following Scores

Complete	Partial
57%	22%

Graph

Students' responses were scored using a three-level scoring guide. The sample student response received a score of **Complete** because the two data points were plotted correctly.

Percentages of Eighth Graders Receiving the Following Scores

Complete	Partial
28%	19%

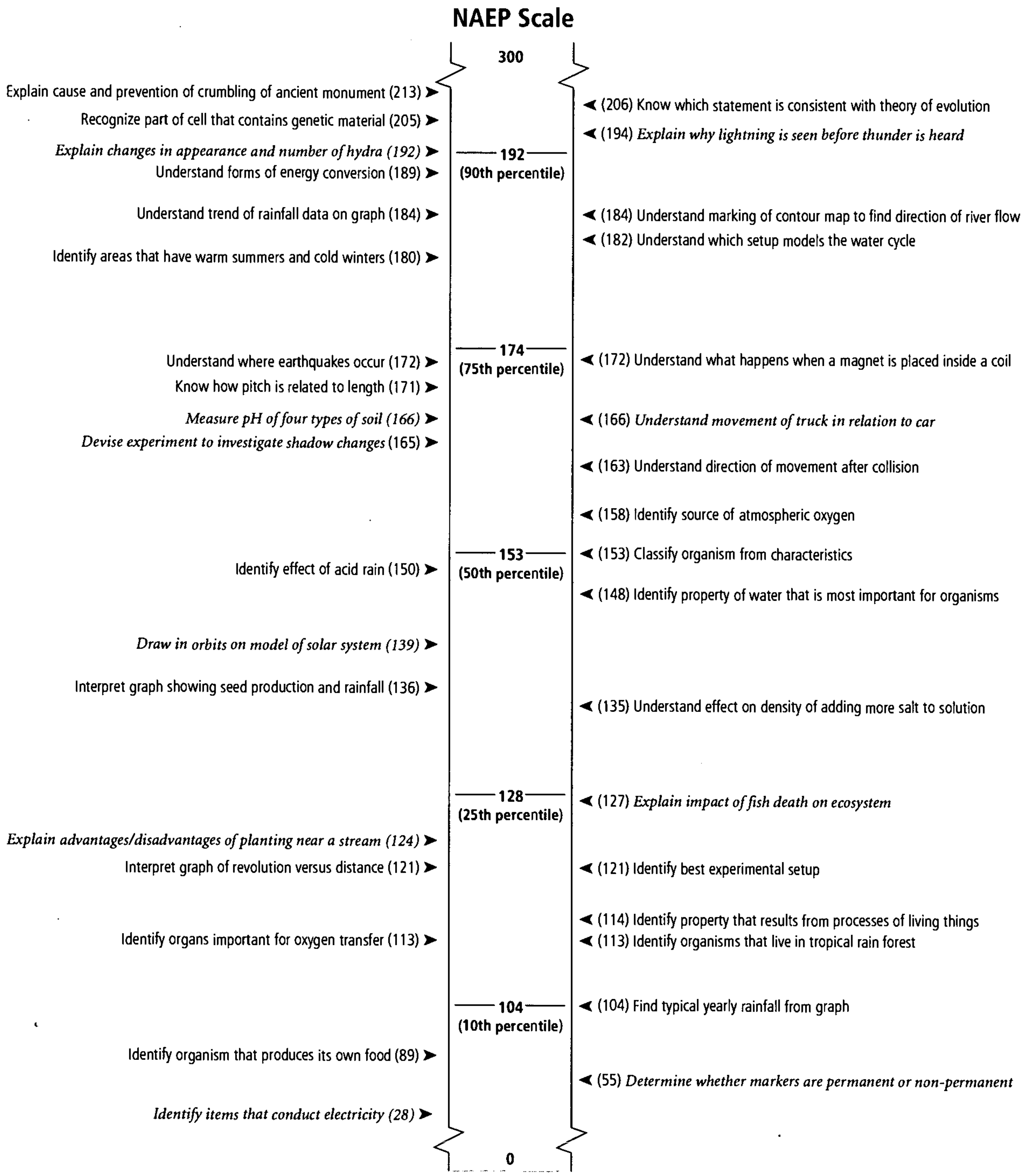
Interpolation

Students' responses were scored using a four-level scoring guide. The sample student response received a score of **Complete** because the concentration of salt in the unknown solution was interpolated correctly and a satisfactory explanation was given.

Percentages of Eighth Graders Receiving the Following Scores

Complete	Essential	Partial
20%	8%	16%

***Figure B-4* Map of Selected Questions on the NAEP Science Scale for Grade 8**



Note : Position of questions is approximate and on appropriate scale range is displayed for grade 8.
Italic type indicates a constructed-response question. Regular type denotes a multiple-choice question.

Each grade 8 science question was mapped onto the NAEP 0-to-300 science scale. The position of the question on the scale represents the scale score attained by students who had a 65% probability of reaching a given score level on a constructed-response question or a 74% probability of correctly answering a 4-option multiple-choice question. Only selected questions are presented. Percentiles of scale score distribution are referenced on the map.

Source: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Science Assessment.

Appendix C
Data Sources and Computations

Data Sources

National Assessment of Educational Progress (NAEP)

The National Assessment of Educational Progress (NAEP) is a congressionally mandated project of the National Center for Education Statistics (NCES) that has collected and reported information for nearly 25 years on what U.S. students know and what they can do. It is the nation's only ongoing, comparable, and representative assessment of student achievement. Its assessments are given to scientific samples of youths attending both public and private schools and enrolled in grades 4, 8, or 12. The assessment questions are written around a framework prepared for each content area reading, writing, math, science, and others that represents the consensus of groups of curriculum experts, educators, members of the general public, and user groups on what should be covered on such a test. Reporting includes means and distributions of scores, as well as more descriptive information about the meaning of different points on the NAEP scale.

NAEP's 1996 mathematics assessment included nearly 250,000 4th, 8th, and 12th grade students attending approximately 10,000 schools across the nation and the states, and the 1996 science assessment included 150,000 students in the same grades. The assessment itself was forward looking, comprising several hundred questions at each of the grades assessed. Consistent with the standards of the National Council of Teachers of Mathematics (NCTM) and the National Research Council (science), many of the questions required students to construct their responses; and some questions asked for explanations of their reasoning. For various portions of the assessment, mathematical and scientific tools and laboratory materials were supplied, including scientific calculators, protractor/rulers, and geometric shapes.

Nationally representative samples of students attending both public and private schools were assessed at grades 4, 8, and 12. Samples of 4th and 8th graders attending public schools were assessed in 44 states and three jurisdictions in math and 8th graders in science.

Schools and Staffing Survey (SASS)

In the 1987-88 school year, NCES launched a new survey with the goal of obtaining comprehensive, reliable data on the characteristics and condition of the nation's elementary and secondary schools and the teachers and administrators in the schools. The Schools and Staffing Survey (SASS) is conducted through questionnaires mailed to teachers, principals, and district administrators in a sample of the nation's public and private schools. It was conducted again in 1990-91 and 1993-94, and will be conducted again in 1999-2000.

The SASS is designed to provide data on the nation's elementary and secondary teaching force, aspects of teacher supply and demand, teacher workplace conditions, characteristics of school administrators, and school policies and practices. A major purpose of SASS is to provide comparable, reliable state-level statistics on the characteristics of schools and educators. The sample is designed to provide national estimates of schools, districts, teachers, and principals, and state-level estimates for public schools, districts, teachers, and principals. The sample for the survey comprised 9,500 public schools and principals, 5,400 school districts, and 56,000 public school teachers. The sample also included 3,000 private schools and 9,000 private school teachers. The survey sample was representative of public schools and teachers in each state. The average state sample included 185 elementary and secondary schools and 950 teachers.

Advanced Placement Examination (AP)

The Advanced Placement (AP) Program, a cooperative educational endeavor, is based on the premise that college-level material can be taught successfully to able and well-prepared secondary school students. Participating colleges, in turn, grant credit or appropriate placement to students who have done well on the AP Examinations. Approximately 57 percent of the nation's 22,000 high schools offer some college-level AP coursework, and more than 625,000 students participate in the AP Program each year. Use by both schools and students has grown steadily in recent years.

In response to increased interest in the AP Program, the College Board produces, as part of its reporting process, a series of tables reflecting student participation in the 1998 AP Examinations. A more detailed understanding of AP trends and related information can be found in the companion publication, the 1998 AP Yearbook.

The College Board annually publishes summary reports for the nation and for each of the 50 states. The reports give tables with the number of students taking examinations and the number receiving each grade: 1 = no recommendation, 2 = possibly qualified, 3 = qualified, 4 = well qualified, 5 = extremely well qualified.

State Data

State departments of education report aggregated totals on course enrollments and teacher characteristics in science and mathematics to CCSSO. Data are collected by states through state management information systems. Six states aggregate data from student records, six states aggregate data from a teacher form, and the remaining states aggregate data from schools and the data are often reported through school districts. The state totals for public schools are aggregated and reported to the Council using common data definitions and reporting forms (CCSSO, 1997). The data refer to the status of students and teachers on or about October 1. Each state's data codes for course enrollments and teacher assignments are cross-walked by CCSSO staff using the course taxonomy and common data category definitions developed by CCSSO with the states (see Appendix D).

For the science and mathematics indicators from the 1997-98 school year, 37 states, DoDEA, and the Virgin Islands reported some state-collected data. Data on science and mathematics teachers were reported by 39 states and course enrollments were reported by 33 states.

Computation of Estimated Proportion of High School Students Taking Selected Mathematics and Science Courses by Graduation

The percentages shown in Tables 7 and 10 for each course are statistical estimates of course taking of high school students by the time they graduate, based on the total course enrollment in grades 9-12 as of fall 1997 divided by the estimated number of students in a grade cohort during four years of high school.

Synthetic cohort statistics have been used previously in education. For example, a synthetic high school dropout statistic has been estimated, based on the sum of the percentages of students who drop out at each grade, for grades 9-12 (Kominski, 1993). Cross-sectional data on dropouts by grade are used to estimate a true dropout rate over a 4-year period of high school. A true dropout rate requires tracking the status of the same group of students (cohort) through four years of high school. If only cross-sectional data are available, the synthetic cohort statistic provides an estimate of the high school dropout rate.

The Science and Mathematics Indicators Project desired a synthetic cohort statistic of the proportion of graduates in a state that take a given course, e.g., Biology 1. Since most states do not collect data by grade, the approach used in computing a synthetic dropout statistic had to be revised. First, the numerator is the total number of students in grades 9-12 that took a given course, e.g., Biology, first year, in Fall 1997. The denominator is an estimate of the number of students in a cohort of students summed over a 4-year period of high school. For each state, the size of the cohort of students that have some probability of taking a given course, e.g., Biology 1, during four years of high school is estimated by: the state student membership in each grade (for grades 9-12) weighted by the regional percentage of students that took the course at each grade level, and summing the weighted memberships for each grade for grades 9-12. The state student memberships by grade are from the 1996-97 Common Core of Data (NCES) and the regional percentages were obtained from the 1994 National Transcript Study (Westat, 1994).

The computation of the science/mathematics course taking synthetic cohort statistic can be summarized as follows, using the example of Biology 1:

Estimated proportion of students taking Biology 1 in state A	=	Biology 1 enrollment (9–12) *(Reported by State A)* / Estimated number of students in cohort in grades 9–12 *(from CCD and regional weights based on NAEP transcript study)*
Estimated students in cohort	=	(M9 x Bio 1/9) + (M10 x Bio 1/10) + (M11 x Bio 1/11) + (M12 x Bio 1/12)
		Where **M9** is the student membership for grade 9 *(from NCES Common Core of Data)*
(Four regions designated by Westat— Northeast, North Central, South Central, and West.)		**Bio 1/9** is the percentage of 1994 graduates in state A's region that took Biology 1 in grade 9 *(from Westat, Inc. transcript data files).*

The estimated percentages of students taking a course by graduation, based on state data, can be compared with rates based on student transcripts from studies conducted by the National Center for Education Statistics. For example, national estimates of course-taking from 1993-94 aggregated state data (Blank & Gruebel, 1995) were: biology 95+%, chemistry 51%, physics 22%; while figures from the National Transcript Study (1994) were: biology 94%, chemistry 56%, physics 24%. In mathematics, state aggregate data reported: geometry 65%, algebra 2 60%, trigonometry/precalculus 33%, calculus 10%; Transcript Study reported: geometry 70%, algebra 2 59%, trigonometry/ precalculus 35%, calculus 9%. (We do not compare algebra 1 because transcript studies generally do not include 8th grade enrollments. State data showed 95+ percent of students taking algebra 1 by graduation; while the transcript study reported 66 percent.)

Thus, the comparison of rates by the two data collection methods show that transcript data produce slightly higher rates of course-taking. One reason for the difference is that CCSSO/state data were reported only during first semester, while the transcript data count all courses taken whether they are year long, first semester, or second semester courses. The transcript study rates have a small standard error (1% to 2%), while CCSSO estimates from state data include some error introduced by imputation for missing states. The CCSSO data from states could also be compared to student self-report data from NAEP assessments in mathematics and science. However, comparisons of self-reported vs. transcript data show that self-report data often have slightly inflated rates of course-taking.

Variability is added to the state estimates through the weighted student membership based on regional weights. Since the weights are not state specific, each estimate has variability. For this reason, estimates over 95 percent of students cannot be made with precision; and enrollments at this level are shown in Tables 7 and 10 as 95+ percent.

Course enrollment rates are based on enrollment as of fall 1997. Some states collect data on student course taking for fall and spring semesters. The state comparisons are based on cross-sectional data collected as of October 1. The indicator does not account for course taking in spring semester courses.

Imputation of estimated proportion of high school graduates taking selected mathematics and science courses for nonreporting states. In 1997-98, 33 states were able to report course enrollment data to CCSSO. To obtain a national total for the estimated proportion of graduates taking selected mathematics and science courses, the state proportions were imputed. The following formula was used for imputation:

$$\text{Estimated proportion of students taking Biology 1 in nonreporting state B} = \frac{\text{[Reg. avg. \% taking Biology 1 (9–12) x state B student membership (9–12)]}}{\text{Sum of estimated numbers of students in cohort in grades 9–12}}$$

(from CCD and regional weights based on NAEP transcript study) (as above)

Where Reg. avg. % taking Biology 1 is the average (mean) percent of students taking Biology 1 among the reporting states in state B's region

Imputation of number of teachers per field (in mathematics, biology, chemistry, etc.) for nonreporting states.

$$\text{Imputed number of teacher of mathematics in state C} = \frac{\text{State student membership (9–12)}}{\text{Regional ratio students/teacher}} \times \text{Regional ratio of mathematics teachers to total teachers (9–12)}$$

$$\text{Regional ratio students/teacher} = \frac{\text{State student membership (9–12)}}{\text{State total teachers (9–12)}} \quad \text{Average for states in region}$$

$$\text{Regional ratio mathematics teachers to total teachers} = \frac{\text{State mathematics teachers (9–12)}}{\text{State total teachers (9–12)}} \quad \text{Average for states in region}$$

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Appendix D

Directory of State Course Titles by Reporting Categories

State Science and Mathematics Indicators (Fall 1997)

CCSSO INDICATORS

Science Course Categories

State Course Titles (from state data forms)

Grades 7–8

General Science, 7–8
General Science 7, 8

Life Science, 7–8
Life Science 7, 8

Earth Science, 7–8
Earth Science 7, 8

Physical Science, 7–8
Physical Science 7, 8

Integrated/Coordinated Science, 7–8
Science I, II; SS&C; Project 2061; Integrated Science 7, 8; Earth/Life/Physical Science 7, 8; Coordinated Science 7, 8

Other Science, 7–8
Other science courses for grades 7 or 8 listed under the "Science" category on state data collection form.

Grades 9–12

Biology, 1st Year
Biology I; General; College Prep.; Regents; Introductory; BSCS I

Biology, 1st Year, Applied
Basic Biology; Applied; Life Science; Biomedical Ed.; Animal Science; Horticulture Sci.; Bio. Science; Health Science; Nutrition; Man & Disease; Agricul. Science; Fundamentals of Biology

Biology, 2nd Year, Advanced Placement
Advanced Placement Biology

Biology, 2nd Year, Advanced
Biology II; Advanced; College; Psychobiology; Physiology; Anatomy; Microbiology; Genetics; Cell Biology; Embryology; Molecular Biology; Invertebrate/Vertebrate Biology; BSCS II

Biology, 2nd Year, Other
Zoology; Botany; Biomedical careers; Field Biology; Ecology; Marine Biology; Other Biological Sciences

Chemistry, 1st Year
Chemistry I; General; Introductory; Regents

Chemistry, 1st Year, Applied
Applied Chemistry; Consumer Chemistry; Technical Chemistry; Practical Chemistry; Chemistry in the Community

Chemistry, 2nd Year, Advanced Placement
Advanced Placement Chemistry

Chemistry, 2nd Year, Advanced
Chemistry II; Advanced; College; Organic; Inorganic; Physical; Biochemistry; Analytical

Physics, 1st Year
Physics I; General; Regents; Introductory

Physics, 1st Year, Applied
Applied Physics; Electronics; Radiation Physics; Practical Physics; Applied/Conceptual Physics; Electricity

Physics, 2nd Year, Advanced Placement
Advanced Placement Physics

Physics, 2nd Year, Advanced
Physics II; Advanced; College; Nuclear Physics; Atomic Physics

Earth Science, 1st Year
Earth Science; Earth-Space Science; Regents Earth Science; Space Science (courses that are generally taught at grade 9 and at introductory level)

Earth Science, 1st Year, Applied
Applied Earth Science; Fundamentals of Earth Science; Soil Science

Earth Science, 2nd Year, Advanced/Other
Advanced Earth Science; Earth Science II;

Oceanography; Aquatic Science; Marine Science; Astronomy; Geology; Meteorology (courses that are generally taught at grade 10, 11, or 12 and at higher level than Earth Science, 1st Year)

General Science
General Science; Basic; Introductory; Consumer Science

Physical Science
Physical Science; Interaction of Matter and Energy; Applied Physical Science

Integrated/Coordinated Science
Science III, IV; SS&C; Project 2061; Integrated Science 9, 10; Unified; Comprehensive Ideas of Investigations in Science; Life/Physical Science; Earth/Life/Physical Science; Coordinated Science

Environmental Science
Environmental Science; Environmental Education

Technology (taught as science course)
Principles of Technology I, II; Science/Technology/Society; Tech. Prep. Science; Biotechnology; Histologic Technology

Other Science
Science/Math; Engineering; Bioengineering; Special Interests Science; Energy; Research Topics; Laboratory Management; Aerospace Science; Aviation; Other science courses for grades 9–12 listed under the "Science" category on state data collection form.

Mathematics Course Categories

State Course Titles (from state data forms)

Grades 7–8

Remedial Math, Grade 7
Remedial Math 7

Math, Grade 7, Regular
Math 7; Exper. Math 7-SS MCIS

Math, Grade 7, Accelerated/Prealgebra
Accelerated Math 7; Prealgebra; Introductory Algebra; Honors Math 7; Enriched Math 7

Remedial Math, Grade 8
Remedial Math 8

Math, Grade 8, Regular
Math 8; Exper. Math 8-SS MCIS

Math, Grade 8, Enriched
Prealgebra; Accelerated Math 8; Honors Math 8; Enriched Math 8

Math Grade 8, Algebra 1/Integrated Math 1
Algebra 1; Beginning Algebra; Elementary Algebra; Integrated Math 1

Grades 9–12

Review Mathematics

Level 1
General Math 1; Basic Math; Math 9; Remedial Math; Developmental; H.S. Arithmetic; Math Comp Test; Comprehensive Math; Terminal Math

Level 2
General Math 2; Vocational Math; Consumer; Technical; Business; Shop; Math 10; Career Math; Practical Math; Essential Math; Cultural Math

Level 3
General Math 3; Math 11; Intermediate Math

Level 4
General Math 4; Math 12

Informal Mathematics

Level 1
Prealgebra; Introductory Algebra; Basic; Applications; Algebra 1A (first year of two-year sequence for Algebra 1); Math A; Applied Math

Level 2
Basic Geometry; Informal Geometry; Practical Geometry; Applied Math 2

Level 3
Applied Math 3, 4; Mathematics of Consumer Economics

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Formal Mathematics

Level 1

Algebra 1; Elementary; Beginning; Unified Math I; Integrated Math 1; Algebra 1B (second year of two-year sequence for Algebra 1); Math B

Level 2

Geometry; Plane Geometry; Solid Geometry; Integrated Math 2; Unified Math II; Math C

Level 3

Algebra 2; Intermediate Algebra; Algebra and Trigonometry; Advanced Algebra; Algebra and Analytic Geometry; Integrated Math 3; Unified Math III

Level 4

Trigonometry; College Algebra; Algebra 3; Precalculus; Analytic/Advanced Geometry; Trigonometry and Analytic/Solid Geometry; Advanced Math Topics; Intro. to College Math; Number Theory; Math IV; College Prep Sr. Math; Elem. Functions; Finite Math; Math Analysis; Numerical Analysis; Discrete Math; Probability; Statistics

Level 5

Calculus and Analytic Geometry; Calculus; Abstract Algebra; Differential Equations; Multivariate Calculus; Linear Algebra; Theory of Equations; Vectors/Matrix Algebra

Level 5 Advanced Placement

Advanced Placement Calculus (AB, BC)

Other Mathematics, 9–12

Used only if state has a code for "Other Mathematics"

Computer Science Course Categories

State Course Titles (from state data forms)

Grades 7–8

Computer Science/Computer Programming

Introductory Programming (any language)

Grades 9–12

Computer Science/Programming I

Introductory Programming (any language); Programming I; Computer Language I

Advanced Computer Science/Programming II

Advanced Programming; Programming II; Computer Language II

Computer Science, Advanced Placement

Advanced Placement Computer Science

Source: Instructions and Reporting Forms for Data on Science and Mathematics Education in (each state).

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